MINISTRY OF HEALTH OF THE REPUBLIC OF MOLDOVA
NICOLAE TESTEMITANU STATE UNIVERSITY OF MEDICINE AND PHARMACY OF THE REPUBLIC OF MOLDOVA

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PENINA OLGA

SOCIO-DEMOGRAPHIC AND REGIONAL DISPARITIES OF MORTALITY IN THE REPUBLIC OF MOLDOVA

331.03. SOCIAL MEDICINE AND MANAGEMENT

Doctoral Habilitation Thesis in Medical Sciences

Scientific consultants: **Raevschi Elena**, Doctor Habilitat in Medical Sciences, Associate Professor

Meslé France, Ph.D. in Medicine

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MINISTERUL SĂNĂTĂŢII AL REPUBLICII MOLDOVA
IP UNIVERSITATEA DE STAT DE MEDICINĂ ŞI FARMACIE
„NICOLAE TESTEMIŢANU" DIN REPUBLICA MOLDOVA

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PENINA OLGA

DISPARITĂȚILE SOCIO-DEMOGRAFICE ȘI REGIONALE ALE MORTALITĂȚII ÎN REPUBLICA MOLDOVA

331.03. MEDICINĂ SOCIALĂ ȘI MANAGEMENT

Teză de doctor habilitat în științe medicale

Consultanți științifici: **Raevschi Elena**, doctor habilitat în științe medicale, conferențiar universitar

Meslé France, Ph.D. în medicină

Autor: **Penina Olga**

CHIȘINĂU, 2023

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Adnotare

Penina Olga

Disparitățile socio-demografice și regionale ale mortalității în Republica Moldova
Teză de doctor habilitat în științe medicale
Chișinău, 2023

Structura tezei: introducere, șase capitole, concluzii generale și recomandări practice, bibliografie (212 surse), 18 anexe, 247 pagini de text de bază, 119 figuri și 35 tabele. Rezultatele obținute sunt publicate în 41 de lucrări științifice.

Cuvinte-cheie: mortalitate, cauze de deces, diferențiere regională, disparități sociale, stare civilă, nivel de educație, exces de mortalitate, tranziție epidemiologică.

Scopul lucrării: examinarea tendințelor de lungă durată și a diferențelor sociale și regionale ale mortalității în Republica Moldova în contextul evaluării calității datelor și elaborarea recomandărilor privind îmbunătățirea monitorizării mortalității și reducerea disparităților în materie de mortalitate.

Obiectivele cercetării: 1) Evaluarea calității datelor privind populația și mortalitatea la nivel național, subnațional și raional și propunerea metodelor de corecție pentru datele problematice; 2) Reconstituirea continuității seriilor de mortalitate conform CIM-10 în Republica Moldova pentru perioada 1965-2020; 3) Analiza schimbărilor în tendințele și modelele pe termen lung ale mortalității după vârstă și cauze de deces în Republica Moldova și determinarea trăsăturilor comune și a particularităților acestora în comparație cu România și Ucraina; 4) Evaluarea mortalității excesive după vârstă și principalele cauze de deces în Republica Moldova în comparație cu modelul european; 5) Examinarea schimbărilor în mortalitatea generală și specifică pe cauze de deces în funcție de mediul de reședință; 6) Examinarea disparităților în mortalitatea generală și specifică pe cauze de deces în funcție de starea civilă și nivelul de educație; 7) Analiza profilului geografic al speranței de viață și al mortalității după vârstă și cauze de deces; 8) Detectarea clusterelor de raioane cu niveluri similare de mortalitate pe cauze de deces prin analiza autocorelației spațiale; 9) Elaborarea de recomandări practice pentru îmbunătățirea monitorizării mortalității și reducerea disparităților în materie de mortalitate în Republica Moldova.

Noutatea și originalitatea științifică: 1) Sistematizarea principalelor probleme de calitate a datelor privind populația și mortalitatea și armonizarea datelor la nivel național, subnațional și raional; 2) Reconstituirea continuității seriilor de mortalitate conform unei clasificări fixe a cauzelor de deces în Republica Moldova pentru perioada 1965-2020; 3) Elaborarea tabelelor de mortalitate în funcție de caracteristicile socio-demografice la nivel național, subnațional și raional; 4) Identificarea subgrupurilor de populație fruntașe și rămase în urmă în ceea ce privește speranța de viață și mortalitatea în funcție de mediul de reședință, starea civilă, nivelul de educație și localizarea geografică; 5) Determinarea componentelor după vârstă și cauză de deces ale diferențierii interregionale a speranței de viață și evaluarea modificărilor acestora pe parcursul perioadei de independență; 6) Detectarea clusterelor spațiale cu mortalitate similară scăzută sau ridicată după cauza de deces în baza autocorelației spațiale.

Problema științifică soluționată în teză: Studiul propune o nouă abordare în analiza evoluției tendințelor pe termen lung și a disparităților sociale și regionale în mortalitatea după cauza de deces în Republica Moldova, având în vedere evaluarea calității datelor primare. Seriile cronologice ale deceselor, reconstituite conform CIM-10 pentru perioada 1965-2020, corespund cerințelor internaționale de comparabilitate, completitudine și regularitate a datelor. Analiza comparativă a seriilor reconstituite asigură compatibilitatea datelor între țări de-a lungul timpului.

Semnificația teoretică: Teza reprezintă un studiu comprehensiv al tendințelor pe termen lung și al disparităților sociale și regionale în ceea ce privește speranța de viață și mortalitatea după cauza de deces în Republica Moldova, cu accent pe aspectele legate de calitatea datelor. Modificările mortalității specifice pe cauze de deces la nivel național, subnațional și raional sunt examinate prin prisma teoriei tranziției epidemiologice și a interpretărilor ulterioare, cum ar fi teoria tranziției în domeniul sănătății, care vizează explicarea diferențelor în tendințele și modelele mortalității în timp și între populații.

Valoarea aplicativă: Rezultatele studiului pot constitui baza pentru consolidarea politicilor de sănătate publică în vederea creșterii speranței de viață a populației și reducerii disparităților în mortalitate. Rezultatele analizei spațiale a diferențierii interregionale a mortalității pot fi aplicate în cadrul politicilor de dezvoltare regională. Rezultatele studiului pot fi utilizate în cercetarea și predarea în domeniile demografiei și sănătății publice.

Implementarea rezultatelor științifice: Baza de date a seriilor de mortalitate reconstituite pentru Republica Moldova a fost integrată în baza de date internațională, The Human Cause-of-Death Database, coordonată de Institutul Național pentru Studii Demografice din Franța și Institutul Max Planck pentru Cercetări Demografice din Germania.

Аннотация

Пенина Ольга

Социально-демографические и региональные различия смертности в Республике Молдова

Диссертация доктор хабилитат медицинских наук, Кишинев, 2023

Структура диссертации: диссертация состоит из введения, шести глав, общих выводов и практических рекомендаций, библиографии (212 ссылок), 18 приложений, 247 страниц основного текста, 119 рисунков и 35 таблиц. Полученные результаты опубликованы в 41 научной работе.

Ключевые слова: смертность, причины смерти, региональная дифференциация, социальные различия, семейное положение, уровень образования, избыточная смертность, эпидемиологический переход.

Цель исследования: изучение долгосрочных тенденций, социальных и региональных различий в смертности в Республике Молдова в контексте оценки качества данных и разработка рекомендаций по совершенствованию мониторинга смертности и сокращению её неравенства.

Задачи исследования: 1) Оценить качество данных о населении и смертности на национальном, субнациональном и районном уровнях и предложить методы коррекции проблемных данных; 2) Восстановить непрерывность рядов смертности по МКБ-10 в Республике Молдова за 1965-2020 годы; 3) Проанализировать изменения в долгосрочных тенденциях и структуре смертности по возрасту и причинам смерти в Республике Молдова и определить их общие черты и особенности по сравнению с Румынией и Украиной; 4) Оценить избыточную смертность по возрастным группам и основным классам причин смерти в Республике Молдова по сравнению с европейской моделью; 5) Изучить изменения общей смертности и смертности по причинам смерти в зависимости от типа поселения (сельская/городская); 6) Изучить различия в общей смертности и смертности от отдельных причин смерти в зависимости от семейного положения и уровня образования; 7) Проанализировать географический профиль ожидаемой продолжительности жизни и смертности по возрасту и причинам смерти; 8) Выявить кластеры районов со схожим уровнем смертности в зависимости от причины смерти на основе анализа пространственной автокорреляции; 9) Разработка практических рекомендаций по совершенствованию мониторинга смертности и снижению неравенства в смертности в Республике Молдова.

Новизна и научная оригинальность: 1) Систематизация основных вопросов качества данных о населении и смертности и гармонизация данных на национальном, субнациональном и районном уровнях; 2) Восстановление непрерывности рядов смертности по фиксированной классификации причин смерти в Республике Молдова за 1965-2020 годы; 3) Разработка таблиц смертности по социально-демографическим характеристикам на национальном, субнациональном и районом уровнях; 4) Выявление ведущих и отстающих групп населения по уровню продолжительности жизни и смертности в зависимости от типа поселения, семейному положению, уровню образования и географическому расположению; 5) Определение компонентов межрегиональной дифференциации продолжительности жизни по возрасту и причинам смерти и оценка их изменений за период независимости; 6) Выявление пространственных кластеров с одинаково низкой или высокой смертностью по причинам смерти на основе пространственной автокорреляции.

Научная проблема, решаемая в диссертации: Исследование представляет новое направление в анализе эволюции долгосрочных тенденций, социальной и межрегиональной дифференциации смертности по причинам смерти в Республике Молдова с учетом оценки качества первичных данных. Временные ряды смертности, реконструированные в соответствии с МКБ-10 за 1965-2020 годы, отвечают международным требованиям сопоставимости, полноты и регулярности данных. Сравнительный анализ реконструированных рядов обеспечивает сопоставимость данных между странами во времени.

Теоретическая значимость: Диссертация представляет собой комплексное исследование долгосрочных тенденций, социальных и региональных различий в смертности по причинам смерти в Республике Молдова с акцентом на вопросы качества данных. Изменения в смертности по причинам смерти на национальном, субнациональном и районном уровнях рассматриваются сквозь призму теории эпидемиологического перехода и ее последующих интерпретаций, направленных на объяснение различий в тенденциях и моделях смертности во времени и между популяциями.

Прикладное значение: Результаты исследования могут служить основой для укрепления политики общественного здравоохранения, направленной на увеличение продолжительности жизни населения и сокращение неравенств в смертности. Результаты пространственного анализа межрегиональной дифференциации смертности могут быть применены в политике регионального развития. Результаты исследования могут быть использованы в исследовании и преподавании в области демографии и общественного здравоохранения.

Внедрение научных результатов: База данных реконструированных рядов смертности для Молдовы была интегрирована в международную базу данных The Human Cause-of-Death Database, координаторами которой являются Национальный институт демографических исследований во Франции и Институт демографических исследований Макса Планка в Германии.

Annotation

Penina Olga
Socio-demographic and Regional Disparities of Mortality in the Republic of Moldova
Doctoral Habilitation Thesis in Medical Sciences
Chisinau, 2023

Structure of thesis: the thesis consists of an introduction, six chapters, general conclusions and practical recommendations, a bibliography (212 references), 18 annexes, 247 pages of the main text, 119 figures and 35 tables. The obtained results are published in 41 scientific papers.

Keywords: mortality, causes of death, regional differentiation, social disparities, marital status, level of education, excess mortality, epidemiological transition.

Aim of the study: To examine the long-term trends and social and regional differences in mortality in the Republic of Moldova in the context of data quality assessment and to develop recommendations to improve mortality monitoring and reduce disparities in mortality.

Study's objectives: 1) To assess the quality of population and mortality data at the national, sub-national and district levels and to propose the methods of correction of the problematic data; 2) To reconstruct the continuity of mortality series according to the ICD-10 in the Republic of Moldova for the period 1965-2020; 3) To analyse changes in long-term trends and patterns in mortality by age and cause of death in Moldova and to determine their commonalities and peculiarities compared to Romania and Ukraine; 4) To evaluate excess mortality by age and main cause of death in the Republic of Moldova compared to the European model; 5) To examine changes in overall and cause-specific mortality by place of residence (rural/urban); 6) To examine overall and cause-specific mortality disparities by marital status and the level of education; 7) To analyse the geographical profile of life expectancy and mortality by age and cause of death; 8) To detect clusters of districts with similar levels of mortality by cause of death based on spatial autocorrelation analysis; 9) To develop practical recommendations for improving mortality monitoring and reducing mortality disparities in the Republic of Moldova.

Novelty and scientific originality: 1) Systematization of main data quality issues on population and mortality and data harmonization at the national, sub-national and district levels; 2) Reconstruction of the continuity of mortality series according to a fixed classification of causes of death in Moldova in 1965-2020; 3) Elaboration of life tables by socio-demographic characteristics at the national, sub-national and district levels; 4) Identification of the vanguard and laggard sub-populations in terms of life expectancy according to the place of residence, marital status, level of education and geographical area of living; 5) Determination of the components by age and cause of death of the inter-regional differentiation in life expectancy and assessment of their changes over independence; 6) Detection of the spatial clusters with similar low or high mortality by cause of death based on spatial autocorrelation.

Scientific problem solved in the thesis: The study presents a new direction in analysing the evolution of the long-term trends and social and interregional differentiation of mortality by cause of death in Moldova, taking into account the assessment of the quality of primary data. The time series of deaths, reconstructed according to ICD-10 for the period 1965-2020, meet the international requirements of comparability, completeness and regularity of data. Comparative analysis of the reconstructed series ensures data compatibility across countries over time.

Theoretical significance: The thesis represents a comprehensive study of the long-term trends and social and regional disparities in mortality by cause of death in the Republic of Moldova, focusing on data quality issues. Changes in cause-specific mortality at the national, sub-national and district levels are examined through the prism of the epidemiologic transition theory and its subsequent interpretations aimed at explaining differences in mortality trends and patterns over time and between populations.

Applicative value: The study results can form the basis for strengthening public health policies to increase population life expectancy and reduce mortality disparities. The results of the spatial analysis of interregional differentiation of mortality can be applied to regional development policies. The results of the study can be used for research and teaching in the field of demography and public health.

Implementation of scientific results: The reconstructed mortality series database for the Republic of Moldova has been integrated into the international database, The Human Cause-of-Death Database, coordinated by the National Institute for Demographic Studies in France and the Max Planck Institute for Demographic Research in Germany.

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ABBREVIATIONS

ATU – Autonomous Territorial Unit

CI – confidence interval

CUATM – Classification of Territorial-Administrative Division

CVD – cardiovascular diseases

e_0 – life expectancy at birth

FAI – fundamental associations of items

FSU –former Soviet Union

HCD – Human Cause-of-Death Database

HMD – Human Mortality Database

ICD – International Classification of Diseases and Causes of Death

IDNP – personal identification number

INED – French Institute for Demographic Studies

MDLT – multiple decrement life table

MH – Ministry of Health of the Republic of Moldova

MITC – Ministry of Information Technology and Communication

Moran's I or MI – Moran's index

NAPH – National Agency for Public Health

NBS – National Bureau of Statistics of the Republic of Moldova

RD – rate difference

RR – rate ratio

SC – Soviet Classification of Diseases and Causes of Death

SDR – standardised death rate (direct method)

SMR – standardised mortality ratio/rate (indirect method)

SPR – State Population Register

TCSU – Central Statistical Administration

ZAGS – Registry of Acts of Civil Status

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INTRODUCTION

Mortality analysis is the primary approach to assessing population health in demography and public health.Over the centuries, mortality has been the main determinant factor of population change and continues to be so in many developing countries. In recent decades, however, the classical demographic analysis of mortality has given way to other phenomena focusing on a positive approach to health and health services [1]. Nevertheless, the analysis of mortality was and remains indispensable for decision-making and evaluation of health policies. Its importance has become particularly critical in recent years, as all countries have faced an unprecedented COVID-19 pandemic. The availability of high-quality mortality data linked to the population register or the population census has led to numerous studies on social and regional differences in mortality trends and patterns. Monitoring health inequalities at the district level has become routine statistical practice in many developed countries [2]. International differences in mortality at the regional level, contrasting national boundaries with “health” boundaries, are the subject of many large-scale international projects [3, 4].

“Disparities” or “inequalities” in health are defined in the literature as differences in health outcomes, such as mortality or morbidity rates, or in the distribution of health determinants among different population groups (e.g., by sex, place of residence, level of education or marital status) [5]. Socio-demographic and regional disparities in mortality within a country or region are well-known in the literature. For instance, in France, there is a noticeable mortality gradient between the south and north [6]. In Italy, infant mortality tends to increase from north to south, while adult mortality shows a decrease [7]. In Germany, mortality rates rise from south to north and from west to east [8]. In Ukraine, the south-eastern regions exhibit the lowest life expectancy at birth [9].

Socio-economic inequalities in health are very persistent in many countries, even in the highly developed countries of Western Europe [10, 11]. Significant differences in health were found between socioeconomic groups of the population, with people with lower levels of education, occupation or income at greater risk of premature death. For example, in Lithuania, life expectancy is 11.0 years higher for men with tertiary education than for men with only primary education [12].

Health inequalities are due to differences between population groups in a wide range of health factors, such as living conditions, education, occupation and income; health-related behaviours; health care, disease prevention and health promotion services; and public policies that influence the quantity, quality and distribution of these factors [13].

The issue of high mortality is critical for the Republic of Moldova (or Moldova), which ranks last in Europe for life expectancy at birth. In 2019, these figures were 66.8 years for men and 75.0 years for women [14], 13.0 and 10.4 years, respectively, lower than in France and 12.0 and 8.3 years lower than in Germany [15]. High mortality has significant negative consequences for any country. It accelerates the process of depopulation, devalues investment in education and training of skilled workers, hampers economic growth and limits the possibilities for insuring pensioners [16].

The socio-economic changes in Moldova, both during the Soviet period and the period of independence (since 1991), have strongly influenced the trends and patterns of mortality by age, cause of death and social characteristics. Previous studies on mortality show that, in spite of large fluctuations in the late 1980s and 1990s, life expectancy at birth in Moldova is at the same level as in the mid-1960s for men and the late 1970s for women [17]. The lack of significant progress in life expectancy stems from persistent differences in health status between different demographic, regional and social groups of the Moldovan population. For these reasons, analysis of mortality at the national level alone is often insufficient to develop effective interventions to overcome the current public health crisis. Reducing inequalities in population health is the main objective outlined in all major national and international health policy documents. An effective solution to the problem of high mortality in Moldova should aim to reduce mortality in a manner that also addresses disparities between regions and various socio-demographic groups.

In the case of Moldova, conducting an objective analysis of demographic processes proves to be complicated due to the lack of reliable population estimates for the years preceding the last census, which took place in 2014. As a result, there exists an information and scientific gap regarding the country's demographic development. In 2019, the National Bureau of Statistics of the Republic of Moldova (NBS) published annual estimates of the usual resident population based on the corrected results of the 2014 census. However, official population estimates for the years prior to the 2014 census remain unavailable.

Despite a considerable number of studies in the field of mortality analysis in Moldova (see section 1.3), no comprehensive analyses of socio-demographic and regional differences in mortality have been carried out in the context of assessing the quality of primary statistical data.

The ***aim*** of the thesis is to examine the long-term trends and social and regional differences in mortality in the Republic of Moldova in the context of a data quality assessment and to elaborate recommendations for improving mortality monitoring and reducing disparities in mortality.

Objectives of the study:

1) To assess the quality of population and mortality data at the national, sub-national and district levels and to propose methods for correcting problematic data;

2) To reconstruct the continuity of mortality series according to ICD-10 in Moldova for the period 1965-2020;

3) To analyse changes in long-term trends and patterns of mortality by age and cause of death in Moldova and to determine their commonalities and peculiarities in comparison with Romania and Ukraine;

4) To evaluate excess mortality by age groups and leading causes of death in Moldova compared with the European model;

5) To examine changes in overall and cause-specific mortality by place of residence (rural/urban);

6) To examine disparities in overall and cause-specific mortality by marital status and the level of education;

7) To analyse the geographical profile of life expectancy and cause-specific mortality;

8) To identify clusters of districts with similar levels of mortality by cause of death based on the spatial autocorrelation analysis;

9) To elaborate practical recommendations for improving mortality monitoring and reducing mortality disparities in Moldova.

The ***hypothesis*** of the study is that the high level of overall mortality in Moldova coexists with significant differences in mortality by cause of death between different social groups of the population and between districts. Different population groups at the sub-national and district levels have progressed differently along the epidemiologic transition pathway, which determines interregional differentiation and social inequalities in the face of death.

Novelty and scientific originality:

1) Systematisation of the main data quality issues on population and mortality and data harmonisation at the national, sub-national and district levels;

2) Reconstruction of the continuity of mortality series according to a fixed classification of causes of death in Moldova for the period 1965-2020;

3) Elaboration of life tables by socio-demographic characteristics at the national, sub-national and district levels;

4) Identification of the vanguard and laggard subpopulations in terms of life expectancy and cause-specific mortality according to the place of residence, marital status, level of education and geographical area of residence;

5) Determination of the components of the interregional differentiation in life expectancy by age and cause of death and assessment of their changes during the period of independence;

6) Detection of the spatial clusters with similar low or high mortality by cause of death based on spatial autocorrelation.

Scientific problem solved in the thesis. The study presents a new approach to the analysis of the long-term trends and social and regional disparities in mortality by cause of death in Moldova, taking into account the assessment of the quality of primary data. The time series of deaths, reconstructed according to the fixed classification of diseases for 1965-2020, meet the international requirements of comparability, completeness and regularity of data. Comparative analysis of the reconstructed series ensures data compatibility between countries over time.

Theoretical and applicative significance of the thesis. The thesis presents a comprehensive study of the long-term trends and social and regional disparities in mortality by cause of death in Moldova, focusing on data quality issues. Changes in cause-specific mortality at the national, sub-national and district levels are examined through the prism of the epidemiologic transition theory and its subsequent interpretations, such as the health transition theory, which aims to explain differences in mortality trends and patterns over time and across populations.

The results of the study can form the basis for strengthening public health policies to increase population life expectancy and reduce mortality disparities. The results of the spatial analysis of interregional differentiation in mortality can have applications in regional development policies. The study's results can be used in research and teaching in the fields of demography, public health and public health.

Summary of research methodology and justification of chosen research methods. The study is population-based and transversal. The *object* of the study is mortality in Moldova. The *subject* of the study is long-term trends and patterns of mortality by cause of death and social and regional differentiation of mortality by cause of death. The study has three *levels*: national (Moldova), sub-national (place of residence, marital status, level of education) and district (second level of territorial-administrative division). The study covers the *period* 1965-2020 at the national level and the period of independence (1991-2020) at the sub-national and district levels.

The study involves the following *steps*:

1) Formulating the research problem and developing the research protocol. Collection of population and mortality data at the most detailed level for the Soviet period and the period of independence;

2) Assessment of the quality of the primary statistical data at the three study levels, adaptation or elaboration of the correction methods;

3) Analysis of the continuous mortality series reconstructed under ICD-10 at the national level by sex, age and detailed cause of death in 1965-2020. Identification of age groups and causes of death responsible for excess mortality in Moldova compared to the European model;

4) Study of the weekly series of deaths from COVID-19 during the pandemic period in Moldova;

5) Analysis of mortality disparities by sex, cause of death and place of residence (rural/urban) in 1991-2020;

6) Analysis of mortality disparities by sex, cause of death and social characteristics (marital status and educational level) of the population aged 30 years and over for 2003-2005 and 2013-2014;

7) Analysis of regional differentiation of mortality by cause of death and its changes after independence;

8) Elaboration of practical recommendations to reduce high mortality and social and regional disparities.

The study used archival data on mortality and causes of death (statistical forms 5, 5b, etc.) collected from the National Archive of the Republic of Moldova (1959-1969), the NBS (1970-1990), the depersonalised database of medical death certificates provided by the NAPH (1991-2020), the depersonalised database of the statistical forms no. 3 "Death" provided by the NBS (1998-2014). The statistical forms no. 5 and 5b for 1965-1990 (deaths by sex, age and cause of death) were provided by the INED in electronic format. We used the continuous mortality series reconstructed under the ICD-10 for some European countries retrieved from the HCD database for comparative analysis. The hospital death records were collected from the official website of the MH during the pandemic period.

The study distinguishes two groups of methods. The first group includes methods adapted or developed within the study to solve specific data quality problems. These methods include 1) the method of reconstructing the continuity of mortality series under a fixed classification of diseases developed by Vallin and Meslé [18]; 2) the correction of the under-recording of infant deaths; 3) the correction of the over-estimation of life expectancy at age 60; 4) the redistribution of deaths coded as "senility without mention of psychosis" between diseases of the circulatory system in the 1990s. This set of methods and the corresponding data quality assessment were presented in Chapter 3.

The second group includes the demographic and statistical methods used to analyse the reconstructed mortality series after preliminary corrections at three levels of the study: abridged life tables with 95% CIs, standardised death rates by direct or indirect methods with 95% CIs, the

method of decomposing the difference in life expectancy (a stepwise replacement method), global (Moran's index) and local (LISA) spatial autocorrelation, thematic maps and LISA maps. In accordance with international recommendations, mortality disparities by place of residence, marital status and educational level were analysed using absolute (rate difference) and relative (rate ratio) measures with 95% CIs. The reference groups were the urban population, the married population and the population with higher education.

Implementation of scientific results. The database of reconstructed mortality series for Moldova has been integrated into the international database, The Human Cause-of-Death Database (HCD, https://www.causesofdeath.org/cgi-bin/main.php), coordinated by the French Institute for Demographic Studies (INED) and the Max Planck Institute for Demographic Research in Germany. The HCD database presents reconstructed series for 16 industrially developed countries, including Moldova. The created database ensures comparability of mortality data by cause of death in Moldova over the period 1965-2020 and between Moldova and other countries for which the mortality series have been reconstructed.

Approbation of scientific results. The main results of the thesis were presented at the following international and national scientific conferences: European Population Conference 2022 (29 June – 2 July 2022, Groningen, the Netherlands); the 11th International Conference on Population Geographies (25-27 August 2022, Tokyo, Japan); IUSSP International Population Conference (5-10 December 2021, Hyderabad, India); European Population Conference (25-28 June 2014, Budapest, Hungary); International Conference "Low fertility and low mortality: observable reality and visions of the future" dedicated to the 25th anniversary of the Institute of Demography (31 October – 1 November 2013, Moscow, Russia); XXVII IUSSP International Population Conference (26-31 August 2013, Busan, South Korea); the National scientific conference with international participation "One Health approach in a changing world" (4-5 November 2021, Chisinau); National scientific conference "Cercetarea în Biomedicină și Sănătate: Calitate, Excelență și Performanță" (20-22 October 2021, Chisinau); Congress dedicated to the 75th anniversary of the establishment of the State University of Medicine and Pharmacy "Nicolae Testemitanu" of the Republic of Moldova (21-23 October 2020, Chisinau); International conference "Economic growth in the conditions of globalisation" (12-13 October 2022; 15-16 October 2021; 15-16 October 2015; 16-17 October 2014; 17-18 October 2013, Chisinau).

Publications on the research topic. The results of the thesis were published in 41 scientific papers, including two monographs, five articles in international journals, 15 in national journals, five in the proceedings of international conferences held abroad and six in the proceedings of the international conferences held in the Republic of Moldova.

Summary of chapters of the thesis. The thesis consists of six chapters, conclusions and recommendations, a list of references and 18 annexes. Chapters 3, 4, 5 and 6 have a "Discussion" section. Each chapter ends with the main conclusions.

In the *first chapter*, we described the epidemiologic transition theory proposed by A. Omran, the main theoretical framework to explain the long-term trends in cause-specific mortality. The interpretations of the theory were analysed with a focus on the health transition theory proposed by Vallin and Meslé. The results of the studies on social and regional disparities in mortality in the FSU countries were discussed. The death registration system and codification of causes of death in Moldova after WW II was examined.

The *second chapter* presented the material and methods used in the study. The population and mortality data were collected at the national, sub-national and district levels. A set of demographic and statistical methods was described with particular attention to the spatial mortality analysis not applied by other researchers in Moldova earlier.

The *third chapter* assessed the population and mortality data quality at the national, subnational and district levels. Original methods, either adapted or elaborated, were presented to overcome the demographic data quality problem. The quality of official population estimates during the Soviet period and after independence was examined. The impact of different types of population estimates on overall mortality at the national level was presented. The quality of population data at the sub-national and district levels for the period of independence was examined. Particular attention was given to mortality assessment and the correction methods for infant mortality rate and life expectancy at older ages. The effect of infant and old-age mortality corrections on life expectancy at birth at the national level was shown. The reconstruction of the continuity of the death time series under the ICD-10 in Moldova for the 1965-2020 period was presented. The problem of mortality growth from ill-defined causes of death in the 1990s was examined, and the correction method was suggested at the national, subnational and district levels.

The *fourth chapter* examined the reconstructed mortality trends and patterns at the national level between 1965 and 2020. First, changes in life expectancy and age-specific mortality rates in Moldova were compared to those in Ukraine and Romania. The contribution of mortality trends by age and cause of death to the changes in life expectancy at birth over the deterioration and improvement periods was shown. Trends in age-standardised death rates by main cause of death and sex in the three countries since 1965 were analysed. Mortality trends by detailed cause of death in Moldova were examined across four age groups: less than one year and children and adolescents aged 1-14 years old, young adults aged 15-39 years old, mature adults aged 40-64 years old and older adults aged 65 years old and over. Weekly trends in mortality from the COVID-19 infection

in Moldova between 18/03/2020 and 19/04/2022 were examined based on individual hospital death records. The excess mortality due to COVID-19 and the impact of the pandemic on life expectancy at birth in 2020 were presented. Excess mortality in Moldova compared to the European model was examined based on the multiple decrement life tables.

The *fifth chapter* was dedicated to analysing mortality disparities at the sub-national level during the period of independence. According to international recommendations, absolute and relative differences in mortality were analysed for overall and cause-specific mortality. The differences in overall and cause-specific mortality were analysed by place of residence (rural/urban), marital status and level of education. Mortality disparities by place of residence were estimated for the whole period of independence and four different subperiods: the period of deterioration (from 1991-1993 to 2003-2005), the period of improvement (from 2003-2005 to 2014-2016), recent changes (from 2014-2016 to 2017-2019) and the COVID-19 pandemic (2020). Mortality disparities by marital status and educational level were analysed for the two periods surrounding the two censuses conducted in 2004 and 2014. Life expectancy at ages 30 and 65 by sex, marital status and education level were estimated for the periods 2003-2005 and 2013-2014. Mortality rate difference and rate ratio with 95% CIs were estimated by leading and some detailed causes of death for the adult population aged 30 years and over.

The *sixth chapter* examined the regional differences in all-cause and cause-specific mortality. Geographical profiles of life expectancy by age and sex around the 2014 census were presented. Thematic maps of standardised death rates from all causes by broad age groups were shown. The difference in life expectancy at birth between Moldova and each administrative unit was decomposed by age groups or main causes of death. The difference in life expectancy at birth between the municipality of Chisinau and the most lagging districts was decomposed by age and cause of death. Thematic maps of standardised death rates from main and some detailed causes of death were examined. The global and local spatial autocorrelation results of mortality analysis were presented for overall and cause-specific mortality. Finally, the evolution of regional mortality differentiation since independence was examined over 1991-1995, 2002-2006 and 2012-2016.

1. POPULATION HEALTH REFLECTED IN MORTALITY TRENDS, PATTERNS AND DISPARITIES (LITERATURE REVIEW)

1.1. Epidemiologic transition and health transition theory

The demographer and social hygienist Abdel R. Omran introduced the concept of the epidemiologic transition in 1971 to explain the rapid increase in life expectancy at birth accompanied by drastic changes in cause-specific mortality patterns that occurred in Western Europe between the mid-18th century and the late 1960s of the 20th century [19]. Later, many scientists, including Omran himself, revised the theory, and it has become the main theoretical framework for explaining mortality trends and patterns.

According to the concept of epidemiologic transition proposed by Omran, all the countries sooner or later go through three stages of the evolution of mortality: 1) the age of "pestilence and famine", when mortality is very high, and life expectancy at birth does not exceed 30 years; 2) the age of "receding pandemics", when life expectancy starts increasing considerably, from 30 to 50 years; 3) the age of "degenerative and man-made diseases" when mortality after further decline tends to stabilise at a low level [19].

Vishnevshy described the epidemiologic transition as the replacement of the "old" mortality model with the "new" model. The essence of the epidemiologic transition is that once a society has reached a certain level of development, there is a rapid replacement, relative to historical standards, of one pattern of diseases and causes of death by another. In the "old" mortality pattern, infectious and respiratory diseases and malnutrition-related diseases occupy an essential place. In the aetiology of the "old" pathologies, exogenous factors play a decisive role. The "new" mortality pattern is dominated by diseases and causes of death caused mainly by endogenous factors associated with natural senility and the age-related decline in vitality [20].

In the 1960s, the increase in life expectancy at birth slowed in many industrialised countries. However, it resumed in Western countries in the 1970s due to a massive reduction in cardiovascular mortality, known as the *"cardiovascular revolution"* [21]. To explain these health improvements, Olshansky and Ault extended the concept of the epidemiologic transition, adding a "fourth age". According to the authors, this stage is called the "age of delayed degenerative diseases" and is characterised by a redistribution of deaths from younger to older age groups, with no change in the pattern of causes of death [22]. Later, Rogers and Hackenberg called the fourth stage the "hybristic stage", which is increasingly influenced by individual behaviours and lifestyles [23].

According to Vallin and Meslé, even after its revision by Olshansky and others, the epidemiologic transition theory does not explain some exceptional situations that occurred in the world in the last decades of the 20th century and at the beginning of the 21st century [21]. First, in Eastern Europe, including the FSU countries, the cardiovascular revolution that gave a new impetus to the increase in life expectancy in Western countries in the 1970s did not take place. Second, in sub-Saharan Africa, the second stage of the epidemiologic transition has not yet been completed because of the spread of AIDS and the resurgence of old infections.

Olshansky et al. proposed the introduction of a fifth stage to explain the global spread of HIV infection – "the re-emergence of infectious and parasitic diseases" [24]. There is even an attempt to include a sixth stage called "health for all" [25].

According to Vallin and Meslé, adding new stages to the epidemiologic transition becomes increasingly artificial. The authors agree with Frenk and his colleagues [26], who suggested replacing the epidemiologic transition with the broader "health transition" concept introduced by Lerner in the early 1970s. Compared to the epidemiologic transition theory, the health transition concept is more comprehensive because it explains changing cause-specific mortality patterns in the context of social and behavioural changes. However, Vallin and Meslé noted that Franklin's work was purely theoretical and lacked concrete historical examples. Based on an analysis of historical mortality trends in different countries, Vallin and Meslé viewed the health transition as a succession of phases of divergence and convergence in mortality. According to the authors, advances in public health inevitably lead to divergent trends in mortality as the wealthiest segments of the population first gain access to new benefits such as better social conditions, medical advances or lifestyle changes. Then, as the less affluent populations become involved in the modernisation process, the phase of mortality convergence and its homogenisation in society begins [21].

Vallin and Meslé argue that from the 18th century to the present, there have been two, perhaps even three, stages of health transition worldwide. In the first stage, the first divergence and convergence in mortality trends occurred in European countries between the second half of the 18th century and the mid-1960s of the last century. Omran's theory of the epidemiologic transition describes this stage of the health transition, in which the reduction in mortality from infectious diseases plays a crucial role in the progress of life expectancy.

The second stage of the health transition refers to a new phase of diverging mortality trends that began in the late 1960s between East and West, between the socialist and capitalist worlds. During this stage, a spectacular increase in life expectancy in Western countries was mainly associated with the control of chronic non-communicable diseases, especially diseases of the

circulatory system. In contrast, Central and Eastern European countries, including the republics of the FSU, experienced unfavourable mortality trends for several decades [27]. Following the economic and political transitions in Central Europe in the late 1980s, many post-socialist countries began to show a steady trend towards convergence with Western countries. Life expectancy growth recovered in the Czech Republic in 1990, in Poland in 1992, in Hungary in 1994 and in Romania in 1997 [28]. Among the FSU countries, the Baltic States were the first to show signs of improving population health in the mid-1990s, but since 2000 there has been some divergence between the three states [29]. Studies show that substantial gains in life expectancy in these countries have been made possible by significant reductions in cardiovascular mortality in working and older age.

"Is there a limit to the increase in life expectancy, and when will it be reached in developed countries?" is one of the main questions occupying demographers today [30]. Some of the most developed countries, such as France and Japan, have entered the third stage of the health transition – slowing down the ageing process. Researchers are leaving open the reserves for further life expectancy growth: neoplasms, senility or other diseases [21].

1.2. Convergence and divergence of mortality trends in European countries in the light of the health transition theory

By the mid-1960s, life expectancies had converged in the industrialised world, marking the end of the first stage of the health transition [21]. The successful reduction of high mortality from infectious diseases during the first stage was made possible by massive, low-cost and effective preventive interventions. Figure 1.1 shows the evolution of life expectancy at birth since 1959 in five countries: Moldova, Romania, Ukraine, the Czech Republic and France. Disparities in overall mortality in the five countries were reduced to a minimum by 1965, especially for men. At the beginning of the period, the health status of the Moldovan and Romanian populations, especially females, was relatively worse than in the other countries. Indeed, in 1959, the difference in life expectancy at birth between these two countries and Ukraine was more than 4.0 years for men and even more than 6.0 years for women. Despite the initial poor health conditions, all-cause mortality in Moldova and Romania had fallen rapidly by the mid-1960s. Subsequently, "degenerative and man-made diseases", as defined by Omran [31], emerged as a new public health challenge in the developed world. Under the new conditions, Western countries developed a new public health strategy to promote healthy lifestyles and prevent the major risk factors associated with chronic non-communicable diseases, first and foremost cardiovascular diseases.

At the same time, the countries of Central and Eastern Europe, including the FSU, have entered a long period of population health deterioration. The steady increase in life expectancy in

France since the 1970s contrasts sharply with the rapid deterioration in population health in Eastern Europe (Moldova and Ukraine) and the stagnation in Central Europe (the Czech Republic and Romania). The new wave of divergence in mortality trends between the West and the East, between the capitalist and communist states, indicated the long-lasting second stage of the health transition.

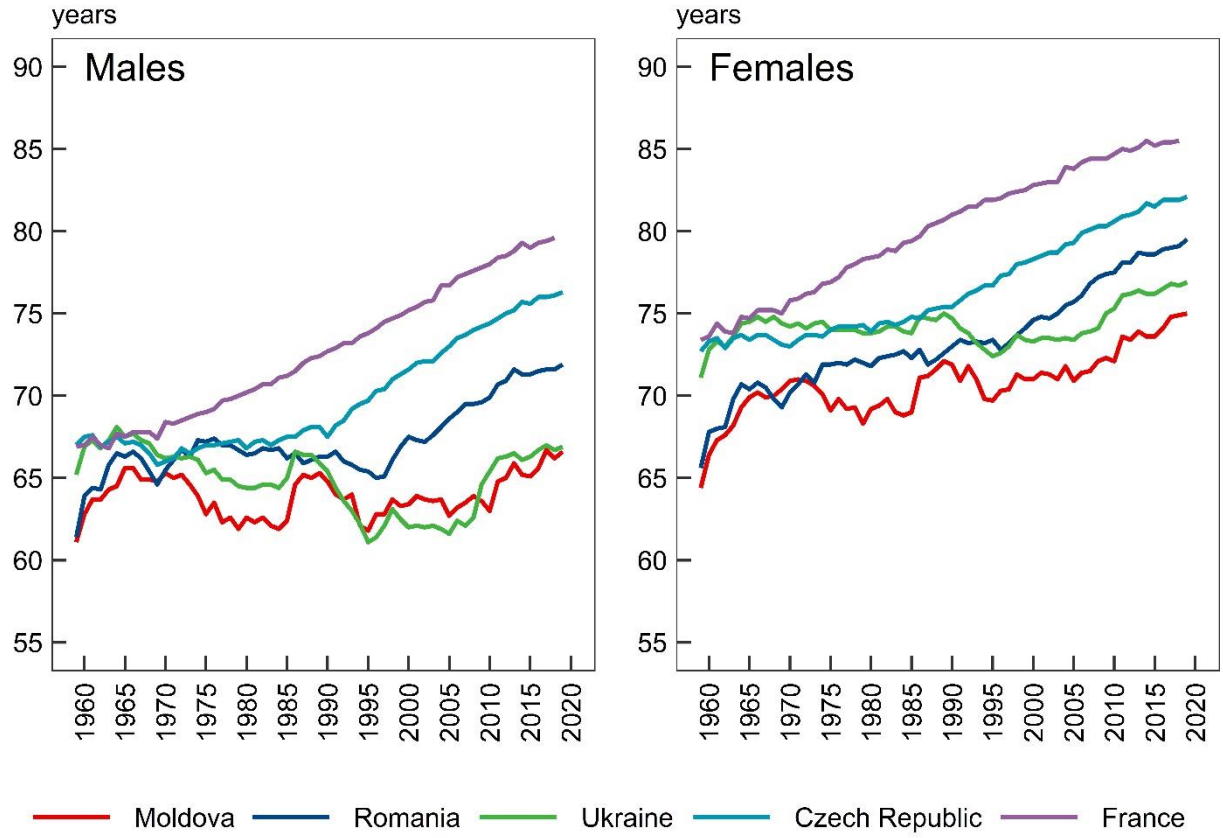


Fig. 1.1 Life expectancy at birth in five European countries since 1959

Note: For Ukraine in 2014-2020, data exclude the temporarily occupied territories of the Autonomous Republic of Crimea, the regions of Donetsk and Luhansk.

Source: Moldova (1959-2020) – calculations based on the NBS data; Romania (1961, 1963, 1965, 1968-2019) – calculations based on the National Institute of Statistics data, https://insse.ro/cms/en; Ukraine (1959-2006) – Meslé and Vallin [32]; Ukraine (2007-2020) –calculations based on the State Statistics Service of Ukraine data, France – the Human Mortality Database, https://www.mortality.org/

Soon after the collapse of the communist regime, the adverse long-term trends in mortality were reversed in most countries of Central Europe [27]. The Czech Republic and Poland were the first countries in the region to experience a sustained increase in life expectancy [28]. Romania experienced a decline in life expectancy at birth immediately after the 1989 revolution and the collapse of the communist regime, followed by sustained progress since 1997 [33].

In Moldova and Ukraine, life expectancy fluctuated without much progress, either during the Soviet period or after independence. The anti-alcohol campaign launched by the Soviets in 1985 led to a significant but short-lived increase in life expectancy between 1985 and 1989. After proclaiming independence in 1991, the health of the population in both countries deteriorated

rapidly. Short-term gains in life expectancy at the end of the 1990s did not indicate a reversal of the unfavourable long-term trend. For Moldovan males, the situation remained stagnant until 2010, followed by moderate improvements. For Moldovan females, a steady increase in life expectancy started in 2005 and, as for males, accelerated after 2010. In 2019 (66.6 years), it was only one year higher than in 1965. Female life expectancy increased by 5.0 years over the same period, reaching 75.0 years in 2019.

Demographers have emphasised that the gap between the FSU countries and the Western world is not general and concerns a specific range of causes of death and age groups [34]. These groups can be considered as risk groups responsible for the high mortality in these countries compared to Western countries. The risk groups can be identified by comparing the mortality pattern in a problem country with that of a Western country or an average model calculated for a group of countries with high life expectancy. The selected Western country or model is used as a threshold, and exceeding it can be considered as *excess* mortality [35].

Researchers have highlighted two key features of the contemporary mortality model that underlie the historical backwardness of the FSU compared to Western countries: very high cardiovascular mortality among middle-aged people and very high mortality from external causes of death among young and middle-aged people [36]. These two causes of death have played a crucial role in the long-term negative trend in life expectancy and its temporary fluctuations during the anti-alcohol campaign of 1985 and the socio-economic crisis of the 1990s in Ukraine [32], Belarus [37] and the Baltic countries [29]. Several explanations for the long-term negative trends in life expectancy in the region have been proposed, including psychosocial stress, income inequality, inadequate medical care, unhealthy lifestyles and failures of the political and economic system [38]. Risky patterns of alcohol consumption, especially among men, contribute significantly to the life expectancy gap between East and West [39].

When examining cause-specific mortality over a long period, methodological issues related to the changes in coding practices need to be taken into account. In all countries, the analysis of long-term mortality trends is complicated by breaks in the time series of deaths induced by the periodic revisions of the classification of causes of death. In rare cases, the responsible statistical office practices a double classification of causes of death during one or two transition years. This practice makes it possible to use the observed transition coefficients to redistribute deaths classified according to the items of an old classification among the items of a new classification. However, in most cases, including in post-Soviet countries, such a double classification is not available, and it is necessary to find a way to estimate the transition coefficients *ex post*. Vallin and Meslé developed such a method based on French data and reconstructed the time series of

causes of death according to the detailed ICD-8 in 1925-1978 [18] and later according to the detailed ICD-9 [40]. This method has been successfully applied to reconstruct cause-of-death mortality series for different countries over different time periods: the Soviet Union for the period 1970-1987 [41], Russia [42], Ukraine [32, 43], the Baltic countries [29], Belarus [37, 44], Armenia and Georgia [45], the Czech Republic and Western Germany [46], Poland [47].

1.3. Autochthonous contributions

The high level of mortality in Moldova is one of the most urgent socio-medical and demographic problems facing Moldovan society. Among the numerous scientific studies in the field of mortality in Moldova carried out at the Nicolae Testemitanu State University of Medicine and Pharmacy, we can mention those on maternal and infant mortality conducted by Gh. Paladi [48, 49], the socio-medical aspects of mortality in old age by D. Tintiuc [50], the epidemiological aspects of malignant neoplasms by T. Grejdean, the study of mortality related to cerebrovascular diseases by E. Zota and L. Spinei [51], the medical and social aspects of mortality in the urban working age population by O. Lozan [52], the medical and social aspects of mortality in the rural working age population by N. Bologan [53]. E. Raevschi studied the evolution of premature mortality from different diseases of the circulatory system [54]. C. Etco et al. studied the evolution of mortality among children aged 0-18 years in 2006-2008 compared to 2003-2005 [55].

V. Moscalu et al. estimated mortality indicators, including by cause of death, in Moldova in the context of European statistics for 2005-2010 [56]. Short-term trends in morbidity and mortality by cause of death were examined by R. Gramma et al. [57]. Several studies on hospital mortality have been conducted. G. Ghidirim et al. analysed hospital mortality in traumatic liver injury according to the level of injury and surgical treatment method [58]. Ustian A. et al. studied hospital mortality from tuberculosis retrospectively based on a sample of 818 cases in the municipality of Chisinau [59].

O. Gagauz et al. have recently conducted several studies concerning the evolution of mortality in Moldova during independence [60–62]. V. Stirba assessed avoidable mortality from cardiovascular diseases [63], I. Pahomii et al. examined trends in mortality from external causes of death [64]. C. Matei studied the evolution of demographic processes in Moldova after independence [65], V. Sainsus examined the territorial-administrative aspects of the Moldovan population [66], A. Grozav studied the evolution of the demographic processes in rural areas over 80 years [67]. A number of scientific papers were devoted to the mortality caused by the COVID-19 pandemic in Moldova. I. Mereuta et al. studied the morbidity and mortality associated with COVID-19 in 2020 [68]. I. Pahomii studied the regional aspects of COVID-19 mortality [69].

1.4. Social disparities in mortality

Studies of social differences in mortality are crucial as they provide valuable information on the risk factors associated with health disparities. Many studies in different countries over different time periods have been devoted to mortality inequalities by different social characteristics such as the place of residence (urban/rural), marital status, educational level, occupation, ethnicity and others. Further, we present the main methodological issues of these studies and the main results, focusing on the FSU countries.

From a methodological point of view, two different types of studies on social inequalities can be distinguished. The first type refers to research based on unlinked mortality and population data. For example, in the FSU countries, including Moldova, during the Soviet period, the statistical offices produced additional tables on the distribution of deaths by social characteristics such as marital status, educational level and ethnicity for a few years around the census year. Based on routine mortality statistics and census data, social disparities in mortality were analysed over different time periods in Russia [70], Estonia [71, 72] and Lithuania [73]. The second type is a census-linked study or a study based on population registers. In this case, a death certificate recorded by a statistical office is linked to an individual census form, and information on the social characteristics of the deceased is taken from the census data.

To our knowledge, the only studies providing evidence on social mortality differentials based on census-linked and census-unlinked data in Eastern Europe come from studies in Lithuania and Estonia [74–76]. Shkolnikov et al. estimated the difference in life expectancy produced based on census-linked and unlinked mortality estimates in Lithuania in 2001-2004. The authors concluded that unlinked data overestimate mortality in disadvantaged groups and underestimate it in advantaged groups. The differences between the two data sources were much more pronounced for educational attainment than for marital status. For example, life expectancy at age 30 for Lithuanian males with higher education was 47.02 years according to the unlinked data and 45.28 years according to the linked data. On the other hand, life expectancy at age 30 among males with less than a secondary education was 32.34 years based on unlinked data compared to 34.42 years based on linked data. The discrepancy was much smaller for marital status [75].

Jasilionis et al. examined the registration of the ethnicity of the deceased in Lithuania based on census and death registry information. The authors revealed the underestimation of deaths for Russian, Polish and other ethnicities and the overestimation for Lithuanian ethnicity. Consequently, this bias led to the underestimation of mortality rate ratios among the three minority ethnic groups [74].

In unlinked census studies, the information on the social characteristics of the deceased is obtained from two different sources [12]. On the one hand, the distribution of deaths by social characteristics is based on death records provided by a relative of the deceased (proxy informant). On the other hand, the distribution of population counts by the same social characteristics is provided by individuals during the census. This mismatch, known as the "numerator-denominator" bias, can be avoided in census-linked or longitudinal studies.

Jasilionis and Leinsalu showed that the effect of numerator-denominator bias changed over time. The authors compared census-linked and unlinked mortality estimates by educational level in Estonia in 2000-2003 and 2012-2015. Their results showed that the impact of the bias on the unliked data was negligible in the first period but increased considerably in the second period. In particular, mortality was overestimated by 23-28% for the population with higher education and notably underestimated for the population with secondary education [76].

Both census-linked and unlinked studies of social disparities in the FSU countries are rare and, to our knowledge, have only been carried out in Russia, Lithuania and Estonia during the period of independence. Studies dedicated to mortality analysis were prohibited in the former Soviet Union for ideological reasons, and researchers did not have access to the statistical tables produced by the statistical offices [77]. Andreev and Dobrovolskaya produced the first estimates of life expectancy by education and ethnic group in Russia in 1993 [78]. They showed that mortality was inversely related to years of education and that the differences between educational strata were as large as in other developed countries. Later, Shkolnokov et al. concluded that educational disparities in mortality in Russia in the late 1980s and 1990s were similar to those observed in other former communist countries such as Hungary or the Czech Republic. In addition, the educational differences in Russian mortality were substantial for accidental causes of death and for infectious and respiratory diseases [79]. The authors concluded that these educational differences in cause-specific mortality in Russia may be partly related to educational differences in alcohol consumption.

Jasilionis et al. examined socio-demographic mortality differentials in Lithuania in 2001-2004 using census-linked data. The authors showed that a lower risk of death was associated with married marital status and higher education. On the other hand, life expectancy at age 30 was 10-11 years lower for never-married, divorced and widowed males than for married males. The gap was even more pronounced between those with more than secondary education and those with less than secondary education [12]. For Lithuania, it was also shown that the unemployed and the economically inactive population had a significantly higher mortality risk, especially for infectious

and respiratory diseases [80]. More recent studies for Lithuania showed an increase in socioeconomic inequalities in mortality in 2005-2007, with a decrease in later years [81, 82].

Leinsalu et al. found a significant increase in social differences in mortality in Estonia after the collapse of the Soviet Union based on census-unlinked mortality data [71, 72]. Between 1989 and 2000, ethnic differences in life expectancy at birth in Estonia increased from 0.4 to 6.1 years for males and from 0.6 to 3.5 years for females [72]. The same authors showed a tremendous increase in educational differences in mortality over the same period. Mortality declined considerably among those with a university education but increased among those with the lowest educational level [71].

At least three types of health inequalities by place of residence have been discussed in the literature. Some studies have pointed to an urban-rural mortality gradient, with higher mortality rates in urban areas than in rural areas in developed countries such as England, Ireland and the Netherlands [83]. As industrialisation progresses, certain population groups in these countries tend to be in poorer health. For example, in Northern Ireland, urban areas were less healthy than rural areas in terms of respiratory disease and lung cancer, suggesting that pollution is a major factor [84]. At the same time, people living in capital cities, such as London, may benefit from a protective "capital effect" [85]. Other studies have shown an inverse mortality gradient when rural populations were in poorer health than urban populations (a rural-urban gradient). These mortality differences were found in post-communist countries, such as Lithuania, for all-cause and amendable mortality [86, 87]. In the United States, since the mid-1980s, there has been a growing discrepancy in mortality between rural and urban counties and a systematic disadvantage of rural all-cause and major-cause mortality [88, 89]. Finally, complex differentiation can be characterised by a U-shaped relationship, with the lowest mortality rates in semi-rural and semi-urban areas and the highest in large cities and remote rural areas [83]. Urban-rural differences in mortality may vary by age group. For example, recent evidence from Germany, England and Wales suggests that urban excess mortality among the older population shifts towards rural excess mortality with age [90].

In Moldova, no studies have been conducted on population-level differences in mortality by marital status and educational level.

1.5. Regional mortality disparities

1.5.1. Regional mortality disparities and causes of death

Several studies of regional mortality differences have been conducted in the FSU countries, including Ukraine, Russia, Belarus and the Baltic States. Poniakina studied the regional diversity of cause-specific mortality patterns in Ukraine over three periods: the Soviet period before the

collapse of the USSR (1988-1991), the period of the population health crisis (2001-2003) and the recovery period (2007-2010) [9]. The first period focused on the years around the Soviet census of 1989, the second on the years around the first post-independence census of 2001, and the third on the post-census annual population estimates. The author distinguished the groups of regions according to their age-specific mortality profiles. The first group included the regions with the most favourable age-specific mortality pattern in western Ukraine. The second group included the south-eastern regions, where the age-specific mortality profile is the most unfavourable. Finally, other regions fell into the third group with low infant mortality but high mortality in other age groups. The leading western regions of Ukraine had much lower old-age mortality, indicating a more advanced epidemiological mortality model. The regional variation of mortality in Ukraine between the leading western regions and the lagging eastern regions for males or the south-eastern regions for females was chiefly related to circulatory system diseases and external causes of death. Deaths from injury and poisoning accounted for a statistically significant gradient in mortality between the West and the rest of Ukraine. Moran's index, which measures the global spatial autocorrelation, was the highest for external causes of death (Moran's I=0.55). At the same time, cancer mortality did not follow a specific regional profile but was highest among females living in Kyiv.

The case of Odesa, which borders Moldova, is of particular interest. In this region, the situation was very unfavourable for females due to increased mortality from circulatory system diseases and external causes of death. Moreover, female mortality from digestive system diseases and infectious diseases was highest in this region of Ukraine. In contrast, life expectancy for both sexes was highest in the Chernivetska region of western Ukraine, which borders the northern districts of Moldova (Briceni, Ocnita).

A group of Franco-Russian demographers studied the regional diversity of cause-specific mortality trends and patterns in Russia for the periods around four population censuses conducted in 1970, 1979, 1989, and 1994 [91]. They found a clear division between the southwest and northeast in terms of overall mortality and cause-specific mortality. The authors identified two major geographical clusters when the data for all four periods were aggregated. The first included western and southern European areas of Russia and was extended by a southwestern Siberian belt along the border with Kazakhstan. The second cluster consisted of the rest of Asian Russia and the north-eastern part of European Russia. Not only was all-period mortality significantly lower in the first cluster than in the second, but these two large clusters also represented two different cause-specific mortality patterns [91].

Danilova conducted a geographical analysis of mortality by cause of death in Russia as a part of her PhD thesis [92]. The author concluded that a decrease in interregional mortality inequality had not accompanied the recent increase in life expectancy in Russia. On the other hand, the reduction in mortality from circulatory system diseases among the older population occurred differently from one region to another, accentuating the divergence between them. Moscow, Saint Petersburg and the North Caucasus republics contributed the most to this interregional differentiation [92, 93]. The two major cities and the North Caucasus republics formed a cluster with a much higher life expectancy and a more advanced epidemiological mortality pattern. Mortality related to injuries and poisoning among young and middle-aged adults and cardiovascular mortality among the middle-aged were responsible for a decline in interregional mortality differentials [92].

Grigoriev et al. demonstrated that the regional mortality differences in Belarus were not very dramatic but have increased in recent years, primarily because of the capital's growing advantage over the rest of the country [94]. This discrepancy was linked to diverging trends in mortality from external causes of death between the country's capital and the Brest oblast, on the one hand, and other regions, on the other. Mortality from circulatory system diseases mainly accounted for the overall discrepancy between the capital and the rest of the country. As in the case of Ukraine, mortality related to neoplasms did not have any particular geographical profile in Belarus. Another interesting finding is a north-south mortality gradient for respiratory system diseases in Belarus and Ukraine. The authors explain this mortality gradient by geographical differences in climatic conditions, the proximity of industrial centres or even by regional differences in diagnosing medical causes of death [9, 94].

Kalediene and Petrauskiene analysed regional life expectancy patterns in 55 administrative units in Lithuania over three periods between 1988 and 1996 [95]. The most favourable situation occurred in the big towns and the resort town of Druskininkai. The principal causes of death responsible for the regional differentiation of mortality in Lithuania are the same as in Ukraine, Russia and Belarus. Kalediene and Petrauskiene demonstrated that mortality associated with external causes of death and circulatory system diseases contributed the most to regional disparities in life expectancy. Moreover, these health inequalities were correlated with education, marital status and urbanisation. On the other hand, the authors found no association concerning the allocation of healthcare sources, unemployment and some other economic well-being characteristics.

Regional mortality information is increasingly available in many countries. The data enables researchers to shift from international mortality comparisons across countries to large-

scale studies on cross-country disparities in mortality, considering the large differences within countries. For example, it was found that the areas along the Belarusian–Lithuanian border, particularly those on the Belarusian side, suffered greatly from the conditions related to increased alcohol consumption, such as liver cirrhosis and deaths provoked by acute alcohol poisoning [3, 96].

Very few studies on regional mortality disparities were carried out for Moldova. In previous studies, Gagauz and Pahomii demonstrated higher mortality rates in central districts compared to the rest of the country [61]. Central and southern districts were more affected in terms of premature mortality due to the COVID-19 infection than the municipality of Chisinau and northern districts [69].

1.5.2. Administrative-territorial division of the Republic of Moldova

After the Second World War, the Republic of Moldova became part of the USSR (MSSR) and adopted the Soviet type of administrative-territorial division. According to Cornea, in 1948, the Supreme Soviet of the USSR liquidated the counties called *"judet"* and formed 60 districts called *"rayon"*. Subsequently, the number of districts was reduced to 46 in 1950, 35 in 1959 and 18 in 1963 [97]. In the 1970s and 1980s, the number of districts increased to 33 in 1975 and 40 in 1989. A district consisted of localities of different types, such as villages, united into village soviets or *"sel'skij sovet"*, towns and town-type settlements or *"posjolok gorodskogo tipa"*. Towns were also differentiated depending on the subordination level. According to the census conducted in 1971, the total number of localities (towns, town-type settlements and villages) was 758, of which 705 were villages. In 1985 the number of localities increased to 885 due to an increase in rural (817) and urban (68) localities. According to the last Soviet census conducted in 1989, the country was divided into 40 districts, four town soviets (*"gorodskoj sovet"*) presented by Chisinau, Balti, Bender and Tiraspol and six republican subordinate towns (Dubasari, Cahul, Orhei, Rabnita, Soroca, Ungheni). According to the 1989 census, there were 11 towns under district subordination in Moldova, 49 town-type settlements and 831 village soviets [98]. In 1990 the Supreme Soviet of MSSR approved the Decision to change and restore the names of some localities and village soviets [99]. For example, the Suvorov district was renamed the Stefan Voda district, the Kotovskij district to the Hincesti district and the Lazo district to the Singerei district [100].

Following the proclamation of independence in 1991, Moldova adopted the Soviet type of administrative-territorial division. In 1994, the law on the territorial-administrative division was adopted, under which the country consisted of 38 districts, four municipalities (Chisinau, Bali, Bender and Tiraspol) and Autonomous Territorial Unit (ATU) Gagauzia with a special status [101]. The country's administrative division was changed in 1999 when the districts were united

into bigger counties called "*judet*". Between 1999 and 20002, the country consisted of ten counties, the municipality of Chisinau, ATU Gagauzia and Transnistria. In 2003, the district division was taken back, and the country was represented by 32 districts, the municipalities of Chisinau and Balti, ATU Gagauzia and Transnistria. Following the return to the district-based division in 2003, the districts of Cainari and Vulcanesti, which existed prior to 1999, were not restored. The Cainari district was split between Causeni, Anenii Noi, Cimislia and Ialoveni. However, much of the district, including the city of Cainari, was assigned to the Causeni district. Since 1999, the districts of Comrat, Ceadr-Lunga and some localities of the Vulcanesti district, including the city of Vulcanesti, were merged into the ATU Gagauzia. Other localities of the Vulcanesti district joined the Cahul district.

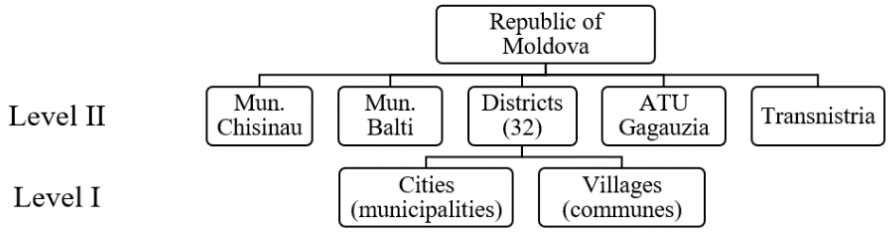


Fig. 1.2 Two levels of the administrative-territorial division of the Republic of Moldova
Source: based on [102]

Fig. 1.3 Geographical location of the Republic of Moldova and its administrative-territorial division

Source: author's elaboration based on [103]

Figure 1.2 presents two levels of the administrative-territorial division of the country. Villages and cities belong to the first level, and villages can be joined into communes. The second level consists of 32 districts, the municipalities of Chisinau and Balti, ATU Gagauzia and Transnistria [102]. Transnistria comprises the municipality of Bender, the municipality of Tiraspol, Camenca, Grigoriopol, Ribnita, Slobozia and a part of the Dubasari district. Transnistria, located in the eastern part of the country, announced its independence in 1990, unrecognised by the Moldovan authorities. A military conflict broke out in 1992. Official statistics do not include the data referring to Transnistria from 1998 onwards. Geographically, the northern, central and southern regions and Transnistria stand out in the country. Figure 1.3 shows the map of Moldova according to the second level of the administrative division with three geographical regions.

1.6. System of death registration and causes of death in Moldova after WW-II

1.6.1. System of death registration

In the USSR, the rules for registering vital events were established after the 1917 Revolution, when the church registration functions were transferred to specially established units known as ZAGS [Registry of Acts of Civil Status, *Zapis' aktov grazhdanskogo sostoiania*]. ZAGS is an administrative office responsible for registering births, deaths, marriages, divorces and other acts referring to the legal status [104]. The death must be registered within three days following the event. After a death, relatives of the deceased must obtain a medical certificate of death from the medical institution in charge and submit it to the ZAGS. In exchange, the deceased's family members receive a civil death certificate as a burial permit and a legal document. The ZAGS then sends the medical death certificate to the regional statistical office.

In the USSR, besides a medical doctor, death could also be certified by a *feldher*, a medical assistant who had an intermediate position between the nurse and the medical doctor. However, if a forensic medical examination was required, a death certificate was issued only by a medical doctor (e.g., violent death, abortion out of the medical unit, death of a child out of the medical unit). Consequently, two types of death certificates existed during the Soviet period: the certificate issued by a medical doctor, known as a medical death certificate of death and the certificate issued by a feldsher, known as a feldsher death certificate. To our knowledge, the Ministry of Health and the TCSU of the USSR issued orders to approve the death certificate in 1954 [105], 1966 [106] and 1984 [107].

The USSR, including the MSSR, adopted a certificate of perinatal death for stillbirth after 28 weeks of gestation and death at 0-6 days in September 1973 [108]. During the Soviet period, the perinatal death certificate was issued in 1974 and revised in 1984. Usually, a case of perinatal death was confirmed by a medical doctor, including in rural areas, if at least two doctors were

present. If only one doctor was in a rural setting or s/he was absent, a feldsher or midwife who assisted delivery or treated a child had the right to certify a perinatal death. Stillbirths were registered based on the perinatal death certificate, while the registration of deaths at age 0-6 days was based on the medical birth certificate and the perinatal death certificate. Before the perinatal death certificate adoption in 1974, stillbirths were recorded based on a special certificate of stillbirth adopted in 1966. Before 1974, deaths recorded during the early neonatal period were registered based on a medical/feldsher death certificate. It should be noted that the introduction of the certificate of perinatal death in 1974 was accompanied by a rise in infant deaths, which varied from one republic to another. In our study, it will be shown that in Moldova, a considerable increase in infant mortality rate occurred a year before, in 1973 (see section 3.2.1.1).

In the Soviets, three types of death certificates issued by either a medical doctor or a feldsher were as follows: “final”, “preliminary”, and “instead of preliminary”. The same three forms were used for the perinatal death certificate. The last two types were used when a case of death was unclear and additional time was required to define the final post-mortem diagnosis.

Along with a civil death certificate, ZAGS issued two identical copies of a death record known as a civil status act [*akt grazhdanskogo sostoiania*] for administrative and statistical purposes. The practice of making two copies of a civil status act was enacted by the Soviets in 1926 [109]. The first copy was kept in ZAGS, while the second was transmitted to the regional statistical office with medical death certificate regularly for data processing. In the MSSR, the processing of second copies of civil status acts was produced at the Central Statistical Administration or TCSU [*Tsentral’noe statisticheskoe upravlenie*]. Based on second copies of civil status acts and death certificates, the TCSU of MSSR compiled different statistical forms according to the instructions of the TCSU of the USSR. The TCSU of the MSSR used death certificates (medical, feldsher or perinatal) to codify causes of death under the Soviet Classification and to prepare statistical tables on causes of death.

The TCSU of the USSR made various attempts to solve the problem of under-registration of births and deaths, which had a considerable degree in some FSU republics, especially in Central Asia and the Caucasian countries. The central statistical office conducted annual *control checks* on the completeness of the registration of deaths and births. The first control check took place in the Northern Caucasus in 1933 on the initiative of the local authorities. Nevertheless, a unique concept was adopted by the Soviets only after 1948 and could vary depending on the place of residence (urban or rural) [110]. In the archives of the NBS, we could find the following description of control checks. In urban settings, individual death and birth records were collected in hospitals and maternity units, whereas in rural settings, they were extracted from so-called

household registers [*pohozeaistvennaia kniga*]. The death and birth records were compared with ZAGS's corresponding civil status acts. In the MSSR, 10% of villages were randomly selected for one control check, but this proportion could be increased to 20% in some republics. The villages were selected according to the special instructions the TCSU of the USSR prepared, which could differ from year to year. In rural settings, death and birth registration completeness was verified for the whole calendar year, whereas in urban settings, only for the last quarter [111].

Table 1.1 Check of the completeness of births and death registration in Moldova in 1971

a) Rural areas (number of villages = 73)

Records registered in the household register			**Records not registered by ZAGS**		
Births	Total deaths	Infant deaths	Births	Total deaths	Infant deaths
5172	2171	114	11 (*0.2%*)	7 (*0.3%*)	3 (*2.6%*)

b) Urban areas (number of medical units = 42)

Records registered by medical units			**Records not registered by ZAGS**					
Births	Total deaths	Infant deaths	Births		Deaths		Infant deaths	
			Residents	Foreigners	Residents	Foreigners	Residents	Foreigners
5865	972	146	56 (*1.0%*)	301 (*5.1%*)	6 (*0.6%*)	47 (*4.8%*)	2 (*1.4%*)	8 (*5.5%*)

Source: TCSU of MSSR (archived data) [112]

Table 1.1 shows the results of an annual check of the completeness of birth and death registration by place of residence in Moldova in 1971. The results of this official annual check were found in the archives of the NBS [112]. The findings suggest that in rural settings, 11% of births, 7% of deaths and 3% of infant deaths were not registered by ZAGS. In urban settings, the difference was made between local and foreign residents. Most unregistered birth and death records were attributed to foreign residents, but the corresponding documents did not explain their origin. For both types of residents (local and foreign), the proportion of under-registration was 6% for births, 5.5% for deaths and 6.8% for infant deaths. However, it will be shown in our study (section 3.2.1.1) that the actual degree of under-registration of infant deaths in the early 1970s was much more severe than the situation described by the official controls, particularly in rural areas. Thus, according to our estimates, the proportion of non-registered infant deaths in 1971 was 42% in rural and 33% in urban settings [113]. Indeed, the official correction coefficients based on the annual control checks in MSSR cannot be used when assessing the quality of infant death registration. Another approach needs to be found to overcome this problem.

In Moldova, the death registration system has not changed significantly during the period of independence. However, substantial changes have occurred in managing vital statistics, such as

establishing the State Population Register (SPR) in the mid-1990s [114]. Figure 1.4 illustrates the circulation of medical death certificates in Moldova since the late 1990s.

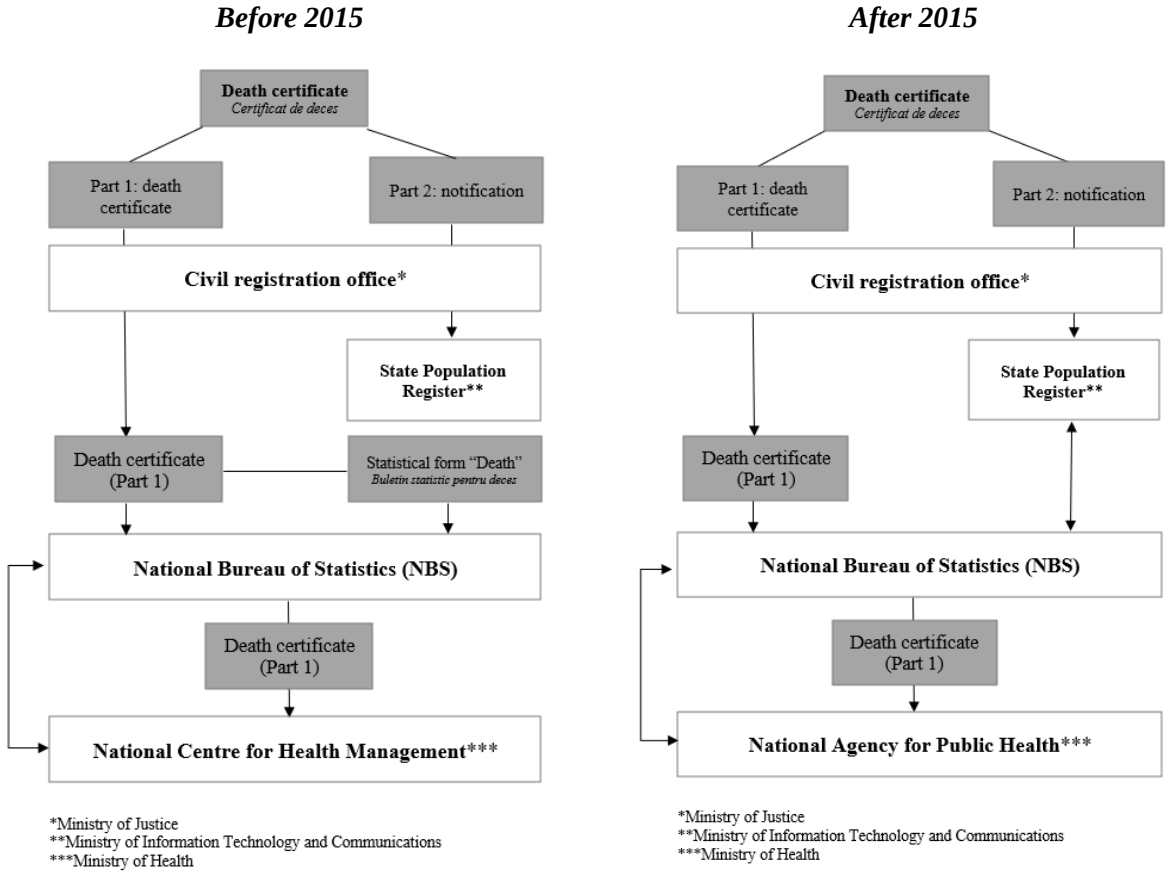


Fig. 1.4 Circulation of medical death certificates in Moldova after independence
Source: author's elaboration

The State Information Resource Centre "Registru", subordinate to the Ministry of Information Technology and Communication (MITC), maintains the SPR. The latter provides information on Moldovan citizens, foreign citizens and stateless persons residing in Moldova permanently or temporarily. The personal information contained in the SPR is linked by a personal identification number (IDNP). The IDNP has 13 numbers and is assigned to an individual on the first record (birth or the first border crossing). The IDNP remains unchanged afterwards and is withdrawn from the SPR in case of death or permanent departure.

The following organisations are involved in the circulation of medical death certificates: 1) NBS; 2) the Ministry of Justice supervises the district civil registration offices; 3) the Ministry of Information Technology and Communications oversees the Centre for State Information Resources "Registru"; 4) the National Agency for Public Health functions within the Ministry of Health and is in charge of the statistics on causes of death.

Making two identical copies of civil status acts adopted by the Soviets remained valid after independence. Presently, however, the two copies are for administrative use only. Instead, in 1997,

the NBS introduced four new statistical forms named the statistical form [*Buletin statistic*]: No. 1 ("Birth"), No. 3 ("Death"), No. 4 ("Marriage") and No. 5 ("Divorce"). The statistical form "Death" was completed based on the medical death certificate and included 17 sociodemographic variables and the deceased's IDNP. The statistical form covered such important social characteristics as the level of education, marital status, occupation and ethnicity. The underlying cause of death was not mentioned in the statistical form. In 2015, the NBS cancelled these forms but received direct online access to the State Register of Population [115].

After independence, the medical death certificate was reviewed in 1998 [116] and 2004 [117]. The system of death registration is as follows at present [117]. Only a medical doctor can issue a medical death certificate after examining the body. In some cases, such as a death at a hospital or violent death, a forensic autopsy is obligatory. The medical death certificate has a serial number given by the MITC and includes the deceased's IDNP. The medical death certificate is divided into two parts. One part is given to the deceased's relatives, who must submit it to the civil registration office within three days. In exchange, they are provided with a civil death certificate. The medical institution sends the other part of the medical death certificate (a notification) to the civil registration office. The civil registration office checks the part of the medical death certificate presented by the deceased's relative and the notification transmitted by the medical institution. A case of death is recorded when the two parts match. Otherwise, the civil registration office informs the police. This practice guarantees that all deaths in the country are registered. The civil registration office transmits the information about each "notification" to the SPR within two days. It also sends the medical death certificate and the corresponding statistical form "Deaths" (until 2015) to the NBS for data processing.

Further, the NBS checks the correctness of the medical death certificates and transmits them to the National Agency for Public Health (NAPH), which is responsible for codifying causes of death under ICD-10. The NAPH holds an electronic database of medical death certificates from 1991. The organisation is also in charge of transmitting the aggregated statistics on causes of death to the NBS for publication and dissemination.

The perinatal death certificate is used for stillbirths and deaths that occurred six days after birth and stillbirths. A forensic examination is compulsory to complete the perinatal death certificate. In our study, we had access to the depersonalised database of the medical death certificates from 1991 provided by NAPH. We also used the depersonalised database of statistical form No.3 "Death" provided by the NBS. Since 2014, the NBS began to publish mortality statistics according to the event and registration dates. At the same time, the mortality data by cause of death

produced by the NAPH is based on the registration date. The two data sources differ slightly (about 0.1%).

1.6.2. Classifications of causes of death in Moldova after WW-II

In Moldova, 78% of the population lived in rural areas, according to the census conducted in 1959. In the USSR, the coverage of mortality data by cause of death was incomplete until the late 1950s because only medical doctors were authorized to certify a cause of death [117]. As a result, the system of cause-of-death death registration could not function properly in rural areas over the early Soviet period due to a considerable shortage of medical doctors. However, in 1958, the Ministry of Health of the USSR passed a new order whereby a feldsher could issue the death certificate in the absence of a physician. As a result, in 1959, the share of death certificates completed by feldsher in rural areas was 15%. Later, this proportion declined to 5-6% in the 1980s [32].

The International Classification of Diseases and Causes of Death (ICD) was never directly used in the USSR, but the Soviet Classification (SC) based on ICD was used. The first revision of the SC was adopted in 1924 [42]. The SC was revised seven times: twice before WWII and five times after. Table 1.2 summarizes the revisions to the SC from 1955. The number of causes of death in the SC varied depending on the revision between 116 (SC-52) and 210 (SC-65).

During the Soviet period, the medical death certificate distinguished three causes of death: the underlying cause, the immediate cause and the contributory cause. The TCSU of the MSSR codified causes of death based on the underlying cause and annually prepared statistical tables on the distribution of deaths by sex, age groups, place of residence (total/urban/rural) and cause of death (statistical table No. 5). Until 1988, the information about deaths from some dangerous infectious diseases (cholera and plague) and deaths from injuries and poisoning (suicide, homicide and occupational accidents) were excluded from statistical table No. 5 and presented in statistical table No. 5b. To maintain the correct totals for all causes of death in table No. 5, deaths from these "hidden" causes were included in the "ill-defined causes". Besides the hidden causes, death certificates issued by a medical doctor or feldsher based on testimonial evidence were also coded under this item. Any publication of mortality data, especially cause-of-death mortality statistics, was prohibited in the USSR from 1974 [77].

Some causes of death presented in statistical form 5b had a "secret" status. In the MSSR, all statistical tables were compiled manually until 1988; then, computerized data processing was introduced. Statistical tables 5 and 5b were changed to table S-51 and table 4 (deaths by sex, age and place of residence) to S-42. In our study, we used statistical tables 5 and 5b for the Soviet period after preliminarily excluding the hidden causes of deaths from "ill-defined" causes.

Table 1.2 Classification of causes of death used in Moldova during the Soviet period

Years	Title	Short title	Number of items	Age groups
1955-1964	1952 Soviet Classification	SC-52	116	0, 1, 2, 3-4, 5-6, 7-13, 14-15, 16-17, 18-19, 20-24, 25-29, 30-39, 40-49, 50-59, 60-69, 70+
1965-1969	1965 Soviet Classification (based on ICD-7)	SC-65	210+13*	0, 1, 2, 3, 4, 5-9, 10-14, 15-19, 20-24, 25-29, … 80-84, 85+
1970-1980	1970 Soviet Classification (based on ICD-8)	SC-70	185+10*	0, 1, 2, 3, 4, 5-9, 10-14, 15-19, 20-24, 25-29, … 80-84, 85+
1981-1987	1981 Soviet Classification (based on ICD-9)	SC-81	185+10*	0, 1, 2, 3, 4, 5-9, 10-14, 15-19, 20-24, 25-29, … 80-84, 85+
1988-1990	1981 Soviet Classification revised for deaths from injury and poisoning (based on ICD-9)	SC-88	175+10*	0, 1, 2, 3, 4, 5-9, 10-14, 15-19, 20-24, 25-29, … 80-84, 85+

Note: * An additional number of items from external causes, according to the character of trauma
Source: author's elaboration

Between 1991 and 1995, two statistical institutions prepared cause-of-death mortality independently. The NBS continued to codify causes of death under the SC-88, while the NAPH codified causes of death under ICD-9. The medical death certificates were transmitted physically by the NBS to the NAPH. Since 1996 the NAPH has been the only institution responsible for codifying causes of death after adopting ICD-10 [118] (Table 1.3). In our study, we illustrated that the double codification of causes of death between 1991 and 1995 was not a genuine case of bridged coding practised by some countries (see section 3.2.2).

Table 1.3 Classification of causes of death used in Moldova after independence

Years	Title	Number of items/ ICD level	Responsible institution	Age groups
1991-1995	1981 Soviet Classification revised for deaths from injury and poisoning (based on ICD-9)	175+10*	NBS	0, 1, 2, 3, 4, 5-9, 10-14, 15-19, 20-24, 25-29, … 80-84, 85 and over
1991-1995	ICD-9	4-digit code	NAPH	Exact age
Sine 1996	ICD-10	4-digit code		Exact age

Note: *An additional number of items from external causes, according to the character of trauma
Source: author's elaboration

Data quality of causes of death

The TCSU of the USSR made several attempts to assess the quality of the mortality data in terms of their completeness and accuracy in diagnosing the medical cause of death. In the early 1970s, a new directive concerning the control checks of the accuracy of the medical death certificate was issued [119]. The general idea was as follows. The national statistical office and medical personnel annually selected the medical / feldsher death certificates from different medical facilities and then compared them with the corresponding information in the medical

documentation (post-mortem report, patient medical card, etc.). Careful consideration was given to the underlying cause of death. The death certificate was considered erroneous if the underlying cause did not correspond to the primary diagnosis from the medical documentation or if an incorrect line of the death certificate was chosen. Typically, 10-15 medical death certificates and 15-20 feldsher death certificates were randomly selected at a medical unit. The information about the underlying, immediate and contributory causes of death and some details about the deceased (sex, age and date of death) were compared based on death certificates and medical documentation.

Working with the archived documentation, we could find the findings of one of such control checks [120]. In 1972, the TCSU of the MSSR randomly selected 128 death certificates from nine medical institutions in different country districts. In 63 cases (49.2%), the underlying cause matched the primary diagnosis mentioned in the medical documentation. In eight cases, the primary diagnosis from medical documentation did not correspond to the underlying cause of death from the medical death certificate (6.3%). In 13 cases, a physician selected the wrong line in the death certificate for the underlying cause (10.2%). In other cases (44 cases), the required medical records were unavailable or did not contain a post-mortem clinical summary. In such a way, nearly 35% of medical death certificates were not verified because of the absence of medical documentation, while the percentage of errors was 16%.

Meslé et al. pointed to three extensive studies on the quality of death registration during the Soviet period conducted in Russia, Belarus and Turkmenistan. The first study occurred in central Russia in the early 1960s, the second in different regions of Russia in 1979, and the third in Belarus and Turkmenistan in 1981-1982. The three studies were carried out as described above for the MSSR. First, the underlying cause of death registered in the medical certificate was compared with the primary diagnosis mentioned in the medical documentation or autopsy report. Then, the accuracy of codifying the underlying cause of death was checked. The proportion of errors was evaluated for medical diagnosis and cause-of-death codification. The share of diagnostic errors varied between 6.6% in Belarus in 1981-1982 and 12.7% in Russia in 1979. The proportion of codification errors ranged from 4.1% in Belarus in 1981-1982 to 17.7% in Russia in 1960 [42, 43, 32].

Although the results of the control check for the MSSR in 1972 were based on a relatively small number of observations, they roughly corresponded to the study results conducted in other parts of the USSR. To our knowledge, no investigation on the quality of cause-of-death registration was undertaken in Moldova after independence.

1.7. Conclusions for Chapter 1

1. The epidemiologic transition theory proposed by Omran is the main theoretical framework to explain the increase in life expectancy and the drastic changes in age- and cause-specific mortality profiles that occurred in developed countries between the middle of the 18th century and the late 1960s. Subsequent interpretations of the theory have attempted to explain the changes in the second half of the last century and the early 21st century. In our study, we accepted the theory of the health transition, according to which all countries go through phases of divergence and convergence in mortality trends.

2. In the mid-1960s, all developed countries, including the FSU countries, completed the first stage of the health transition due to a substantial reduction in mortality from infectious and acute respiratory diseases, especially in infancy. In the 1960s, differences in life expectancy at birth between the countries were minimal, and degenerative and "man-made" diseases dominated the cause-specific mortality pattern. From the 1970s onwards, Western countries resumed a sustained increase in life expectancy due to a massive reduction in cardiovascular mortality, accompanied by a shift in deaths towards older ages. These improvements contrasted sharply with a continuing deterioration in the health of the population in Central and Eastern European countries. In Central European countries, signs of a cardiovascular revolution and sustained life expectancy growth began to emerge after the collapse of the communist regime in the late 1980s and the early 1990s. In some FSU countries, including Moldova, progress did not begin until 2005.

3. In the FSU countries, such as Ukraine, Belarus, Russia and Lithuania, circulatory system diseases and deaths due to injury and poisoning were the main determinants of changes in life expectancy at the national level and the interregional differentiation in mortality. Mortality from external causes, which in these countries is closely linked to hazardous alcohol consumption, had a more critical effect on geographical disparities than cardiovascular mortality.

4. Educational level and marital status have a significant impact on mortality disparities in the FSU countries, such as the Baltic States. The census-unlinked studies may overestimate mortality rates in the most disadvantaged social groups, especially by educational attainment.

5. The codification system of causes of death in Moldova during the Soviet period was the same as in the USSR. The Soviets used the Soviet classification of causes of death based on the revisions of the ICD. The accuracy of diagnosing medical causes of death in Moldova was more or less satisfactory and similar to that in other European countries of the FSU. After independence, Moldova adopted ICD-9, but two statistical institutions codified causes of death in 1991-1995, according to the SC-88 and ICD-9. After the adoption of ICD-10 in 1996, medical death certificates were codified by only one statistical body.

2. DATA AND METHODS

2.1. Data

According to the study's objectives, the population and mortality data were collected at national, sub-national and district levels. Nationally, data were analysed for the 1959-2020 period. Sub-nationally, the mortality analysis was carried out depending on the place of residence (rural/urban), marital status and level of education. The mortality analysis was done at the district level according to the second level of the country's administrative division (districts, municipalities, ATU Gagauzia and Transnistria) (see section 1.3.2). The analysis period for the sub-national and district levels varied depending on the variable and data availability but always included the years around the last two censuses conducted in 2004 and 2014.

Further, we provide detailed information on the population and mortality data collected according to three study levels. Population and mortality data for other countries used in the study are described separately.

2.1.1. Population data

Table 2.1 gives information on the collected population data by sex and age according to three study levels.

Table 2.1. Population data used in the study: national, sub-national and district levels

No.	Time	Type	Description of variables	Source	Comments
National level					
1.	1959-2004	Intercensal estimates (HMD-like data)	Sex: male/female Age: 0,1,2,3...110+	Penina, Jdanov, Grigoriev [121]	According to the HMD methodology (see section 3.1.1), without Transnistria since 1996
2.	January 1, 2014-21	Annual estimates	Sex: male/female Age: 0,1,2,3...85+	NBS	Post-census estimates, usual resident population, without Transnistria
Sub-national level: the place of residence					
3.	October 5, 2004	Census	Sex: male/female Age: 0,1,2,3...85+ Area: urban/rural	NBS	Respondent population, without Transnistria.
4.	January 1, 2014-21	Annual estimates	Sex: male/female Age: 0,1,2,3...85+ Area: urban/rural	NBS	Post-census estimates. Usual resident population
Sub-national level: marital status					
5.	October 5, 2004	Census	Sex: male/female Age: 15, 16, 17, ... 85+ Marital status: single, legally married, union, divorced, separated, widowed	NBS	Respondent population, without Transnistria
6.	May 12, 2014	Census	Sex: male/female Age: 15, 16, 17, ... 85+ Marital status: single, legally married, union, divorced, separated, widowed	NBS	Respondent population, without Transnistria

No.	Time	Type	Description of variables	Source	Comments
Sub-national level: the level of education					
7.	October 5, 2004	Census	Sex: male/female Age: 1,2,3 ...70+ Level of education: higher, secondary specialized, secondary general, general obligatory, primary, no primary, illiterate	NBS	Respondent population, without Transnistria
8.	May 12, 2014	Census	Sex: male/female Age: 1,2,3...70+ Level of education: higher, post-secondary vocational, secondary vocational, upper secondary, lower secondary, primary, without education	NBS	Respondent population, without Transnistria
District level					
9.	January 1, 1991-1995	Annual population estimates	Sex: male/female Age: 0-4,5-9,...70+ Administrative units: 44	NBS	Post-census estimates, including Transnistria
10.	October 5, 2004	Census	Sex: male/female Age: 0,1,2,3...100+ Administrative units: 35	NBS	Respondent population, without Transnistria
11.	2004	Census	Sex: male/female Age: 0,1,2,3...100+ District: Transnistria		Respondent population
12.	May 12, 2014	Census	Sex: male/female Age: 0,1,2,3...100+ Administrative units: 35	NBS	Respondent population and adjusted usual resident population, without Transnistria

Source: author's elaboration

The quality of population data was verified at the national, sub-national and district levels and required preliminary processing in some cases (see section 3.1). The author computed annual intercensal estimates for 2004-2014 at the national level based on the cohort-component method [122]. Gagauz recently published similar results concerning the intercensal population estimates [123].

The classification of territorial-administrative division (CUATM) during the independence period was changed in 1991, 2003 and 2009 (see section 1.3.2). We analysed mortality according to the second level of the administrative division for three periods: 1991-1995, 2002-2006 and 2012-2016. We relied on the population structure in 1993, 2004 and 2014 with some adjustments described in Chapter 3. According to the last two censuses, the division was the same but differed from the one in 1991-98. The districts of Cainari and Vulcanesti existed under the 1991 CUATM but were not restored in terms of the 2003 CUATM. We attributed the Cainari district to the Causeni district and the Vulcanesti district ATU Gagauzia. The same assumption was made for death counts in 1991-1995.

The population censuses conducted in Moldova in 2004 and 2014 did not cover Transnistria. In this region, the census was conducted independently in 2004 and 2015. In our

study, we had the results for the first post-independence census in Transnistria, while the data for the last census was unavailable.

Birth counts by sex, age and place of residence (rural/urban) for the 1945-2020 period were collected from the National Archive of the Republic of Moldova (1945-1969, unpublished), the archive of NBS (1970-1979, unpublished) and retrieved from NBS website for 1980-2020, https://statistica.gov.md.

2.1.2. Mortality data

For the Soviet period (1959-1990), the mortality data exist only at the national level. The original statistical forms 5 and 5b regarding the distribution of deaths by sex, age and detailed cause of death were collected. The French Institute for Demographic Studies (INED) provided the corresponding computerized statistical forms. Some missing statistical tables were computerized by the author based on the original tables collected at the National Archive of the Republic of Moldova and the archive of the NBS. Additionally, statistical form 4 (deaths by sex, age and place of residence) and form 4a (infant deaths by sex and age) were collected and computerized by the author for 1959-90.

For the period of independence, mortality data were collected at the national, sub-national and district levels. Two databases of individual death records were used in the study. The first is the database of medical death certificates (form 106/e) provided by the NAPH. The second is the dataset of statistical form No. 3 "Death" provided by the NBS. The first database covers the period 1991-2020, while the second covers the period 1998-2014. As mentioned earlier (see section 2.1.2), statistical forms were completed based on the medical death certificate.

For every death record in the NAPH database, the following information is given: 1) year of death registration; 2) the exact date of death (year, month and day); 3) the exact date of birth (year, month and day); 4) sex; 5) the underlying causes of death, according to the 4-digit ICD-9 code (1991-1995) or ICD-10 code (1996-2020); 6) district code of the deceased's place of residence; 7) locality code of the deceased's place of residence.

The following variables were retrieved from the NBS database: 1) year of death registration; 2) the exact date of death (year, month and day); 3) the exact date of birth (year, month and day); 4) sex; 5) locality code of the deceased's place of residence; 6) marital status: a) never-married (single); b) married (with a distinction between the first marriage and the second and higher order); c) divorced; d) widowed; e) unknown; 7) level of education: a) university; b) incomplete higher education; c) secondary special; d) secondary general; e) general obligatory; f) primary; g) without primary; h) analphabet.

Even though the statistical form No. 3 includes other variables such as ethnicity or occupational status, but the share of undeclared status for these categories was very high. For example, in 2014, 95% of death records had "unknown" occupational status, which made it impossible to analyse mortality disparities for this social category. At the same time, the share of death records with the unknown marital status was less than 2%, and the unknown level of education was less than 2.5%. For this reason, the study analysed social disparities according to three categories: place of residence, marital status and educational attainment.

Since the NBS database does not include data on the underlying cause of death, it was merged with the NAPH database of medical death certificates. The two databases were joined by the following variables: sex, the exact date of death (day, month and year), the exact date of death (day, month and year) and locality code. In such a way, it was possible to analyse differences in cause-specific mortality by marital status and the level of education. After the linkage, the proportion of unlinked records varied between 5% in 2013-2014 and 15% in 2003-2005. Unlinked death records were those with no corresponding cause of death, i.e., a death record in the NBS database for which a corresponding match was not found in the NAPS database. We applied an additional linkage for both periods, subsequently deleting one variable except for sex (e.g., without adding locality code). After the additional linkage, the proportion of unlinked records was tiny (less than 1.5%). Deaths with an unknown cause (unlinked death records) were redistributed proportionally by sex, age and social category (marital status or educational level).

Regional mortality data for the districts of Cainari and Vulcanesti in 1991-1995 were processed as described above for the population data. We grouped deaths in 2002-2006 by district based on the locality code, according to the 2003 CUATM classification. In such a way, the mortality data in 2002-2006 corresponded to the population data under the 2004 census. In the same way, we processed the mortality data in 2012-2016 to correspond to the 2014 census based on the 2009 CUATM classification. The CUATM revised in 2003 and 2009 at the second level of the administrative division did not change. In such a way, population and mortality data over the three periods were aggregated according to the same administrative division covering the municipalities of Chisinau and Balti, 32 districts, ATU Gagauzia and Transnistria. Mortality data for Transnistria was available only for the second period at the level of main groups of causes of death.

Table 2.2 represents the datasets tabulated from the NBS and NAPH databases for the period of independence at the national, sub-national and district levels.

Table 2.2. Mortality data used in the study at the national, sub-national and district levels

No.	Time	Description of variables	Source	Comments
National level				
1.	1965-1970	Sex: male/female; Age: 0,1-4,5-9....85+; Cause of death: SC-65	TCSU of USSR	Data provided by INED
2.	1971-1980	Sex: male/female; Age: 0,1-4,5-9....85+; Cause of death: SC-70	TCSU of USSR	Data provided by INED
3.	1981-1990	Sex: male/female; Age: 0,1-4,5-9....85+; Cause of death: SC-81 revised in 1988	TCSU of USSR	Data provided by INED
4.	1991-1995	Sex: male/female; Age: 0,1-4,5-9....85+; Cause of death: SC-81 revised in 1988	NBS	
5.	1991-1995	Sex: male/female; Age: 0,1,2,3...100+; Cause of death: 4-digit ICD-9	NAPH	
6.	1996-2020	Sex: male/female; Age: 0,1,2,3...100+; Cause of death: 4-digit ICD-10	NAPH	Without Transnistria
Sub-national level: the place of residence				
7.	1991-1993	Sex: male/female; Area: rural/urban; Age: 0,1,2,3...100+; Cause of death: 4-digit ICD-9	NAPH	
8.	2003-2005 2014-2016 2017-2019 2020	Sex: male/female; Area: rural/urban; Age: 0,1,2,3...100+; Cause of death: 4-digit ICD-10	NAPH	Without Transnistria
Sub-national level: marital status				
9.	2003-2005	Sex: male/female; Age: 30,31,32...85+; Marital status: single, married, divorced, widowed, unknown; Cause of death: 4-digit ICD-10	NAPH ; NBS	Two databases were merged by sex, date of death, date of birth and locality code.
10.	2013-2014	Sex: male/female; Age: 30,31,32...85+; Marital status: single, married, divorced, widowed, unknown; Cause of death: 4-digit ICD-10	NAPH ; NBS	Two databases were merged by sex, date of death, date of birth and locality code.
Sub-national level: the level of education				
11.	2003-2005	Sex: male/female; Age: 30,31,32...100+; Level of education: Higher, incomplete higher, secondary specialized, secondary general, general obligatory, primary, no primary, illiterate; Cause of death: 4-digit ICD-10	NAPH ; NBS	Two databases were merged by sex, date of death, date of birth and locality code.
12.	2013-2014	Sex: male/female; Age: 30,31,32...100+; Level of education: Higher, secondary specialized, secondary general, general obligatory, primary, no primary, illiterate; Cause of death: 4-digit ICD-10	NAPH ; NBS	Two databases were merged by sex, date of death, date of birth and locality code.
District level				
13.	1991-1995	Sex: male/female; Age: 0,1,2,3...100+; Administrative units: 44	NAPH	Including Transnistria

No.	Time	Description of variables	Source	Comments
		Cause of death: 4-digit ICD-9 code		
14.	2002-2006	Sex: male/female; Age: 0,1,2,3...100+; Localities (in 2004): 1475 Cause of death: 4-digit ICD-9 code	NAPH	Without Transnistria
15.	2012-2016	Sex: male/female; Age: 0,1,2,3...100+; Localities (in 2014): 1417 Cause of death: 4-digit ICD-10 code	NAPH	Without Transnistria

Note: The number of localities includes the localities where deaths were recorded.
Source: author's elaboration

Death counts at the sub-national (place of residence, marital status and level of education) and the district level were aggregated according to a short list of causes of death presented in Table 2.3. The ill-defined causes of death were preliminarily redistributed between other causes of death by a special method. The problem of ill-defined causes of death at the national, sub-national and district levels and how it was addressed are described in section 3.2.3.

Table 2.3. A short list of causes of death used at the sub-national and district levels with the corresponding ICD-9 and ICD-10 codes

Causes of death	ICD-9	ICD-10
1. Infectious diseases	001-139	A00 to B99, U07.1
2. Neoplasms, *including:*	140-239	C00 to D48
Digestive system neoplasms	*140-159*	*C00 to C26*
Respiratory system neoplasms	*161-165*	*C30 to C39*
Breast neoplasms	*174-175*	*C50*
Genitourinary system neoplasms	*180-189*	*C51 to C68*
Other neoplasms	*170-173, 176, 190-208, 210-239*	*C40 to C49, C69 to D48*
3. Circulatory system diseases, *including:*	390-459	I00 to I99, G45
Heart diseases	*390-429*	*I00 to I52*
Cerebrovascular and other circulatory diseases	*430-459*	*I60 to I99*
4. Respiratory system diseases	460-519	J00 to J98, U04
5. Digestive system diseases, *including:*	520-579	K00 to K93
Liver diseases	*570-571*	*K70 to K77*
Other digestive system diseases	*520-569*	*K00 to K69, K78 to K93*
6. External causes of death, *including:*	E800-E999	V01 to Y98
Transport accidents	*E800-E807, E810-E849*	*V01 to V99*
Suicide, homicide and undetermined injury	*E950-E999*	*X60 to Y34*
Other external causes	*E850-E949*	*W00 to X59, Y35 to Y98*
7. Other diseases and causes of death	240-389, 580-779, 798	D50 to G44, G47 to H95, L00 to Q99, R95
8. Senility and ill-defined causes of death	780-797, 799	R00-R94, R96-R99
All causes	*001-799, E800-E999*	*A00 to Y98, U07.1*

Note: deaths from senility and ill-defined causes were preliminarily redistributed (see section 3.2.3)
Source: author's elaboration based on [124, 125]

Death records due to the COVID-19 infection

The first case of COVID-19 death was recorded in Moldova on 18/03/2020. The Ministry of Health (MH) published daily hospital death records on its website until 19/04/2022. Between 18/03/2020 and 19/04/2022, 11487 individual hospital death records were published. The author collected the following information for every published death record: 1) date of publication; 2) sex; 3) age in complete years; 4) district; 5) date of death (since 12/11/2021).

The collected mortality data (by sex, age, date of publication and date of death) was prepared weekly by the author during the pandemic period and presented to the International Database "The Demography of COVID-19 deaths" coordinated by INED (see Implementation Act in Annexe 18).

Deaths from COVID-19 recorded in Transnistria (1241 records) or among foreign citizens (12 records) over the study period were preliminarily excluded from the data to ensure the consistency between events and the population at risk. We also excluded from the analysis 579 records published on 30/12/2021 as "unregistered" or "missing" deaths detected by the MH due to verifying the completeness of hospital death registration. In such a way, 9655 hospital death records (laboratory-confirmed cases) were selected for analysis. For 2020, the medical death certificates with an underlying cause of death U07.1 were retrieved from the depersonalised database provided by the NAPH (n=2819).

2.1.3. Population and mortality data for other countries

Ukraine

Cause-specific mortality data for Ukraine for the 1965-2013 period were retrieved from the Human Cause-of-Death Database (HCD) [126]. For the 2014-2020 period, the time series were prolonged with the data of the State Statistics Service of Ukraine [127]. For the period 1965-2013, we used the reconstructed mortality series according to ICD-10 groups of causes of death [32, 128]. Since 2014 the State Statistics Service of Ukraine has not published data on the temporarily occupied territories of the Autonomous Republic of Crimea. On the other hand, official death rates for the regions of Donetsk and Luhansk are highly under-registered. We excluded the data for the occupied territories from the official statistics for 2014-2020 due to the reasons mentioned above.

Romania

The cause-specific mortality series for Romania were reconstructed according to ICD-10 4-digit items by the author for 1980-2018 (see Implementation Act in Annexe 17). For the comparative analysis presented in Chapter 4, the reconstructed data were prolonged with 1965-1979 data at the level of main groups of causes of death based on the WHO mortality database [129]. The reconstructed death series for Romania are available in the HCD database [126].

Other countries (the Czech Republic, England & Wales, Germany and Poland)

The excess mortality in Moldova was studied relative to the European model presented by two Western European countries (Germany and England & Wales) and two Central European countries (the Czech Republic and Poland). We used the reconstructed ICD-10 mortality series available for the four countries since 2001. The data were completed with unreconstructed time series for the recent period until 2019 [129]. Mortality data for Ukraine, Romania and countries included in the European model were aggregated according to seven groups of causes of death presented in Table 2.3.

2.2. Methods

We distinguish two groups of methods used in the study. The first group consists of methods specially developed to meet specific methodological needs when assessing the quality of population and mortality data. These methods are not classical and need to be either adapted to the given empirical data or developed. This group, which is presented along with the data quality issues in Chapter 3, includes the following methods: 1)Production of annual population estimates at the national level for 1959-2004 according to the HMD method by Penina, Jdanov and Grigoriev [121] and intercensal estimates for 2004-2014 (section 3.1.1); 2) Correction of infant mortality and old-age mortality in Moldova (section 3.2.1); 3) Reconstruction of mortality series according to a fixed classification developed by Vallin and Meslé [18] and adopted for Moldova (section 3.2.2); 4) The distribution of deaths coded as "senility" and other ill-defined causes of death (section 3.2.1).

The reconstruction of the mortality series by cause of death was partially automated using the R function to detect fundamental associations of items (FAI) written by C.G. Camarda and M. Pechholdová [130]. We also used the VBA macros that V. Bâzgan and the author developed to build FAI tables and compute the transition coefficients [131]. The statistical coherence of the mortality series was checked using the R function written by C.G. Camarda and M. Pechholdová [132].

This section describes the second group of methods used to analyse the mortality data at the national, sub-national and district levels after the preliminary data quality assessment and correction.

The data were analysed in R (version 4.1.0) [133] and RStudio (version 1.4.1717) [134].

2.2.1. Life tables and 95% CI

Abridged life tables by sex were computed using the Chiang method [135]. At the national level, life tables were produced for 1959-2020. At the sub-national and district levels, life tables by sex were computed for the corresponding study periods presented in Table 2.1.

Age-specific death rates m_x at age x for a period, for example, 1991-1993, were computed as follows [136]:

$$m_{x\,(1991-1993)} = \frac{D_{x\,(1991-1993)}}{3 \times \frac{P_{x\,(January\ 1,1991)} + P_{x\,(January\ 1,1994)}}{2}} \qquad (2.1)$$

Where:

$D_{x(1991-1993)}$ – deaths at age x registered during the period 1991-1993;

$P_{x(January\ 1,1993)}$ and $P_{x(January\ 1,1994)}$ – population at age x estimated at the start (January 1, 1991) and the end (December 31, 1993, or January 1, 1994) of the period 1991-1993.

At the national level, we used the infant mortality rate before and after corrections as q_0 in life tables.

We used the Silcocks et al. method to calculate the 95% CIs for life expectancy at the sub-national and district levels [137]. The results were close to those obtained using the method proposed by E. Andreev and V. Shkolnokov [138]. Life tables by marital status and the level of education with corresponding 95% CIs were computed for the population aged 30 years and over.

Life tables and 95% CIs were calculated using the "PHEindicatormethods" package (version 1.4.2) [139]. The minimum population size required for producing a life table using this package was 5000. Life tables and 95% CIs by marital status and level of education for the population aged 30 years and over were computed using the R function written by C.G. Camarda [140].

2.2.2. Multiple decrement life tables

Excess mortality in Moldova compared to the European model was examined in section 4.4. The model was calculated as a simple mean of age- and cause-specific death rates for the four European countries (Germany, England and Wales, Czech Republic and Poland). Abridged life tables and multiple decrement life tables (MDLT) by cause of death were produced for the model and Moldova for 2001-2019.

Life expectancy at birth and age x is computed for a hypothetical cohort equal to 100000, which is the radix of the life table. In a classical life table, the membership in a cohort is terminated by a single attrition factor (exclusion), such as a death. In MDLT, there could be two or more attrition factors, such as death from different causes i ($i_1, i_2, \ i_n$) [141].

Table 2.4 shows certain functions retrieved from a life table (m_x, q_x, l_x, d_x, e_x) and MDLT for circulatory system diseases (m_{xi}, q_{xi}, l_{xi}, d_{xi}) computed for Moldovan males in 2019. Life table deaths or table deaths (d_x) at age x represent the life table function. In MDLT, life table deaths from a cause i (d_{xi}) was calculated as follows:

$$d_{xi} = d_x \times C_{x_i} \qquad (2.2)$$

Where C_{x_i} – the proportion of deaths from cause *i* at age *x* in the total deaths. C_{xi} was computed as the ratio of the age-specific death rate from cause *i* (m_{xi}) to the age-specific death rate from all causes (m_x).

In our study, excess deaths from cause *i* were estimated as the difference between life tables deaths in Moldova and the model:

$$d_{x_i}^{Moldova} - d_{x_i}^{Model} \qquad (2.3)$$

Summing up life table deaths by all causes and ages, the table radix is obtained.

It is important to note that life table deaths are *not* influenced by the population's age structure and reflect the mortality intensity in the compared populations. From this point of view, life table deaths computed for two different populations can be compared.

Table 2.4. Functions of life table and multiple decrement life table for circulatory system diseases computed for Moldovan males in 2019

Age (x)	m_x	q_x	l_x	d_x	e_x	C_{xi}	m_{xi}	q_{xi}	l_{xi}	d_{xi}
0	0.0087	0.0086	100000	860	66.61	0.007	0.0001	0.0001	53975	6
1	0.0004	0.0017	99140	169	66.18	0.000	0.0000	0.0000	53969	0
5	0.0003	0.0014	98971	143	62.29	0.040	0.0000	0.0001	53969	6
10	0.0003	0.0017	98828	167	57.38	0.077	0.0000	0.0001	53964	13
15	0.0008	0.0041	98661	403	52.47	0.068	0.0001	0.0003	53951	27
20	0.0013	0.0065	98258	635	47.68	0.041	0.0001	0.0003	53923	26
25	0.0014	0.0070	97623	683	42.97	0.130	0.0002	0.0009	53898	89
30	0.0024	0.0119	96940	1154	38.26	0.209	0.0005	0.0025	53809	241
35	0.0043	0.0215	95786	2057	33.69	0.185	0.0008	0.0040	53567	381
40	0.0078	0.0384	93729	3595	29.37	0.252	0.0020	0.0097	53186	907
45	0.0109	0.0529	90134	4771	25.44	0.293	0.0032	0.0155	52279	1398
50	0.0154	0.0742	85363	6333	21.73	0.330	0.0051	0.0245	50881	2092
55	0.0228	0.1077	79030	8514	18.27	0.369	0.0084	0.0397	48789	3141
60	0.0315	0.1461	70515	10299	15.17	0.415	0.0131	0.0606	45649	4277
65	0.0454	0.2038	60216	12273	12.34	0.524	0.0238	0.1069	41372	6436
70	0.0575	0.2515	47943	12059	9.86	0.620	0.0357	0.1560	34936	7479
75	0.0981	0.3938	35884	14130	7.33	0.692	0.0679	0.2726	27458	9782
80	0.1465	0.5361	21754	11661	5.46	0.777	0.1138	0.4163	17676	9057
85	0.2571	1.0000	10093	10093	3.89	0.854	0.2196	0.8540	8619	8619

Note: m_x- age-specific death rate, q_x – the probability of death, l_x – the number of persons surviving to exact age *x*, d_x – life tables, e_x – life expectancy at age *x*, C_{xi} – the proportion of deaths from cause *i* (circulatory system diseases). Functions m_{xi}, q_{xi}, l_{xi} and d_{xi} are the corresponding functions for circulatory system diseases.
Source: author's elaboration

2.2.3. The method of decomposition of the difference in life expectancy

The difference in life expectancy at birth between two values, e.g., between two populations or two years, was decomposed using a stepwise replacement method proposed by E. Andreev, V. Shkolnikov and A. Begun [142]. We used this method to decompose the difference between two life expectancies by age group and cause of death. The method estimates the contribution of the differences between two age- and cause-specific mortality rates to the overall differences between two life expectancies. The contribution is measured in years.

We decomposed the difference between the two life expectancies using the R package "DemoDecomp" (version 1.0.1) [143].

2.2.4. Standardization of death rates and 95% CI

At the national and sub-national levels, death rates were standardised by age using the direct method based on the WHO European Population (2013) as a standard [144]. The standardised death rate could be interpreted as the hypothetical crude rate if the Moldovan population had the age distribution of the standard population. The standardised death rate (SDR) for all causes of death was computed as follows [145]:

$$SDR = \frac{\sum w_x m_x}{\sum w_x} \qquad (2.4)$$

Where:

m_x – the age-specific death rate at age x

w_x – the weight for age x derived from the European standard population

The standardised death rates were computed by cause for the whole population, main age groups and social categories (place of residence, marital status and level of education). Standardised death rates by marital status and level of education were computed for the population aged 30 years and over.

At the district level, death rates were standardised using the indirect method due to relatively small death counts. In this case, we needed only the total number of deaths in the study population (a district) $\sum D_x$ and the age distribution of the study population P_{1x}. The age-specific death rates were computed for the Moldovan population m_{0x}, which was used as a reference.

First, the standardised mortality ratio (SMRatio) was computed as the ratio of the observed deaths to the expected deaths in the study population. The expected deaths were obtained by multiplying the number of the population at age i in the study population P_{1i} by the age-specific death rate in the reference population m_{0x}.

$$SMRatio = \frac{\sum D_1}{\sum P_{1x} \frac{D_{0x}}{P_{0x}}} = \frac{\sum D_1}{\sum P_{1x} R_{0x}} = \frac{Observed\ deaths}{Expected\ deaths} \qquad (2.5)$$

Then, we multiplied the standardised mortality ratio in the study population by the crude death rate in the reference population CDR_0 to obtain the standardised mortality rate (SMR) in the study population. In this case, CDR in the reference population was a reference rate or baseline [146].

$$SMR = SMRatio \times CDR_0 \qquad (2.6)$$

95% CIs were computed based on the Dobson or Gamma methods for death rates standardised by the direct method. For mortality rates standardised by the indirect method, 95%

CIs were estimated using Byar's method (when the number of death counts was at least 10) or the exact χ^2 method (when death counts were less than 10) [147].

Standardised mortality rates were computed by district and cause. First, we analysed the regional mortality profile for 2012-2016. In this case, reference rates were age-specific death rates for the Moldovan population in 2012-2016. When we studied the evolution of regional mortality patterns throughout independence, the reference rates were computed for 1991-1995. Table 2.5 summarizes the information about the standardisation methods used in the study.

Table 2.5. Selection of standardisation method of death rates and standard population depending on the population level

Study level	Period	Standardization method	Standard population/ reference rate	95% CI
National level	1959-2020	Direct	The 2013 European standard population	-
Sub-national level: place of residence	1991-1993 2003-2005 2014-2016 2017-2019 2020	Direct	The 2013 European standard population	Dobson method
Sub-national level: marital status	2003-2005 2013-2014	Direct	The 2013 European standard population	Gamma method
Sub-national level: level of education	2003-2005 2013-2014	Direct	The 2013 European standard population	Gamma method
District level	2012-2016	Indirect	The age- and cause-specific death rate for both sexes in Moldova in 2012-2016	Byar's or exact χ^2 methods
District level	1991-1995 2002-2006 2012-2016	Indirect	The age- and cause-specific death rate for both sexes in Moldova in 1991-1995	Byar's or exact χ^2 methods

Source: author's elaboration

SDR and 95% CIs by place of residence (rural/urban) were computed with the help of the "dsr" package (version 0.2.2) [148]. At the district level, we computed SMR with 95% CIs using the "PHEindicatormethods" package (version 1.4.2) [139].

2.2.5. Absolute and relative mortality differences and 95% CIs

According to the international recommendations, absolute and relative mortality differences by sociodemographic characteristics (place of residence, marital status and level of education) were used. The urban population (place of residence), the married population (marital status) and the population with higher education (level of education) served as reference groups. The absolute or rate difference (RD) was calculated as the difference between standardised death rates (SDR) in the population group under consideration and SDR in the reference group. The relative difference or rate ratio (RR) was assessed as the ratio of SDR in the population group

under consideration to SDR in the reference group. Rate ratio and rate difference are weighted averages computed as the ratio or difference of directly standardised death rates [149].

The rate ratio (RR) can be presented as follows [145]:

$$RR = \frac{\sum w_x m_{1x} \div (\sum w_x)}{\sum w_x m_{0x} \div (\sum w_x)} = \frac{\sum w_x m_{0x} \widehat{RR_x}}{\sum w_x m_{0x}} = \frac{\sum w'_x \widehat{RR_x}}{\sum w'_x} \quad (2.7)$$

Where:

w_x – the standard weight in age group *x* (see Table 2.5)

m_{1x} – rate among the group under consideration (e.g., divorced men) in age group *x*

m_{0x} – rate among the reference group (e.g., married men) in age group *x*

$w'_x = w_x m_{0x}$

$\widehat{RR_x}$– rate ratio in age group *x*

Similarly, rate difference (RD) can be computed in the following way [145]:

$$RD = \frac{\sum w_x m_{1x}}{\sum w_x} - \frac{\sum w_x m_{0x}}{\sum w_x} = \frac{\sum w_x (m_{1x} - m_{0x})}{\sum w_x} = \frac{\sum w_x \widehat{RD_x}}{\sum w_x} \quad (2.8)$$

Where:

$\widehat{RD_x}$– rate difference in age group *x*

The change in rate difference (RD) and rate ratio (RR) between the period *t* and period *t+n* was calculated as follows:

$$\left(RD_{period\ t+n} - RD_{period\ t}\right) \div RD_{period\ t} \times 100 \quad (2.9)$$

$$\left(RR_{period\ t+n} - RR_{period\ t}\right) \div RR_{period\ t} \times 100 \quad (2.10)$$

We used 95% CI to compare an estimate (e.g., SDR in divorced males) against a reference value (e.g., SDR in married males). When the reference value was outside 95% CI for the estimate (non-overlapping CI), the difference between the estimate and the reference was statistically significant ($p<0.05$). Non-overlapping confidence intervals for RD and RR signified a statistically significant difference ($p<0.05$) [150].

95% CI were estimated for RD and RR using the R package "dsr" (version 0.2.2) [148].

2.2.6. Thematic maps

The shape files for Moldova were retrieved from the GADM website to produce thematic maps [103]. Thematic maps were built with the help of the "tmap" package elaborated by Martijn Tennekes [57]. In most cases, we used Jenks' optimization method of classifying a statistic, such as life expectancy at birth, which maximises the differences between the categories of observations [151]. Some thematic maps in our study also include the histogram representing the distribution of a statistic, like life expectancy at birth or standardised mortality rate, across districts.

2.2.7. Spatial mortality analysis

2.2.7.1. General concepts

Spatial autocorrelation is an essential concept of spatial analysis with a rich history [152]. If the traditional correlation detects the relationship between independent and dependent variables, then the autocorrelation is related to the correlation of the same variable but in different locations. One can say that spatial autocorrelation shows how the value of the variable of interest in a specific location is related to the values of the same variable in neighbouring locations [153].

Spatial randomness is one of the critical concepts that can be defined as an absence of any pattern or structure in spatial data. Luc Anselin's interpretation of spatial randomness is based on two perspectives. In the simultaneous perspective, spatial randomness exists when the observed spatial pattern is as probable as any other. In the conditional perspective, spatial randomness occurs when values of the variable of interest in one location are not dependent on its values in the surrounding locations [154].

The null hypothesis (H_0) in spatial autocorrelation suggests a random distribution of a variable of interest in space. In other words, H_0 implies spatial randomness. The alternative hypothesis (H_1) points to evidence of pattern or structure in the spatial data or *clustering*. If H_1 is accepted, both positive and negative autocorrelation can be possible.

In the case of *positive autocorrelation*, similar values of a variable of interest (low or high) in neighbouring locations occur more frequently than spatial randomness. In other words, positive autocorrelation signifies that the variability of the values is lower than that of spatial randomness. If *negative autocorrelation* occurs, dissimilar values of a variable of interest (low vs high) occur more frequently than spatial randomness. One can say that negative autocorrelation suggests that the variability of the values is higher than that of spatial randomness. Positive autocorrelation is closely related to *clustering*, i.e., the presence of patterns or clusters in spatial data and indicating a location of clusters with similar values on a map [154].

Spatial autocorrelation can be quantified with indices represented by *global spatial autocorrelation* and *local spatial autocorrelation*. The first type of statistic is used to accept or reject the null hypothesis about spatial randomness. However, the global spatial autocorrelation statistic does not identify clusters on a map. The second type of statistic detects the locations of clusters with similar values on a map. The two spatial autocorrelation indices require an assessment of significance or the probability of making the Type 1 error when rejecting H_0.

2.2.7.2. Spatial weights

The spatial analysis starts with identifying neighbours between localities (spatial units) and constructing a spatial weights matrix. This study tested two types of spatial weights: contiguity

and distance-based weights. The definition of "neighbour" in the case of contiguity-based spatial weights is based on a common border. Furthermore, the contiguity-based weights matrix can be constructed according to the *rook's* or the *queen's* criterion. The first one eliminates corner neighbours, while the second keeps them (Figure 2.1). A distinction can be made between the first-order contiguity, which includes only the nearest neighbours, and the second-order contiguity when the localities next to the nearest neighbours are also included [155]. The other definition of the neighbourhood used in our study referred to *k* nearest neighbours. According to this approach, all spatial units have *k* (e.g., four) neighbours [156].

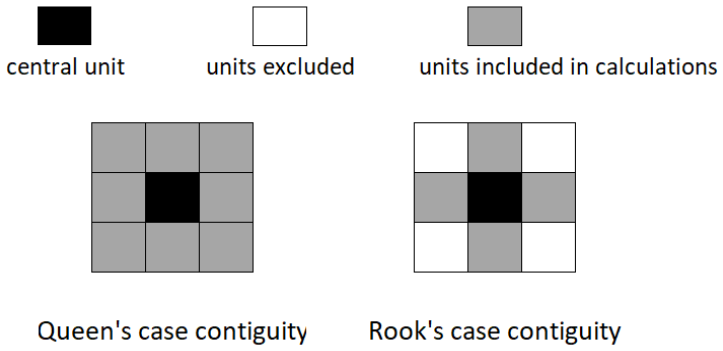


Fig. 2.1 Two types of the contiguity-based matrix

Source: based on [157]

The spatial weights define the neighbourhood structure between localities *i* and *j* as a $n \times n$ matrix *W*. The neighbourhood relation is binary with weights equal to 1 or 0. The spatial weights (w_{ij}) are equal to one when localities *i* and *j* are neighbours and to zero if not [158]:

$$W = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1n} \\ w_{21} & w_{22} & \cdots & w_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ w_{n1} & w_{n2} & \cdots & w_{nn} \end{bmatrix} \qquad (2.11)$$

2.2.7.3. Global spatial autocorrelation

Based on global spatial autocorrelation, we can reject H_0 about spatial randomness in favour of H_1 about the presence of clustering in data. However, global spatial autocorrelation does not point to the location of the clusters on a map.

The most known statistic of global spatial autocorrelation is Moran's index or Moran's I proposed by Patrick Alfred Pierce Moran [159]:

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij}(y_i - \bar{y})(y_i - \bar{y})}{\sum_i (y_i - \bar{y})^2} \qquad (2.12)$$

Where:

N – total number of spatial units or localities;

$\bar{y}$ – arithmetic mean of the variable of interest y (e.g., life expectancy at birth or standardised mortality rate);

The sum of spatial weights, $\sum_i \sum_j w_{ij}$, also referred to as S_0, is equal to the number of localities when the spatial weights matrix is row-standardised ($S_0 = N$).

Moran's index can be presented more simply as follows [160]:

$$I = \frac{N}{S_0} \frac{\sum_i \sum_j w_{ij} z_i z_j}{\sum_i {z_i}^2} \qquad (2.13)$$

Where: z_i – deviation from the mean of a variable y.

Moran's index usually takes the values between -1 and +1 as the classical correlation coefficient with an identical interpretation. If Moran's index is equal to zero, it indicates that the distribution of a variable of interest y in space is random (H_0 about spatial randomness is accepted).

When Moran's index has positive values, it means spatial clustering of *similar* values (high or low). In other words, locality i, where the value of a variable y is lower than the mean, is surrounded by other localities j with values also below the mean. And *vice versa*.

When Moran's index has negative values, it points to spatial clustering of *dissimilar* values: locality *i* with high values of a variable *y* is surrounded by localities *j* with low values of the same variable and *vice versa* [160].

We used the significance test based on a Monte Carlo (permutation) approach to estimate the significance of Moran's index. An obtained value of the index was compared to reference distribution from a series of randomly permuted patterns (number of permutations = 9999). It is considered that 1000 permutations give reliable results [159]. We rejected H_0 about the spatial randomness and accepted H_1 about clustering if the p-value for the significance test was less than 0.05.

2.2.7.4. Local spatial autocorrelation

The global spatial autocorrelation index informs only about the presence of clustering in spatial data for a variable of interest y and its intensity. Local spatial autocorrelation statistics identify the location or clusters with similar values of a variable of interest y on a map. These clusters of high or low values are also referred to as "*hot spots*" and "*cold spots*" [159].

The local indicators of spatial association or LISA were computed to measure the local spatial autocorrelation as follows [160]:

$$I_i = (y_i - \bar{y}) \sum_j w_{ij} (y_i - \bar{y}) \qquad (2.14)$$

If z_i is the deviation from the mean of a variable y $(y_i - \bar{y})$, then:

$$I_i = z_i \sum_j w_{ij} z_i \qquad (2.15)$$

The Monte Carlo approach was applied to estimate if "high-high" and "low-low" clusters were statistically significant at a confidence level of 0.05.

2.2.7.5. Moran's scatterplot

Local spatial autocorrelation indices can be presented graphically with the help of Moran's scatterplot built between the spatially lagged variable of interest y on the y-axis and the observed values of variable y on the x-axis. The spatially lagged variable y is the weighted average of a variable y in neighbouring localities.

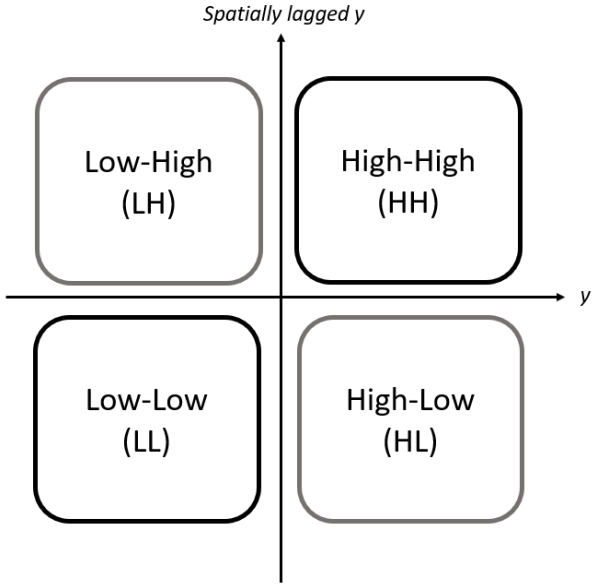


Fig. 2.2 A schematic presentation of Moran's scatterplot

Source: based on [159]

Moran scatterplot has four quadrants corresponding to the four types of local indicators of spatial association. The "*high-high*" (upper right) quadrant corresponds to the localities with high values of a variable of interest y surrounded by localities with high values of the same variable (higher than the mean). High-high clusters are often called "*hot spots*". The "*low-low*" (lower left) quadrant corresponds to the localities which have low values of a variable y and are surrounded by the localities where the values of the variable y are also low (lower than the mean). Positive global spatial autocorrelation occurs when most localities (observations) fall within the "high-high" and "low-low" quadrants.

In the "high-low" quadrant, high values of a variable y are surrounded by low values, while in the "low-high" quadrant, low values are surrounded by high values. The global spatial autocorrelation is negative when most observations are located within these two quadrants. Localities in "low-high" and "high-low" quadrants are referred to as "spatial outliers".

LISA cluster maps were used to represent the location of local indicators of spatial association. Five LISA categories were as follows: “high-high”, “low-low”, “high-low”, “low-high” ($p<0.05$) and “not significant” ($p>0.05$).

Global and local spatial autocorrelation analysis of mortality were produced with the help of the following R packages: “sp” (version 1.6-0) [161, 156], “sf” [162], “spdep” [156, 163] and “rgeoda” (version 0.0.9) [164].

2.3. Conclusions for Chapter 2

1. According to the study’s objectives, the mortality and population data were collected at the national, sub-national and district levels. At the national level, mortality analysis covers the Soviet period and the period of independence. The mortality data for 1965-1990 were provided by the INED according to the Soviet classification of causes of death, subsequently changed in 1965, 1970, 1981 and 1988. For the 1991-2020 period, we used the depersonalised electronic database of medical death certificates codified under ICD-9 (1991-1995) and ICD-10 (1996-2020). The official population data at the national level refer to the usual resident population and is available only from 2014. The official population counts must be checked for data quality and re-estimated for the earlier period.
2. At the sub-national and district levels, the data were collected for the period of independence. We created a database of death records by sex, age, the underlying cause of death, marital status and level of education by merging the database of medical death certificates and the database of statistical form No. 3. The population data by marital status and level of education are the respondent population according to the censuses conducted in 2004 and 2014 and need to be corrected to be in line with the usual resident population. The population data at the district level are the official annual estimates based on the 1989 census, the results of the 2004 census and the post-census annual estimates for 2014-2020.
3. We collected hospital death records due to COVID-19 published daily by the MH between 18/03/2020 and 19/04/2022.
4. The data were analysed using the following demographic methods: life tables and multiple decrement life tables, standardised death rates and standardised mortality ratio, a stepwise replacement method of the decomposition of the difference in life expectancy, absolute and relative measures of mortality disparities (rate difference and rate ratio), global and local spatial autocorrelation. 95% CI were computed for statistics at the subnational and district levels. Data were analysed in R.

3. ASSESSING POPULATION AND MORTALITY DATA QUALITY AT THE NATIONAL, SUB-NATIONAL AND DISTRICT LEVELS

Chapter 3 is dedicated to assessing population and mortality data quality at the national, sub-national and district levels. At the national level, the data were analysed for the Soviet period and the period of independence. The analysis is restricted only to the period of independence at the sub-national and district level.

3.1. Population data quality

3.1.1. Population data at the national level

The quality of the Moldovan population data is highly questionable. This section discusses the nature of the erroneous official population data and presents possible data correction methods for the Soviet and post-independence periods.

3.1.1.1. During the Soviet period

After World War II, four censuses were conducted in Moldova in 1959, 1970, 1979 and 1989. In Soviet censuses, two types of the population were traditionally distinguished. The first type was the *de jure* population, i.e., the permanent residents in the given territory, including the temporary residents. The second type referred to the *de facto* population, i.e., the population present on the given territory at the census moment, including the temporary absent population. During the Soviet period, the difference between *de jure* and *de facto* populations was insignificant due to low international migration flows. The official population counts for the Soviet period were available by age and sex for 1965-1990 and referred to as the de jure population.

Checking the data for 1965-1979 identified some quality problems for older ages. Figure 3.1 illustrates annual trends in counts of persons 60 years of age and older in 1965-1979. Some changes in the number of older persons are fully expected. For example, a decrease in population counts for the 60-64 age group in 1976-1979 is explained by a reduction in births during World War I. In 1970, when the census was conducted, the sudden decline in population counts for the 70-84 age group was accompanied by a moderate increase in the 60-69 age group. The population trend was not seriously modified for ages 85 and over. The more accurate reporting of age in the 1970 census than in the 1959 census may cause these interruptions in population counts among older adults.

In our study, we preferred substituting the official population counts for the Soviet period with the intercensal estimates produced according to the standard Human Mortality Database protocol (HMD-like estimates) produced by Penina, Jdanov and Grigoriev [121]. The HMD-like estimates for older age groups were produced using the extinct cohort method based on death

counts without considering the erroneous population counts at older ages. The intercensal trends in annual population counts became much more consistent in time due to the elimination of a sudden drop in 1970. The official annual population counts for 1980-1989 were consistent by age and year and referred to intercensal estimates. The official annual population counts were used for the given period to produce the population exposure according to the HMD standard protocol.

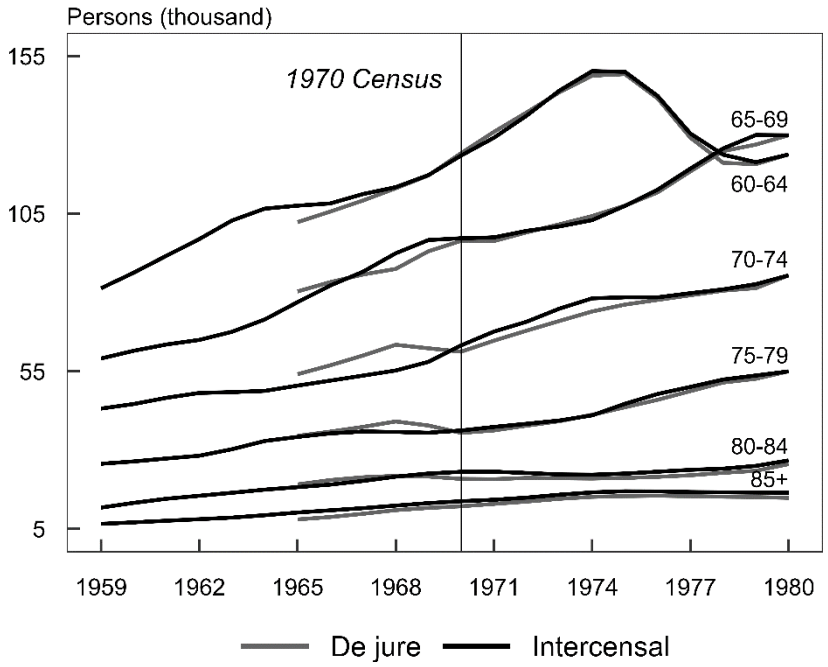


Fig. 3.1 Official estimates (1965-1979) and intercensal estimates (1959-1979) of the older population by age in Moldova, both sexes (abs., thousand)

Note: Vertical lines refer to the census dates: 15/01/1959, 15/01/1970, 17/01/1979 and 12/01/1989.
Source: Official de jure estimates – unpublished TCSU of USSR archived data; intercensal estimates – Penina, Jdanov and Grigoriev [121]

3.1.1.2. After independence

After independence, the first census was conducted on the 5th of October 2004 and the second on the 12th of May 2014. Unlike the four Soviet censuses, the two censuses for the independence period did not include the Transnistrian region representing about half a million or 14% of the total Moldovan population in 2004. The two censuses were conducted independently in 2004 and 2015 in this region. In 2004 and 2014, the difference between the *de jure* and de facto populations was much more significant than in Soviet times. According to the 2004 census, the number of Moldovan residents absent for twelve months or longer was 130 thousand persons or 3.9% of the *de jure* population. This proportion increased to 7.0% at the moment of the 2014 census. The NBS corrected the official results of the 2014 census based on post-census survey and electricity suppliers' data [165]. These corrections were considerable in the municipality of Chisinau, where the census coverage was 59%.

To calculate official social and demographic indicators, the NBS computed annual *de jure* population counts (so-called "stable" population or "populație stabilă") until 2019. Using the *de jure* population, including long-term emigrants, created a systematic bias since deaths and births referred to the *de facto* population, i.e., events that occurred within the country. Moreover, the *de jure* population estimates were based on the 1989 census and did not consider the 2004 and 2014 censuses. In 2019, the NBS introduced the concept of the "usually resident population", referring to the residents who have lived in the country for at least the last twelve months and who intend to live in the country for the next 12 months, excluding temporary absences for holidays or work assignments [166]. The NBS published the annual estimates of the usually resident population based on the 2014 adjusted census, vital statistics by date of occurrence and individual border crossing migration data (Figure 3.2).

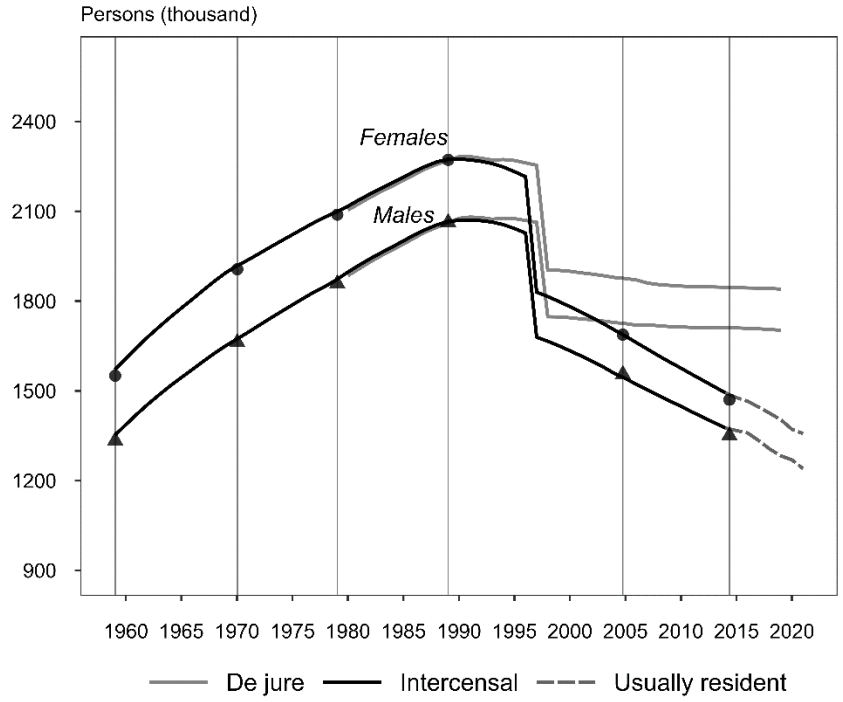


Fig. 3.2 Population estimates in Moldova: 1981-2019 de jure population; 2014-2020 usually resident population; 1959-2013 intercensal population

Note: Vertical lines refer to the census dates: 15/01/1959, 15/01/1970, 17/01/1979, 12/01/1989, 05/10/2004 and 12/05/2014. Since 1998 official population statistics do not include the Transnistrian region.
Source: official estimates – NBS https://statistica.gov.md/; intercensal 1959-2003 estimates – Penina, Jdanov and Grigoriev [121]; intercensal 2004-2013 estimates – author's calculations.

In this study, we used the following population estimates for Moldova: intercensal population estimates for the 1959-2003 period computed by Penina, Jdanov and Grigoriev according to the HMD methodology [121], intercensal estimates for the 2004-2013 period computed by the author, according to the cohort-component method, and the postcensal "usually resident" population estimates for the 2014-2020 period produced by the NBS.

Using the *de jure* population for the period of independence can lead to a numerator-denominator bias and considerable underestimation of mortality and fertility rates. Table 3.1 presents life expectancy at birth computed based on the intercensal and postcensal estimates of the usually resident population compared to the *de jure* population estimates. In the early 1990s, the difference in life expectancy at birth was insignificant (-0.19 years in males and -0.02 years in females in 1995). After the 2004 census, the discrepancy in life expectancy at birth based on two different population data sources increased to -1.06 years in males and -0.72 years in females in 2005. Finally, in 2019, life expectancy at birth computed based on the *de jure* population must be reduced by 3.24 years in males and 2.58 years in females.

Table 3.1 Life expectancy at birth calculated based on different types of population data in Moldova after independence by sex (years)

Year	Based on intercensal population estimates	Based on the official "de jure" population estimates	Based on the official "usually resident" population estimates	Difference
Males				
1991	63.99	64.14	-	-0.15
1995	61.75	61.94	-	-0.19
2000	63.37	63.99	-	-0.62
2005	62.70	63.76	-	-1.06
2010	62.96	64.84	-	-1.88
2015	-	67.50	65.11	-2.39
2019	-	69.84	66.60	-3.24
Females				
1991	70.89	70.83	-	0.06
1995	69.72	69.74	-	-0.02
2000	70.97	71.31	-	-0.34
2005	70.92	71.64	-	-0.72
2010	72.11	73.38	-	-1.27
2015	-	75.56	73.61	-1.95
2019	-	77.57	74.99	-2.58

Source: author's calculations based on the data from NBS and Penina, Jdanov and Grigoriev [121]

3.1.2. Population data at the sub-national level (place of residence, marital status and level of education)

The National Bureau of Statistics published the annual population estimates by place of residence for the 2014-2022 period only in 2022 based on the adjusted results of the 2014 census, vital statistics and individual border crossing migration data. For the period before 2014, we produced our proper estimates for 1991-1993 and 2004 based on the official data by place of residence and HMD-like intercensal estimates produced at the national level (see section 3.1.1).

The difference between official annual estimates and the national HMD-like intercensal estimates in the early 1990s was negligible (0.5% in 1991 and 1% in 1994). This observation allowed us to use the official annual estimates by place of residence for this period. The official

population structure by sex, age and place of residence in 1991-1993 was applied to the HMD-like intercensal estimates for the corresponding years. In the same way, the population counts by place of residence were estimated for 2004. The population structure by place of residence according to the 2004 census was applied to the HMD-like data in 2004. In such a way, the produced estimates by place of residence became more consistent with the population data used at the national level.

Figure 3.3 shows population pyramids by place of residence for 1991, 2004, 2014 and 2020. Throughout independence, the rural population prevailed over the urban population, with about 60% of the total structure. In the early 1990s, when the data covered Transnistria, the share of the urban population was somewhat more prominent compared to other periods (47% in 1991 vs 38% in 2004). The ageing process was more pronounced in rural than urban areas, but the pace of the population ageing was more marked in urban than rural areas. The share of older people aged 60 and over increased from 16% in rural areas and 10% in urban areas in 1991 to 23% and 21% in 2020, respectively. The population ageing was particularly pronounced among the female population, with a share of 26% in rural areas and 24% in urban areas in 2020. In 1991, the proportion of young men aged about 20 was higher in urban areas than in rural areas. This finding is likely to be an artefact resulting from the registration of the military contingent during the 1989 Soviet census.

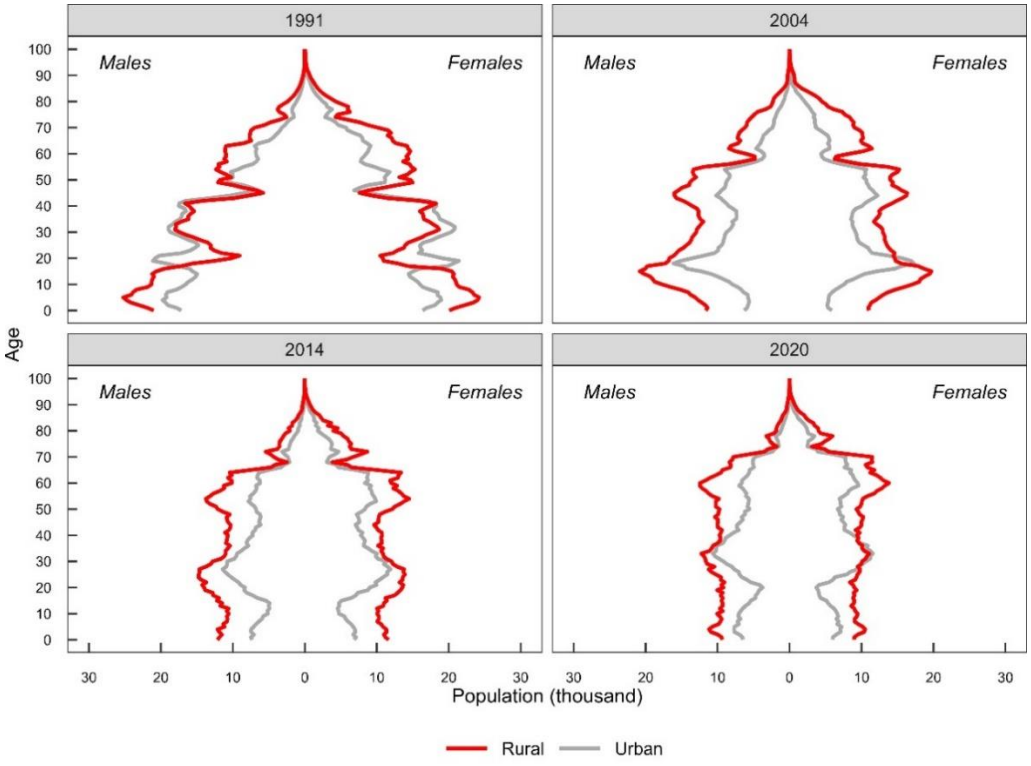


Fig. 3.3 Population counts by sex, age and place of residence in 1991, 2004, 2014 and 2020 (thousand)

Note: In 1991, the data includes Transnistria.
Source: for 1991 and 2004 - author's calculations based on the data from NBS and Penina, Jdanov and Grigoriev [121]. For 2014 and 2020 – NBS data was adjusted for age groups over 85.

Figure 3.4 illustrates the population pyramids according to the legal marital status produced based on the population censuses conducted in 2004 and 2014. The population structure by sex, age and marital status was estimated based on the HMD-like population counts at the national level and the population structure by legal marital status according to the 2004 and 2014 censuses. The 2014 census recorded four legal marital status categories presented in the above figure: never-married, married, divorced and widowed. Such classification was used to identify the deceased's marital status in the statistical form No. 3 "Death" (see section 1.4). The 2004 census distinguished more marital status categories than the 2014 census. In particular, besides the four legal marital status categories, the "separated" status was included in the 2004 census. Less than 1% of the respondent population indicated this status. In 2004, the group "married" consisted of subgroups "legally married" and "living in a union". To be consistent between the two censuses, we estimated the population composition for 2004 according to four legal marital statuses. The population structure by sex, age and marital status was applied to the HMD-like population estimates by sex and age in the corresponding years. In such a way, we ensured the consistency between the population estimates at the national and sub-national levels.

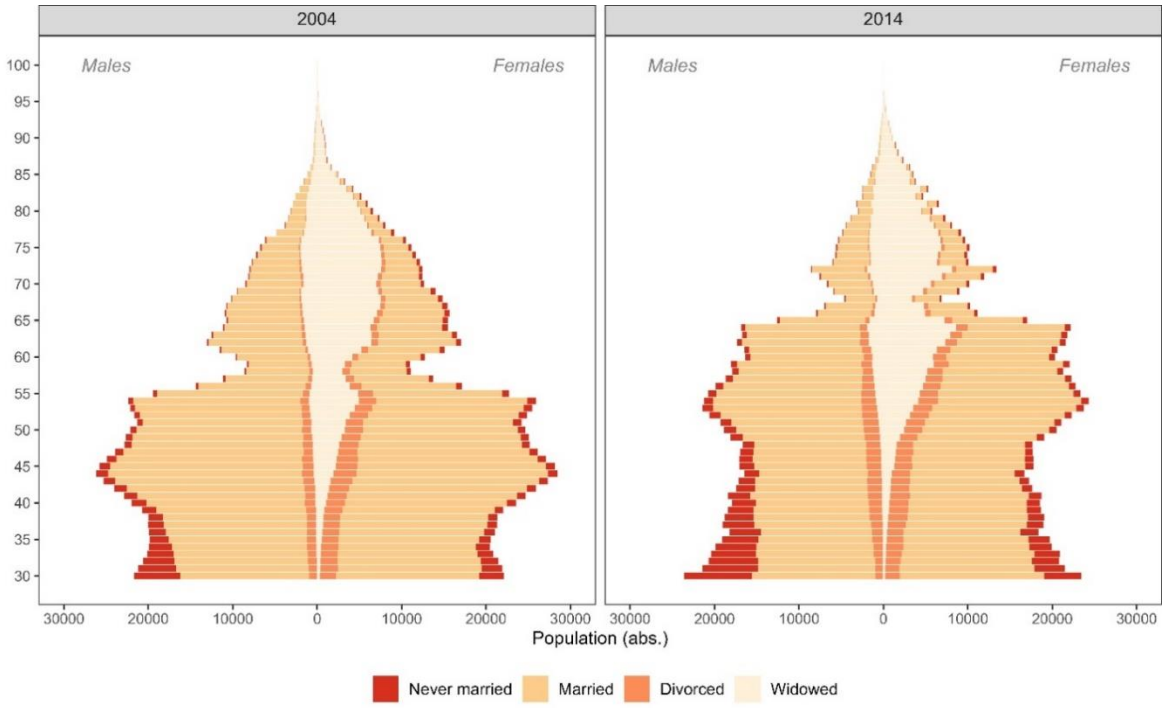


Fig. 3.4 Estimates of the population aged 30 years and over by sex, age and legal marital status in Moldova in 2004 and 2014 (abs.)

Source: author's calculations based on the data from NBS and Penina, Jdanov and Grigoriev [121]

Between the two censuses, the population structure by marital status was relatively constant, with the "married" category 68-73% of the population aged 30 years and over. For all ages, the share of married men (75% in 2014) was higher than married women (61%). Among adults aged 60 years and over, the share of the "widowed" category was almost twice as high in

women (53% in 2014) than in men (20% in 2014). The share of older adults above 80 who lost their partner was more than 80% in females and 50% in males. The "divorced" population represented less than 10% of those aged 30 years and over without marked differences by sex. By contrast, the share of "never-married" men was higher than "never-married" women (10% vs 6% in 2014).

During the census, the level of education was identified according to seven categories in 2004 and eight in 2014. The educational attainment of the deceased in the statistical form No. 3 "Death" corresponded to the classification used in the 2014 census (Tab. 3.2). The population structure by sex, age and level of education under the 2004 and 2014 censuses were applied to the HMD-like population estimates in the corresponding years.

Table 3.2 Levels of education according to the 2004 census, 2014 census and statistical form No. 3 "Death"

Level	2004 census	2014 census	Statistical form No. 3 "Death"
Primary or lower	- illiterate - without education - primary	- illiterate - without education but can write and read - primary	- illiterate - no primary but can read and write - primary
Secondary	- general obligatory - secondary general - secondary specialized	- lower secondary - upper secondary - secondary vocational - post-secondary vocational	- general obligatory - secondary general - secondary specialized
Higher	- higher	- higher	- incomplete university - university

Source: based on NBS data

The analysis of mortality disparities (see section 5.3) was restricted to three broad educational categories presented in Figure 3.5: primary education or lower, secondary education and higher education. Between the two censuses, the distribution of the population aged 30 years and over by educational level evolved more drastically than by marital status. Between 2004 and 2014, the proportion of the population aged 30 years and over with primary or lower education declined from 18% to 9%. The share of the population with a primary or lower education was the most prevalent among older adults, especially women. The proportion of women aged 60 years and over with primary education or lower was reduced from 60% in 2004 to 29% in 2014.

The effect of WW-II on access to education among the cohorts born before and after WW II explains a relatively higher share of the older population with primary education or lower in 2004 (54%) compared to 2014 (24%). In 2004, people aged 60 and over belonged to the cohorts born before and during WW II. In 2014, the older population included the post-war generations that could access secondary and higher education.

The population aged 30 years and over with secondary education increased from 70% in 2004 to 75% in 2014. These changes were most evident among the older population due to the abovementioned factors (38% in 2004 vs 63% in 2014). The population with higher education increased from 13% in 2004 to 16% in 2014. The share of people with higher education was 12% for both sexes in 2004 and 16% a decade later, with minor sex differences. However, among adults aged 30-45, higher education was more prevalent for women (16% in 2004 vs 23% in 2014) than men (12% in 2004 vs 17% in 2014).

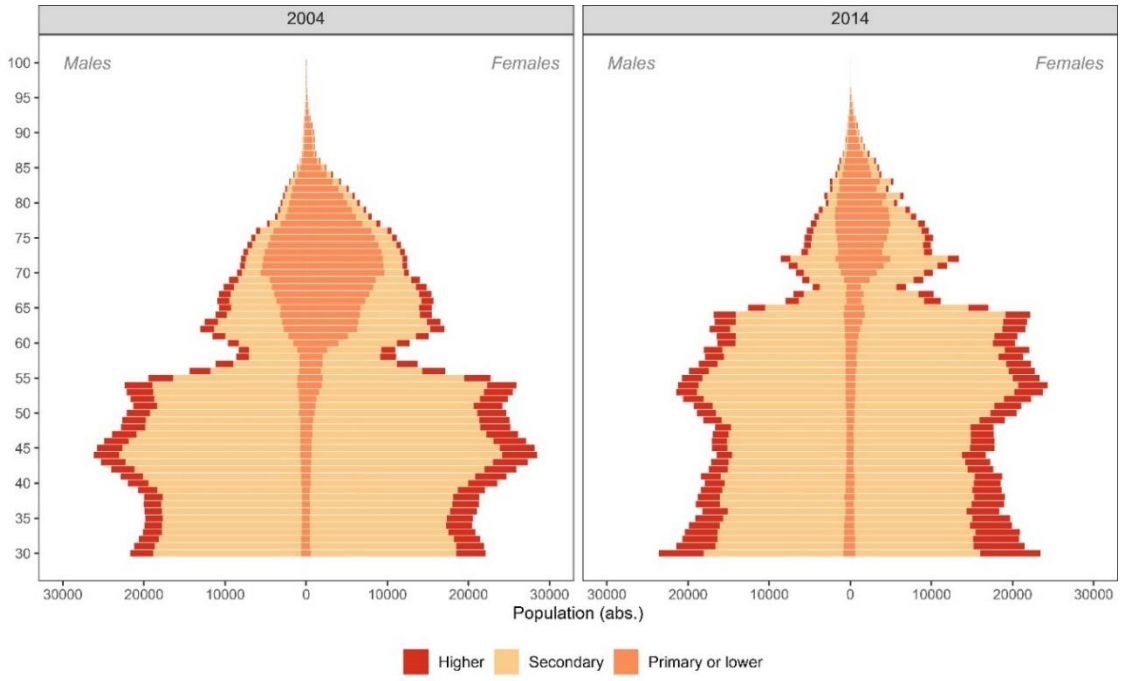


Fig. 3.5 Estimates of the population aged 30 years and over by sex, age and the level of education in Moldova in 2004 and 2014

Source: author's calculations based on the data from NBS and Penina, Jdanov and Grigoriev [121]

3.1.3. Population data at the district level

The NBS provides two types of population counts in the regional profile, according to the 2014 census. The first type refers to the respondent population consisting of the usually resident population and non-residents, i.e., Moldovan citizens who were absent in the country for twelve months or longer at the moment of the census. The second type of the 2014 census data is the usually resident population (without non-residents) after the official adjustments due to incomplete population coverage at the census moment (see section 3.1.1.2).

Figures 3.6 and 3.7 illustrate the population pyramids of 34 administrative units and the municipality of Chisinau for the respondent and usually resident populations according to the 2014 census. For most districts, the respondent population's size corresponded to the estimates of the usually resident population. The exception was ATU Gagauzia, where the usually resident population in working age groups was visibly smaller than the respondent population, including

the temporarily absent population. The situation was entirely different for the municipality of Chisinau, where the population coverage at the moment of the 2014 census was less than 60%. In this case, post-census adjustments concerned almost all age groups, especially the working-age population between the ages of 20 and 40.

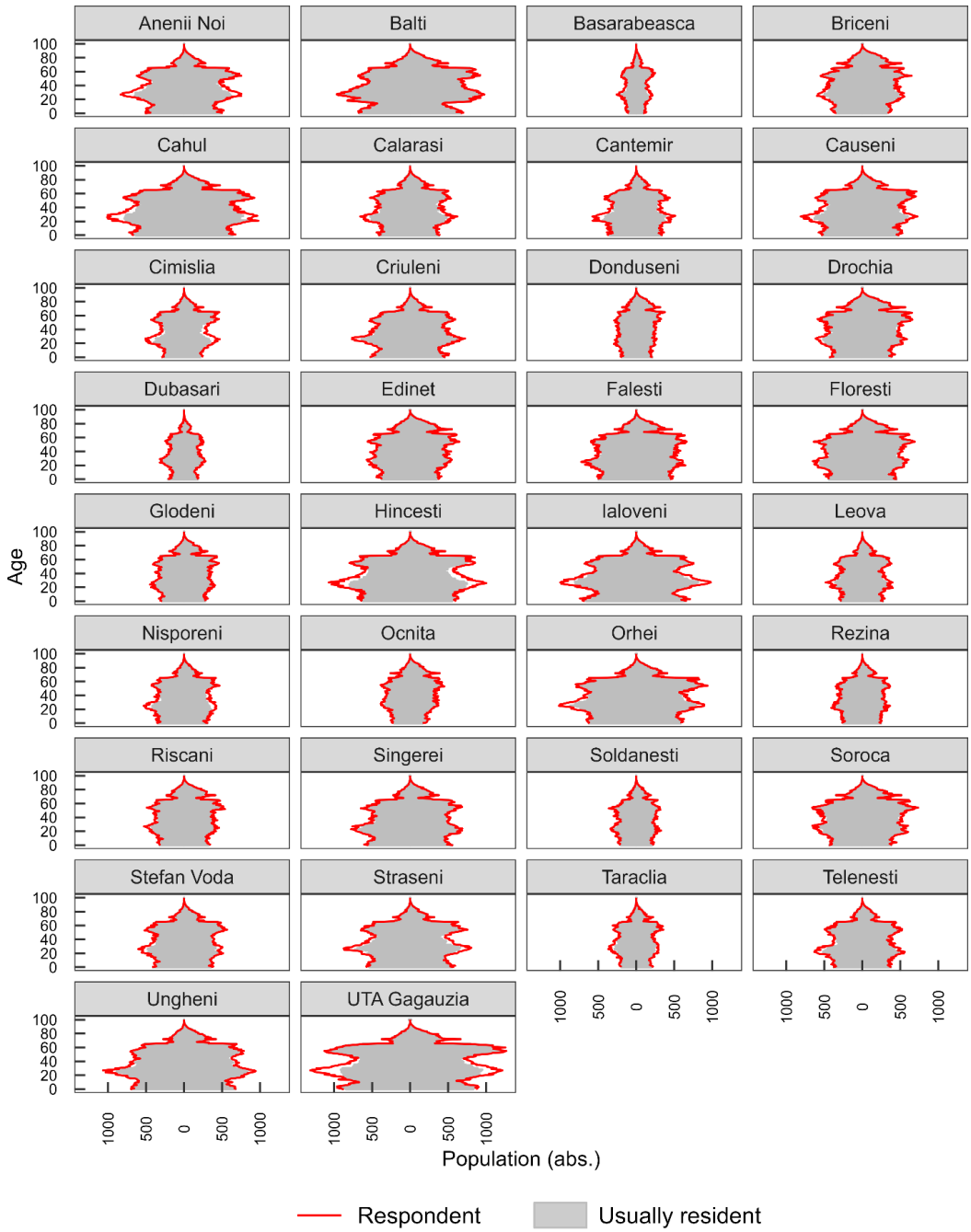


Fig. 3.6 Respondent and usually resident population by sex, age and district according to the 2014 census

Note: non-residents are included in the respondent and excluded from the usually resident population
Source: author's elaboration based on the NBS data

Over 30 years of independence, the distribution of districts by population size changed drastically as a result of a continuing depopulation process (Figure 3.8). The number of districts with more than 100 thousand population was reduced from 9 districts in 1989 to six districts in

2004 and one district (ATU Gagauzia) in 2014. At the same time, the number of districts with less than 60 thousand people increased from 7 districts in 1989 to 16 districts in 2014. In absolute values, the population size of the municipality of Chisinau declined from 715 thousand persons in 1989 to 676 thousand persons in 2014. However, in relative terms, the share of people living in the capital rose from 16% in 1989 to 18% in 2004 and 24% in 2014.

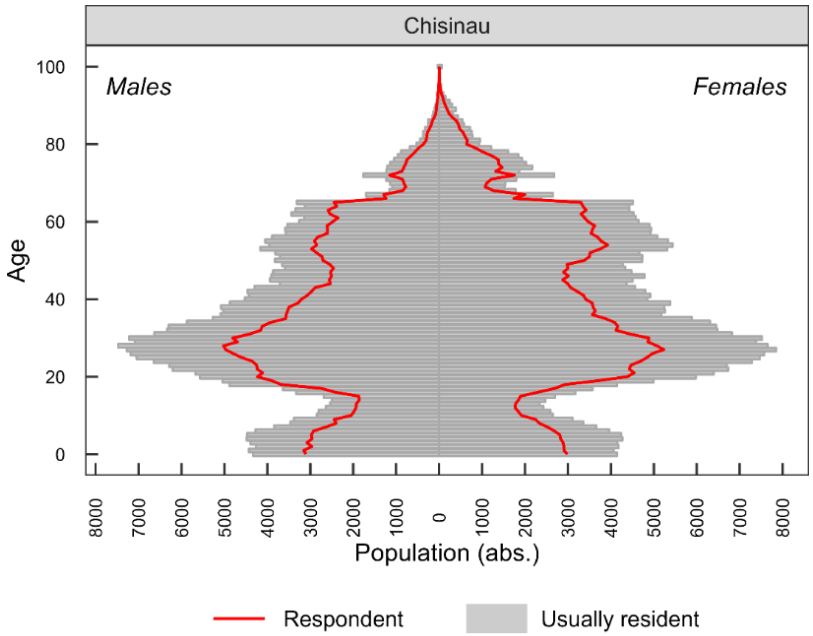


Fig. 3.7 Respondent and usually resident population by sex and age in the municipality of Chisinau according to the 2014 census

Note: non-residents are included in the respondent and excluded from the usually resident population
Source: author's elaboration based on the NBS data

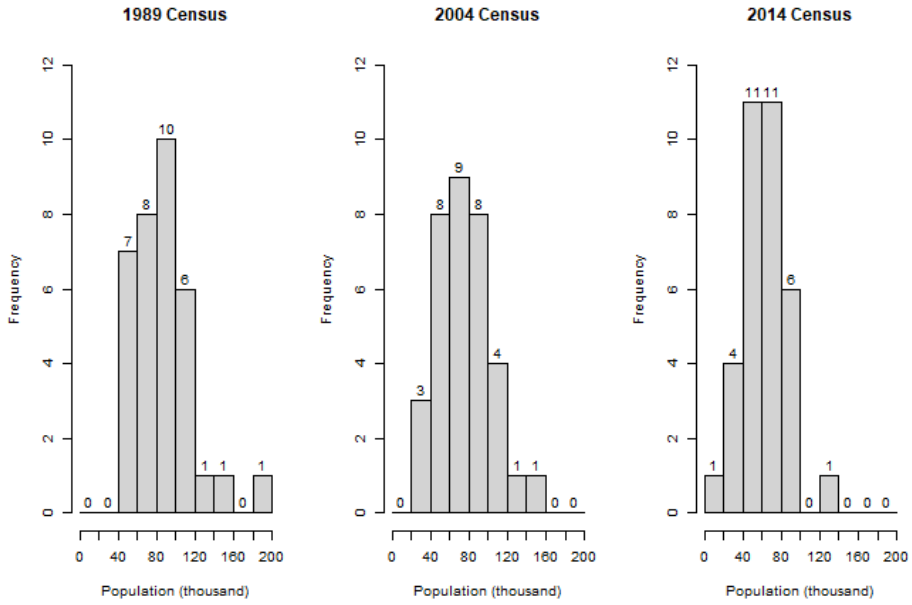


Fig. 3.8 Distribution of districts by population size according to the censuses conducted in 1989, 2004 and 2014 (without the municipality of Chisinau and Transnistria)

Note: The total number of districts is 34. The districts of Cainari and Vulcanesti that existed within the 1989 census were joined with the districts of Causeni and ATU Gagauzia, respectively.
Source: author's calculations based on the NBS data

According to the 2014 census, the average population size across the district was 81 thousand persons (with the municipality of Chisinau) and 63 thousand persons (without the municipality of Chisinau). In 22 of the 35 administrative units, the size of the population varied between 40 and 80 thousand; in 8 districts, it was 80 thousand people and more; in 5 districts, it was less than 40 thousand people. The minimum population size was 19 thousand in the Basarabeasca district, and the maximum was 676 thousand in the municipality of Chisinau.

3.2. Mortality data quality

Two methodological issues can be distinguished concerning mortality data quality at the national level. The first is related to the quality of death registration in infancy and at older ages, especially problematic in the 1960s and 1970s. The second relates to reconstructing the continuity of the time series of deaths interrupted by periodic changes in the classification of causes of death. A special reconstruction method proposed by Meslé and Vallin was applied to eliminate discontinuities in the mortality series by cause of death.

The given methodological problems regarding the data analysed at the sub-national and district levels can be partly omitted. First, the problem of incomplete death registration in infancy during the period of independence is of minor importance, and the quality of death registration at older ages has been satisfactory since the 1980s. Second, the analysis is limited to the leading causes of death that are considered robust to changes in cause-of-death classification. The only exception is the growth in mortality from Senility and ill-defined causes of death in the 1990s, which requires special treatment of the raw data at the sub-national and district levels.

3.2.1. Assessing age-specific mortality profile at the national level

Assessing the mortality rates by age can help to estimate the data quality and find possible under-registration of deaths at specific age groups. Special attention must be paid to infant mortality and old-age mortality.

3.2.1.1. Infant mortality correction

Assessing infant mortality trends in Moldova since World War, two types of underestimation of infant deaths can be distinguished. The first refers to an under-registration of infant deaths in the country until the mid-1970s. The second is related to the problem of the definition of live births.

In the FSU countries, including Moldova, the increase in infant mortality was registered in the 1970s. Unlike Ukraine or Russia, where the infant mortality rate increased moderately in the early 1970s, Moldova saw a sudden jump in 1973. Between 1972 and 1973, the increase in infant mortality rate was more than 50%, from 24.5 per 1000 in 1972 to 36.8 per 1000 live births. This sudden growth is connected to the new TCSU instructions introduced in the FSU on registration

practices for infant deaths. The new instructions on infant death registration were closely related to introducing a new form of the perinatal death certificate in 1974 and new statistical forms on medical causes of death (form 5d) tabulated based on the perinatal death certificate.

The growth in infant mortality in 1973 was much more pronounced in rural areas than in urban areas due to the much higher under-registration of infant deaths in rural than urban areas. If in urban settings, infant mortality increased by 25% (from 24 per 1000 in 1972 to 30.5 per 1000 in 1973), then in rural areas by 60% (from 24.7 per 1000 in 1972 to 39.9 per 1000 in 1973). Improved registration led to a sharp increase in early neonatal mortality (0-6 days), whose level rose suddenly by 120% in 1973. Late neonatal mortality (7-28 days) also increased sharply (+110%).

The increase in post-neonatal mortality (29 days – 11 months) was much less than the neonatal component (+38%) but contributed considerably to the increase in overall infant mortality (Figure 3.9). The sharp growth in early neonatal mortality resulted from improved registration of deaths in the first days of life by distinguishing between early neonatal deaths and stillbirths. It is also possible that the new directives on accurate registration of infant deaths also contributed to better registration of late neonatal and even post-neonatal deaths.

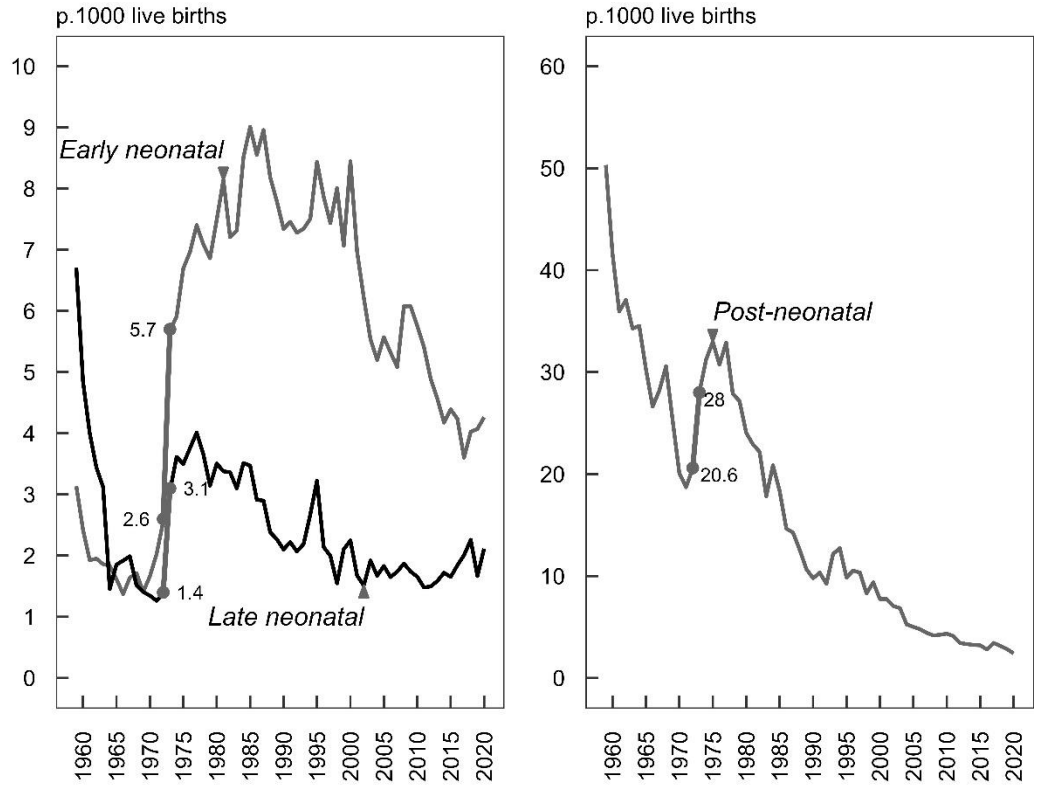


Fig. 3.9 Early and late neonatal mortality (panel A) and post-neonatal mortality (panel B) in Moldova in 1959-2020

Source: author's calculations based on the NBS data

To re-estimate infant deaths for the years before 1973, we hypothesised that the sudden increase in 1973 was attributed to improved registration of infant deaths. A more moderate rise in

infant mortality until the late 1970s likely reflects a further improvement in infant mortality registration. On the other hand, the moderate rise in infant deaths in the late 1970s, including for the post-neonatal component, may also point to real health deterioration, especially in rural areas. A minimum adjustment was undertaken since there is no obvious way to separate the effect of artificial growth resulting from improved registration from the actual health deterioration. Our study corrected the sudden rise in infant deaths in 1973 without modifying the more moderate increase in subsequent years.

The correction of the infant mortality rate for the years prior to 1973 was made by sex and place of residence (urban/rural) for neonatal (early and late) and post-neonatal components. Two different approaches were used. The first was an "absolute correction" when the absolute difference between the 1972 and 1973 rates was applied to all the preceding years. This method of correction was used for early and late neonatal mortality rates. The second was a "relative correction" when a relative difference in mortality rates between 1972 and 1973 was used. This method was applied for post-neonatal mortality rates. Figure 3.10 illustrates the trends in neonatal, post-neonatal and infant mortality rates corrected for years prior to 1973 (*correction 1*) using the combined correction method (absolute correction for neonatal mortality and relative correction for post-neonatal mortality).

After the improved registration in the 1970s, infant mortality in Moldova remained slightly under-estimated during the Soviet period and after independence. This under-registration of infant deaths was linked to the definition of live birth used in Moldova, which differed from the standard definition recommended by the World Health Organization (WHO). According to WHO, all new-borns showing any sign of life must be registered as born alive, disregarding their gestational age or weight. In Moldova, a so-called Soviet definition of live birth was used until 2008. This definition considered infants as live-born only if they had a gestational age of 28 weeks or longer, weighed 1000 grams or more, or the body length was more than 35 centimetres.

According to a new definition of live birth introduced in 2008, infants presenting any signs of life are considered live-born if they have a gestational age of at least 22 weeks or their weight is 500 grams or more. The new definition caused a 20% increase in the early neonatal mortality rate (5.1 per 1000 in 2007 vs 6.1 per 1000 in 2008). In the Baltic countries, the transition from the Soviet definition of live birth to the WHO recommendations in the early 1990s resulted in a 50% increase in early neonatal mortality [167]. Based on the experience of the Baltic states, we assumed that the transition to a new definition of live birth was incomplete in Moldova in 2008. For all years before 2008, a 50% correction of early neonatal mortality was produced (*correction 2* in Figure 3.10). For 2008 and 2009, early neonatal death rates were interpolated, assuming that the

transition to a new live birth definition was incomplete during these two years. From 2010 onwards, no infant mortality correction was made.

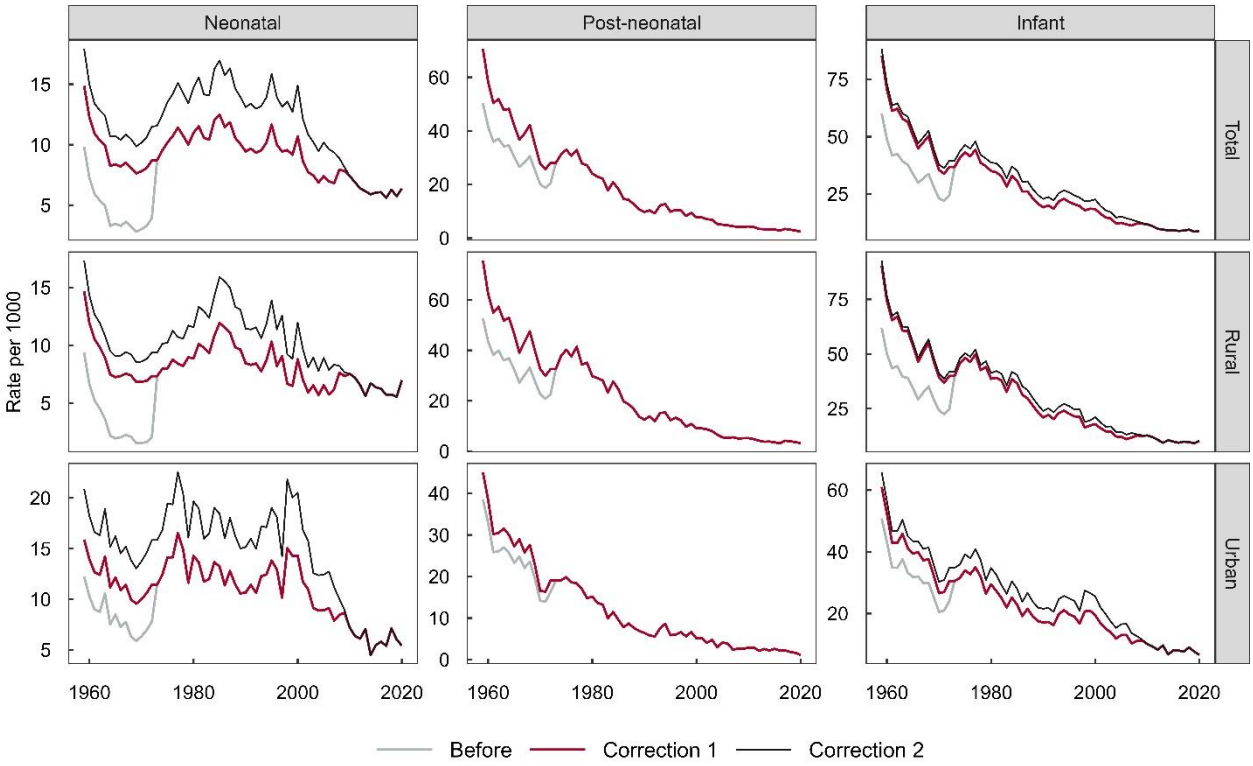


Fig. 3.10 Trends in neonatal, post-neonatal and infant mortality rates before and after two corrections in Moldova in 1959-2020

Source: author's calculations based on the data from NBS and Penina, Meslé and Vallin data [113]

In such a way, based on the two infant mortality corrections, "missing" or unregistered deaths were estimated. The "missing" infant deaths after the first adjustment (prior to 1973) were redistributed proportionally between all causes of the reconstructed time series of infant deaths. The "missing" deaths estimated after the second adjustment (prior to 2010) were redistributed proportionately only between the perinatal conditions and congenital malformations (see section 3.2.2). The number of live births was also re-assessed after each infant mortality correction.

3.2.1.2. Old-age mortality correction

There are two distinct problems with Soviet statistics on old-age mortality. The first problem concerns the official population estimates that are unreliable at older ages, as discussed earlier (see section 3.1.1.1). This study used the intercensal population estimates produced according to the HMD methodology for 1959-2003. Population counts for the age groups 70 years and over were computed using the extinct cohort method based on the distribution of deaths in preceding years. Nevertheless, old-age mortality rates computed based on HMD-like population estimates are suspiciously low in Moldova compared to Western countries in the 1960s and 1970s. For example, the life expectancy at age 80 in Moldova compared to Sweden is about two years higher in males and females in 1960 [121]. The underestimation of old-age mortality rates in the

1960s and 1970s is the second data quality problem resulting from incorrect age registration at death, so-called age heaping in deaths. The misreporting of age at death among the elderly is a typical data quality problem in the FSU countries, including Moldova.

This study corrected the underestimated old-age mortality rates using the Coale-Demeny model life tables [168]. The model life tables consist of four families (North, South, West and East), each including 25 levels. We used the five-year moving average of the corrected infant mortality rates (see section 3.2.1.1) to select the appropriate level in one of the four families. Suppose we had used middle-aged mortality as a key to selecting a level. In that case, it could have caused misleading results since exceptionally high mortality among middle-aged persons is a specific characteristic of the mortality pattern in Moldova and other FSU countries.

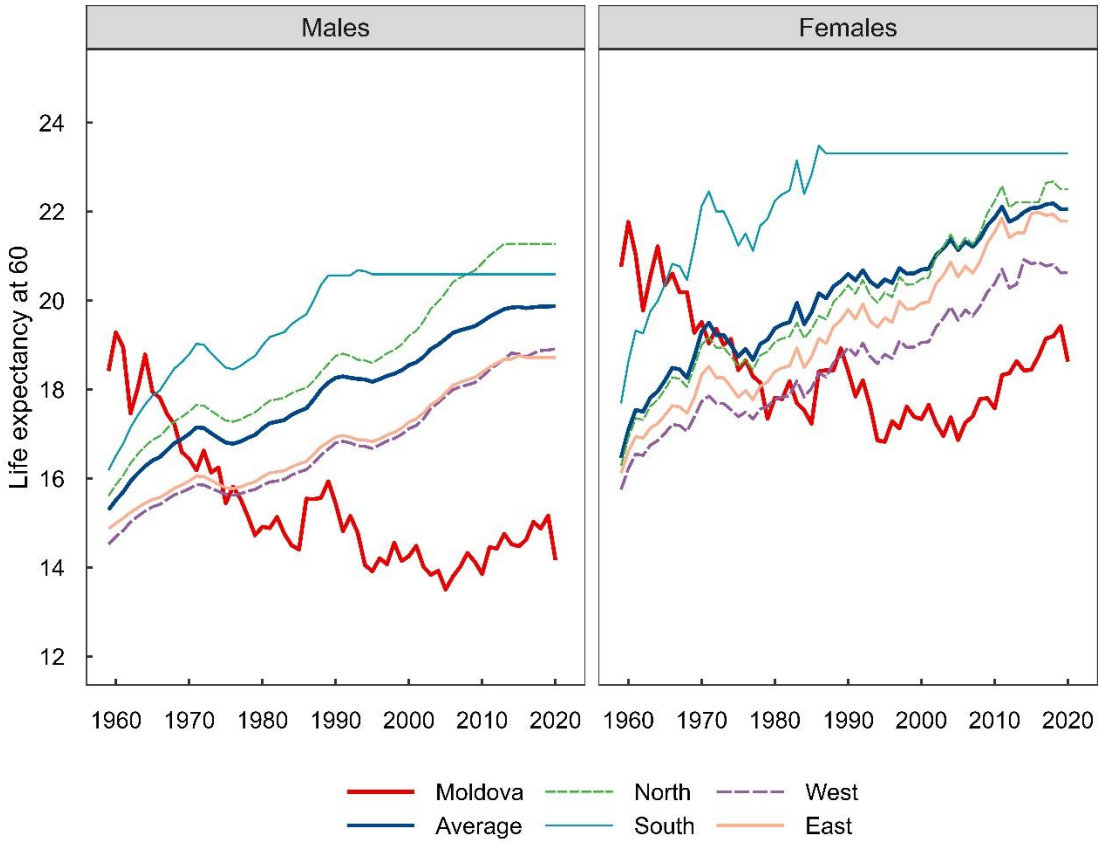


Fig. 3.11 Life expectancy at age 60: observed values in Moldova and values from Coale and Demeny models corresponding to the same level of infant mortality rate in 1959-2020

Note: If the observed q_0 is lower than the model q_0, the model e_{60} corresponds to the last level.
Source: author's calculations based on the NBS and NAPH data

In Figure 3.11, the observed life expectancy at age 60 is compared to life expectancy at age 60 retrieved from the four regional models and their average in 1959-2020. In 1960, the life expectancy at age 60 in Moldova was 4.7 years higher in women and 3.8 years higher in males than the model. In 1965, the recorded life expectancy at age 60 was 2.1 years higher in females and 1.5 years higher in males compared to the average model. The difference persisted until 1975 in women and 1969 in men.

The situation has been reversed since the 1980s. Whatever the regional model we selected, the model life expectancy at age 60 was always higher than the observed values. In 1980, the average model was 2.2 years higher in males and 1.5 years higher in females than in Moldova. In 2020, the gap widened to 5.7 years in males and 3.5 years in females.

Like other FSU countries, Moldova has been facing a severe population health crisis since the mid-1960s, mainly affecting the adult population, including older adults. The situation observed after the 1980s was anticipated. By contrast, the unusual observation in the 1960s and 1970s was due to old-age mortality underestimation and required the corresponding corrections.

We computed new age-specific rates for older age groups using the average life expectancy at age 60 of the four regional models. Then, the life tables were re-assessed for 1959-68 for men and 1959-70 for women. Among women, the difference between the average model and the observed life expectancy at age 80 was maintained even after correcting life expectancy at age 60. We corrected female life expectancy at age 80 and over until 1977. New age-specific death rates were multiplied by the population counts, and new death counts were obtained. The "missing" deaths, i.e., the difference between the recorded and estimated deaths, were redistributed proportionally among all causes.

3.2.1.3. Re-assessment of life tables since 1959

Abridged life tables were calculated by sex for 1959-2020. Figure 3.12 shows life expectancy at birth before mortality corrections, after the first infant mortality adjustment (prior to 1973), the second infant mortality adjustment (prior to 2010) and the old-age mortality correction.

After the first infant mortality correction, life expectancy at birth was reduced by 1.7 years in men and 1.9 years in women in 1959. The effect of the correction declined progressively over time and was 0.9 years in 1972. The second infant mortality correction produced for the 1959-2008 period had a minor effect on life expectancy at birth, ranging between 0.2 and 0.3 years. The adjustment of life expectancy at age 60 had a much more significant effect on life expectancy in females than males, especially in the late 1950s and early 1960s. In 1960, this correction diminished life expectancy at birth by 2.8 years in males and 3.8 years in females. Among males, the impact of the old-age mortality correction decreased gradually till the late 1960s (1.12 years in 1965 and 0.3 years in 1968). Among females, the adjustment of life expectancy at older ages affected life expectancy at birth until 1978 (0.2 years in 1975). The maximum combined effect of two infant mortality and old-age mortality correction on life expectancy at birth was 4.5 years in men and 5.6 years in women in 1960. In 1965, the combined effect was 2.5 years in males and 3.1 years in females.

The corrected infant and old-age death rates considerably reduced the life expectancy at birth in the 1960s and 1970s and drastically altered the trend (Figure3.12). The infant mortality correction before 1973 smoothed the observed decline in life expectancy at birth between 1965 and 1985 by eliminating a sudden drop in 1973. The old-age mortality adjustments shifted the turning point in life expectancy trends from the mid-1960s to the early 1970s.

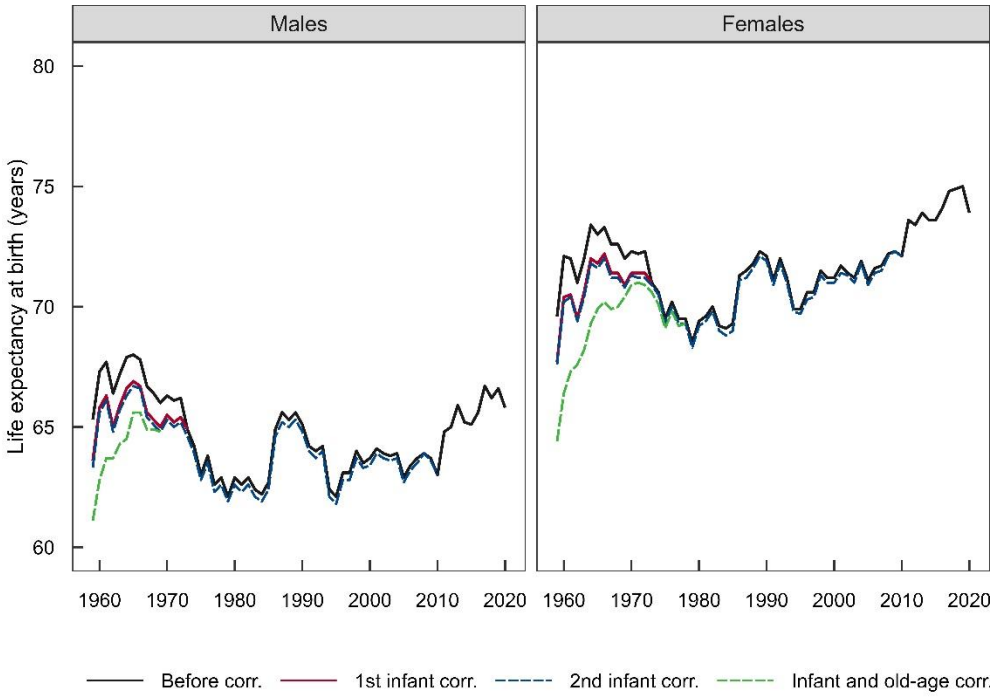


Fig. 3.12 Trends in life expectancy at birth before and after infant and old-age mortality corrections in Moldova in 1959-2020 by sex

Note: Life expectancy at birth before corrections were calculated based on the intercensal (1959-2013) and postcensal (2014-2020) population data; the first infant correction: 1959-1972; the second infant correction: 1959-2009; old-age mortality correction: 1959-1968 in males and 1959-1979 in females.
Source: author's calculations based on the NBS and NAPH data [17]

Annexe 1 provides estimates of life expectancy at birth before and after mortality corrections.

3.2.2. Reconstruction of the continuity of mortality series according to ICD-10 in Moldova in 1965-2020

Analysing long-term mortality trends is complicated by disruptions in the death time series due to periodic changes in the classification of causes of death. In rare cases, the statistical office performs a double codification of causes of death over one or two years of transition from one classification to another. This practice allows applying the observed transition coefficients to redistribute the deaths classified under an old classification into the items of a new classification. In most countries, including Moldova, such a double classification is not practised, and the transition coefficients must be computed ex-post. In our study, we used an original method developed by Meslé and Vallin to reconstruct the mortality series in France [18, 40].

This method was adopted for the Moldovan data for the 1965-2020 period. Four transitions were performed: 1) from the 1965 Classification to the 1970 Classification; 2) from the 1970 Classification to the 1981 Classification revised in 1988; 3) from the 1988 Classification to ICD-9; 4) from ICD-9 to ICD-10.

This section briefly describes the reconstruction method based on the empirical Moldovan data. More attention is given to the first transition. Each transition from an old classification to a new one includes three steps: correspondence tables, fundamental associations of items and transition coefficients. Technical annexes providing detailed information on each transition (correspondence tables, FAI and transition coefficients) are available online https://github.com/PeninaOlga/MortalityTrendsByCausesOfDeath/tree/main/Technical%20Annexes.

The database on the reconstructed mortality series for Moldova was integrated into the international database The Human Cause-of-Death Database https://www.causesofdeath.org/cgi-bin/main.php, coordinated by the French Institute for Demographic Studies (INED) and the Max-Plank Institute for Demographic Research from Germany, Rostock (Annexes 16 and 17).

3.2.2.1. Transition from 1965-SC to 1970-SC

For the first transition, we had death time series classified under the 1965 Soviet Classification (1965-SC) for 1965-1969 and the 1970 Soviet Classification (1970-SC) for 1970-1980. After the reconstruction, we produced continuous time series by sex and age classified under 1970-SC for 1965-1980. Further, the three steps of the reconstruction are presented.

A) Correspondence tables

A correspondence table (CT) between items of the old classification (1965-SC) and items of the new classification (1970-SC) was constructed based on the medical definitions. The first table presents the correspondence between old and new items, but the second shows the correspondence between the new and old items. Annexe 2 shows the extract of these two tables. At this step, the medical content of the causes of death is considered.

B) Fundamental associations of items

Based on the correspondence table, we produced fundamental associations of items (FAIs). FAI includes old and new items with the same medical content and deaths in the transition years (in our case, 1969 and 1970). Depending on the relationship between old and new items, four types of FAI can be identified: type 1:1 or simple, type 1:n or splitting, type n:1 or merging and type n:n or complex. Table 3.3 provides examples of each type. Simple, splitting and merging types are the most straightforward situations. A complex FAI №137 was produced for some accidents. In this FAI, four items from 1965-C (195, 199, 206 and 2010) were related to three from 1970-C (177,

181 and 185) based on the correspondence table. Deaths classified under old items 195 and 199 were attributed totally (T) to new item 181. Deaths under old item 210 were also related totally to new item 185. Deaths coded under old item 206 were related partially (P) to all three new items (177, 181 and 185).

Table 3.3 FAIs 44, 106, 121 and 137 built between 1965-SC and 1970-SC

1970-SC		Number of deaths		1965-SC		
	Title	1970	1969	Item	T/P	Title
a) FAI 44, type 1:1 (simple)						
48	Malignant neoplasm of stomach	565	616	52	T	Malignant neoplasm of stomach
44	**48**	**565**	**616**			**52**
b) FAI 106, type n:1 (merging)						
142	Abortions out of the hospital and unspecified	23	7	159	T	Abortion out of the hospital without mention of toxaemia or sepsis
			15	161	T	Abortion out of the hospital with sepsis
			1	163	T	Abortion out of the hospital with toxaemia without mention of infection
106	**142**	**23**	**23**			**159, 161, 163**
c) FAI 121, type 1:n (splitting)						
160	A motor vehicle traffic accident, excluding occupational	357	528	186	P	Motor vehicle accidents, excluding occupational
161	A motor vehicle traffic accident involving a collision with a pedestrian	140	"	186	P	
121	**160, 161**	**497**	**528**			**186**
d) FAI 137, type n:n						
177	Accidents caused by electric current, excluding occupational	92	346	206	P	Other accidental causes, excluding occupational
181	Other accidents, excluding occupational	278	"	206	P	
			9	195	T	An accident caused by machinery, excluding occupational
			20	199	T	An accident caused by a hot substance, corrosive liquid, steam or radiation, excluding occupational
185	Injury undetermined, whether accidentally or purposely inflicted	32	"	206	P	
			5	210	T	Injuries due to war operations
137	**177, 181, 185**	**402**	**380**			**195, 199, 206, 210**

Note: T/P – Deaths counts are transferred from an old item to a new one totally (T) or partially (P)
Source: author's calculations based on the data of TCSU of the USSR (archived data provided by INED) [17].

The fundamental associations of items constructed based on the medical correspondence of items were checked for statistical coherence. For each association, we checked if the total death number under the old classification was close to the total death number under the new classification. To ensure statistical consistency, we examined the annual trends in standardised

death rates for each FAI in 1965-1980 under the 1965 and 1970 classifications. We examined if changes in death counts in 1969-1970 were consistent with annual trends for the whole period. We used a method specially developed by Camarda and Pechholdová that predicts mortality series according to the statistical significance level [132]. Figure 3.13 presents the statistical consistency verification results for FAIs in Table 3.3. The absence of the red flag (upper right corner) indicates that the FAI is statistically consistent over the transition years.

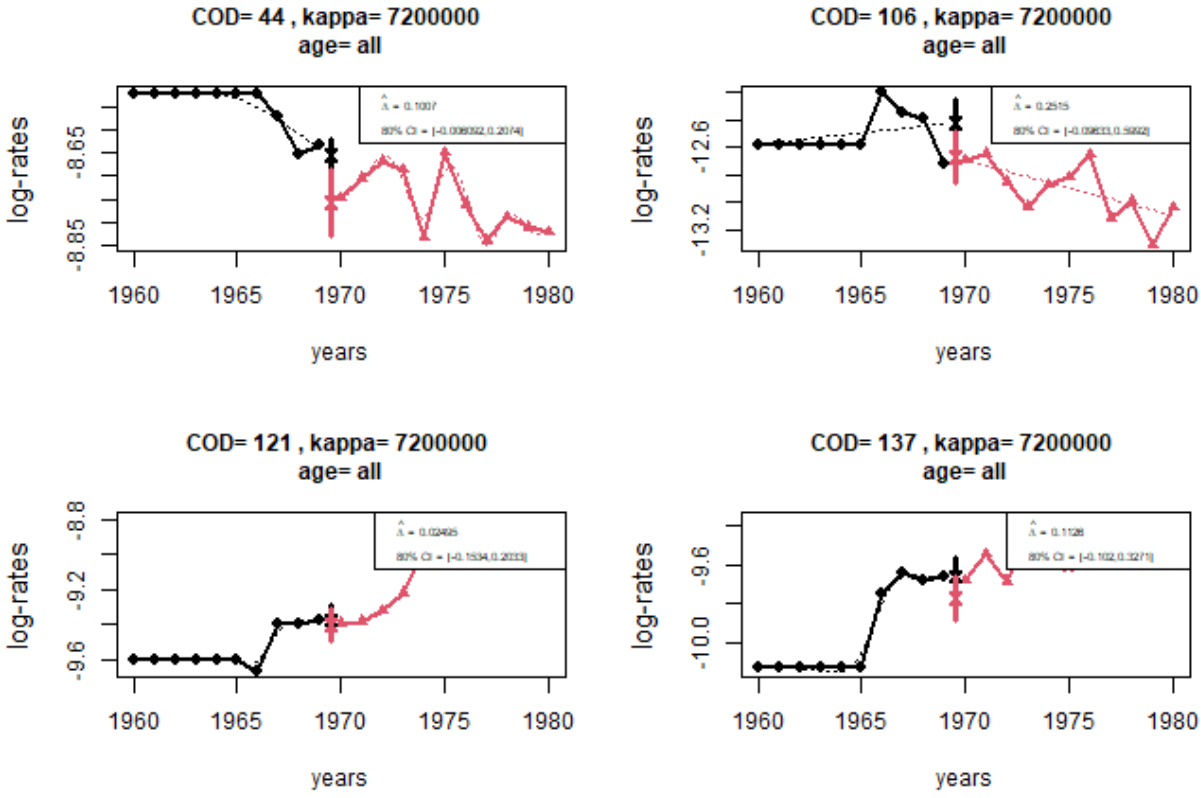
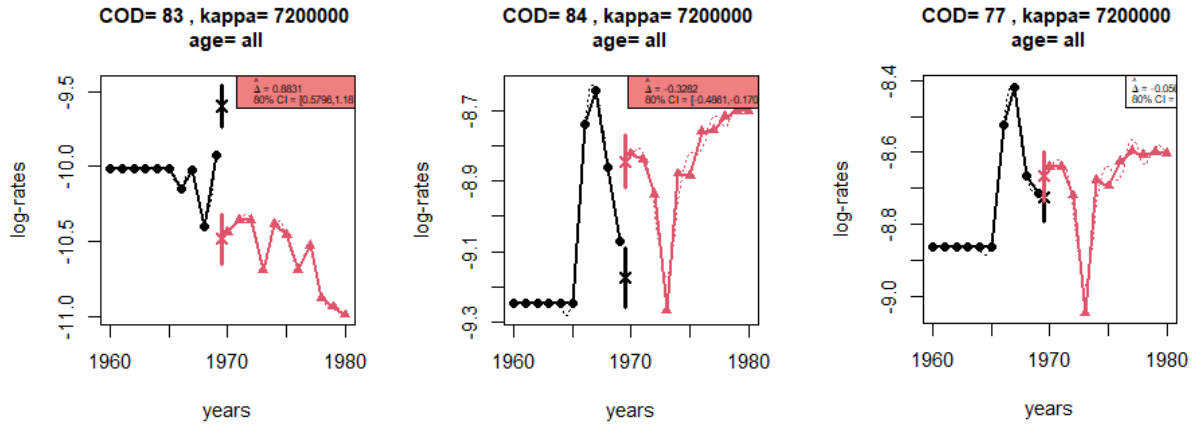


Fig. 3.13 Checking the statistical consistency of FAIs 44, 106, 121 and 137 built between 1965-SC (1965-1969) and 1970-SC (1970-1980), Moldova (log rate)

Note: Death counts in 1960-1964 were added artificially to ensure a proper function of a statistical package [132]
Source: author's calculations based on the data of TCSU of the USSR (archived data provided by INED) [17]

However, for some FAIs, an interruption in the time series was detected in the transition year. This situation indicated a discrepancy between the medical content of the items and the codification practices. When such a disruption was detected for one association, finding the item corresponding to the actual coding practices was necessary. For example, two simple FAIs referring to acute myocardial infarction with hypertension (FAI 83) and without hypertension (FAI 84) were constructed based on the medical correspondence tables. However, the continuity of the mortality series for these two associations of type 1:1 was not statistically significant (red flag in the upper right corner in Figure 3.14, panel A). The two simple associations were joined in a complex one to eliminate the disruptions detected in the transition years. The subsequent statistical

verification did not check the disruption (Figure 3.14 panel B). The discontinuity in the mortality series resulted from changes in coding practices for acute myocardial infarction after the transition from SC-1965 to SC-1970.



Panel A) *Panel B)*

Fig. 3.14 Checking the statistical consistency of FAIs referring to acute myocardial infarction with and without hypertension according to 1965-SC (1965-1969) and 1970-SC (1970-1980) before (panel A) and after (panel B) corrections, Moldova (log rate)

Note: Death counts in 1960-1964 were added artificially to ensure a proper function of a statistical package [132]
Source: author's calculations based on the data of TCSU of the USSR (archived data provided by INED) [17]

While the automation procedure provided an excellent tool for identifying the discontinuities, we could not completely replace the simple classical visualization of mortality trends [169]. In some cases, we had to accept FAIs with statistical discontinuities.

Table 3.4 FAIs and death counts by type based on the medical correspondence (M) and statistical correspondence (S). Transition from 1965-SC to 1970-SC

Association type	Associations				Deaths (in 1970)			
	Number		Proportion, %		Number		Proportion, %	
	M	S	M	S	M	S	M	S
type 1:1	117	99	75	70	14939	7014	56	26
type 1:n	7	9	5	6	1325	1019	5	4
type n:1	17	14	11	10	522	162	2	1
type n:n	14	19	9	14	9808	18399	37	69
Total	155	141	100	100	26594	26594	100	100

Source: author's calculations based on the data of TCSU of the USSR (archived data provided by INED) [17]

Table 3.4 provides the distribution of FAIs by type and number of deaths built on the medical and statistical correspondence for the first transition. We produced 155 FAIs relying on the medical correspondence of items, i.e., before the statistical checking. Most associations belonged to the simple type (117 associations or 75%). The number of simple associations based on statistical correspondence was reduced (99 or 70%) since simple associations were merged into complex ones. The distribution of deaths in a transition year according to the type of association followed more essential changes after the statistical verification. Simple FAIs covered 56% of the

total deaths in 1970 based on medical correspondence and 26% based on statistical correspondence. At the same time, the death counts involved in the complex associations increased from 37% to 69%. After checking FAIs for their statistical consistency, 9% of FAIs belonged to type 1:n and 14% to type n:1, but these associations concerned a small proportion of deaths (5%).

The new classification in 1970 introduced some significant changes in cause-of-death codification independent of the medical definitions of items. It was especially evident for diseases of the circulatory system. A complex association 74 concerning cardiovascular diseases covered 90% of all cardiovascular deaths and 40% of the total deaths in 1970. When the statistical continuity of FAIs was ensured, the next step was calculating the transition coefficients.

C) Transition coefficients

Transition coefficients were computed in the framework of an association to redistribute deaths classified under an old classification (1965-SC) among items of a new classification (1970-SC). For FAI of type 1:1, 100% of deaths under an old item were transferred to a new item. The same technique was used for FAI of type n:1. In the case of type 1:n, deaths coded under a single item in the old classification were redistributed according to the observed proportions in a new classification.

Table 3.5 Double classification cross-table for FAI 137 built between 1965-SC and 1970-SC (a) and transition coefficients (b)

A)

1970-SC	*1965-SC*				
	206	195	199	210	Deaths in 1970
177	*92*				92
181	*247*	*10*	*21*		278
185	*27*			*5*	32
Estimated deaths in 1970	*366*	*10*	*21*	*5*	402
Observed deaths in 1969	346	9	20	5	380

B)

1970-SC	206	195	199	210
177	25.1			
181	67.6	100.0	100.0	
185	7.3			100.0
Total	100.0	100.0	100.0	100.0

Note: The estimated numbers are shown in italic
Source: author's calculations based on the data of TCSU of the USSR (archived data provided by INED) [17]

In the case of complex associations (type n:n), transition coefficients were derived from a double classification cross-table produced for each FAI. Table 3.5 (panel A) gives an example of such a table for FAI 137 presented in Table 3.3. The shaded cells mean the absence of correspondence between old and new items. We assumed that the distribution of deaths in 1970 across the old items (estimated deaths in 1970) was proportional to the distribution observed in 1969. Knowing the distribution of deaths by rows and columns, the deaths inside the cross-table

were redistributed. The transition coefficients were computed from the completed cross-table (panel B of Table 3.5). In our example, 100% of deaths codified under old items 195 and 199 were transferred to new item 181. Deaths coded under old item 206 were redistributed between new items 177, 181 and 185 with coefficients 25.1%, 67.6% and 7.3%.

The reconstructed time series of deaths under 1970-SC for 1965-1969 were prolonged with the observed time series for 1970-1980. In such a way, a continuous series of deaths classified according to 1970-SC was produced for 1965-1980. Figure 3.15 demonstrates annual trends in standardised death rates reconstructed under 1970-SC for items involved in FAI 137 presented in Table 3.3. The reconstructed time series were checked for statistical consistency in the same manner as FAIs.

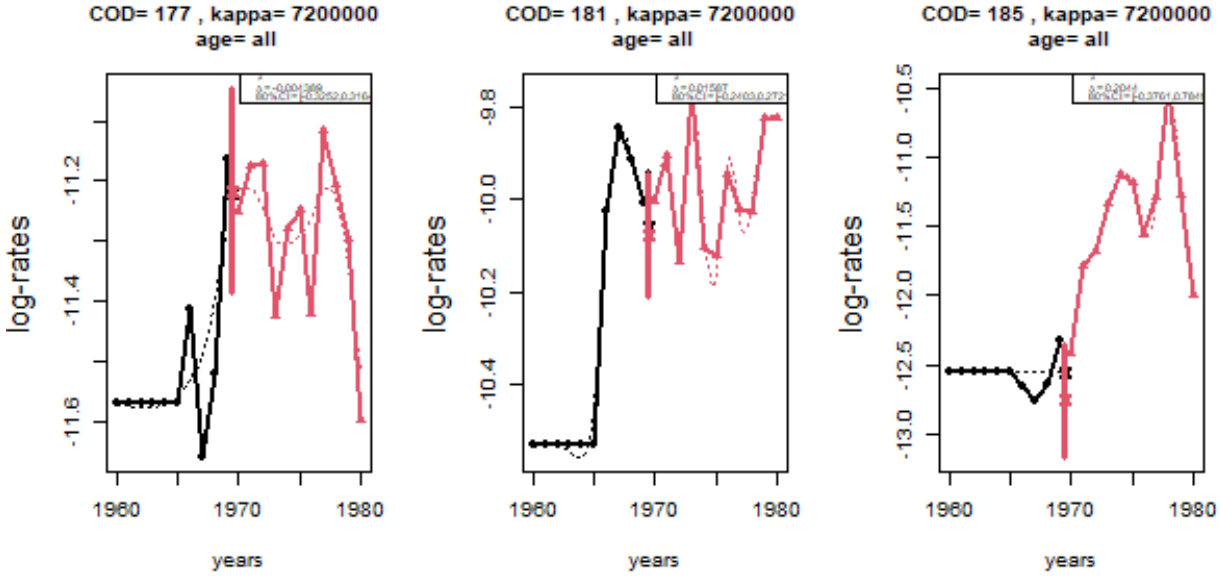


Fig. 3.15 Checking the statistical consistency of items 177, 181 and 185 from FAI 137 reconstructed under 1970-SC for 1965-1980, Moldova (log rate)

Note: Death counts in 1960-1964 were added artificially to ensure a proper function of a statistical package [132]
Source: author's calculations based on the data of TCSU of the USSR (archived data provided by INED) [17]

The statistical continuity of the reconstructed series was checked for the total of death and by main age groups (less than one year, 1-59 years and 60 years and over). In 20 out of 210 items, the transition coefficients were adjusted by age.

3.2.2.2. Transition from 1970-SC to 1981-SC revised in 1988

During the second transition, we reconstructed the death time series under 1970-SC in 1965-1980 according to the items of 1981-SC. Then, we prolonged the reconstructed mortality series with the observed series under 1981-SC for 1981-1987. In such a way, we produced continuous series for 1965-1987 according to 1981-SC. The procedure of the reconstruction was the same as for the first transition.

Table 3.6 presents the FAIs by type with corresponding death counts produced during the second transition. The proportion of FAIs of type 1:1 was the biggest, accounting for 90% and 84% of associations based on the medical and statistical correspondences. After verifying statistical consistency, the proportion of deaths attributed to simple associations decreased from 88% to 25%.

Conversely, the number of complex associations based on medical and statistical correspondence was small in absolute and relative terms. However, after the statistical verification of FAIs, the proportion of deaths involved in complex associations increased from 1% to 69%. Transition coefficients for 19 out of 185 items were adjusted by age.

Table 3.6 FAIs and death counts by type based on the medical correspondence (M) and statistical correspondence (S). Transition from 1970-SC to 1981-SC

Association type	Associations				Deaths (in 1981)			
	Number		Proportion, %		Number		Proportion, %	
	M	S	M	S	M	S	M	S
type 1:1	158	129	90	84	36683	10265	88	25
type 1:n	8	6	5	4	3809	1935	9	5
type n:1	7	6	4	4	514	466	1	1
type n:n	2	13	1	8	470	28810	1	69
Total	175	154	100	100	41476	41476	100	100

Source: author's calculations based on the data of TCSU of the USSR (archived data provided by INED) and NBS [17]

In 1988, a particular amendment concerning accidental causes of death was adopted. Under 1981-SC, every accident, with a few exceptions, was presented as occupational and non-occupational death. In 1988, this rule was cancelled. We reclassified deaths from accidents by merging the two items of the 1981-SC (occupational and non-occupational) into one item of the 1988-SC.

3.2.2.3. Transition from 1988-SC to ICD-9

In 1991-1995, NBS used 1988-SC to codify causes of death, but NAPH adopted ICD-9. This situation allowed us to estimate the transition coefficients based on two data sources *a priori*. First, 4-digit ICD-9 data were aggregated into 214 groups of causes of death. Next, the annual trends in deaths under 1988-SC and ICD-9 were compared for 214 items. Figure 3.16 shows annual trends in deaths from *"Infectious renal diseases"* (Item 590 under ICD-9 and 130 under 1988-SC) and *"Other nephritis and nephrosis, including nephrotic syndrome"* (Items 581-589 under ICD-9 and Item 129 under 1988-SC). In 1991, the total number of deaths classified under the two classifications was the same.

In 1992, there was an abrupt increase in deaths from item 129 and a symmetric decline in deaths from item 130. The exchange of deaths between the two 1988-SC items continued in the subsequent years. On the other hand, annual trends in deaths from ICD-9 items continued the 1988-

SC time series smoothly. Similar examples were detected for several causes of death. Our findings showed that the double coding in 1991-1995 did not represent a genuine "bridge coding" practised by some countries.

Table 3.7 FAIs and death counts by type based on medical correspondence and by type and age based on statistical correspondence. Transition from 1988-SC to ICD-9

a) based on medical correspondence, all ages

Type of association	Associations		Deaths in 1991	
	Number	%	Number	%
type 1:1	137	83	23897	52
type 1:n	19	11	2995	7
type n:1	3	2	11504	25
type n:n	6	4	7451	16
Total	165	100	45848	100

b) based on statistical correspondence, by age

Type of association	**Less than year**			
	Associations		Deaths in 1991	
	Number	%	Number	%
type 1:1	113	80	353	25
type 1:n	16	11	75	5
type n:1	3	2	0	0
type n:n	9	7	1012	70
Total	141	100	1441	100

Type of association	**1-59 years**			
	Association		Deaths in 1991	
	Number	%	Number	%
type 1:1	87	71	2320	17
type 1:n	11	9	478	3
type n:1	1	1	347	3
type n:n	24	19	10459	77
Total	123	100	13605	100

Type of associations	**60 years and older**			
	Association		Deaths in 1991	
	Number	%	Number	%
type 1:1	92	74	2152	7
type 1:n	15	12	1397	5
type n:1	1	1	630	2
type n:n	16	13	26624	86
Total	124	100	30804	100

Source: author's calculations based on the NBS and NAPH data [17]

To calculate the transition coefficients, we produced FAIs based on the redistribution of deaths under ICD-9 and 1988-SC in 1991. The FAIs were constructed separately for three age groups: less than one year, 1-59 years and 60 years and older (Table 3.7). After verification of the statistical continuity, more than 70% of all deaths in 1991 were included in complex associations.

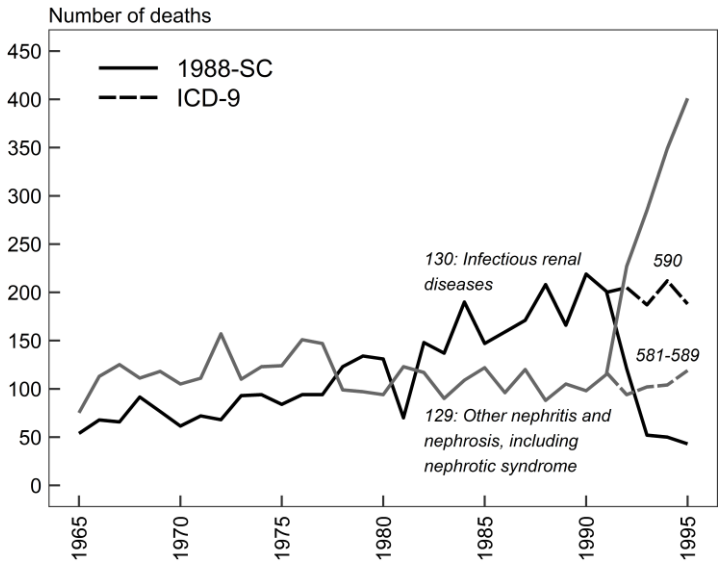


Fig. 3.16 Trends in annual deaths from "Infectious renal diseases" and "Other nephritis and nephrosis, including nephrotic syndrome" classified under 1988-SC (1965-1995) and ICD-9 (1991-1995)

Source: author's calculations based on the data of TCSU of the USSR, NBS and NAPH [17]

After the third transition, we produced continuous death series according to 214 groups of ICD-9 items in 1965-1995.

3.2.2.4. Transition from ICD-9 to ICD-10

Data codified under ICD-10 four-digit items (1996-2020) were tabulated into 211 causes of death with medical content similar to 214 categories of ICD-9 items. For 2020, we added a code referring to COVID-19 (U07.1).

Table 3.8 FAIs and death counts by type based on the medical correspondence (M) and statistical correspondence (S). Transition from ICD-9 to ICD-10

Type of association	ICD-10							
	Associations				Deaths (in 1996)			
	Number		Proportion, %		Number		Proportion, %	
	M	S	M	S	M	S	M	S
type 1:1	197	142	95	85	49106	17560	98	35
type 1:n	4	2	2	1	277	424	1	1
type n:1	6	4	3	2	676	5	1	0
type n:n	0	20	0	12	0	32070	0	64
Total	207	168	100	100	50059	50059	100	100

Source: author's calculations based on NAPH data.

Table 3.8 shows the distribution of FAIs by type with death counts in 1996. FAIs based on medical correspondence belong almost wholly (197 or 95%) to the type 1:1, with four associations of type "splitting" (1:n) and six of type "merging" (n:1). We did not construct any "complex" associations based on medical correspondence. However, after verification of the statistical consistency, we produced twenty FAIs of type n:n, which covered 64% of the total deaths. At the same time, the number of death counts involved in simple associations was reduced from 98% to

35%. Our findings for the fourth transition demonstrated that the adoption of ICD-10 has led to changes in coding practices, independent of the medical content of causes of death.

Figure 3.17 shows a case of some obstructive pulmonary diseases. In 1996, when ICD-10 was adopted, the standardised death rate from *bronchiectasis and other obstructive pulmonary diseases* (items 494-496 under ICD-9 and items J44, J47 under ICD-10) increased unexpectedly, but the rate for *chronic bronchitis and emphysema* (items 490-492 under ICD-9 and items J40-J43 under ICD-10) declined symmetrically (panel A). To offset the death discrepancy, we joined the two simple associations into a complex one (FAI 109). After applying the transition coefficients, smoothed mortality series were produced for the two causes of death (panel B).

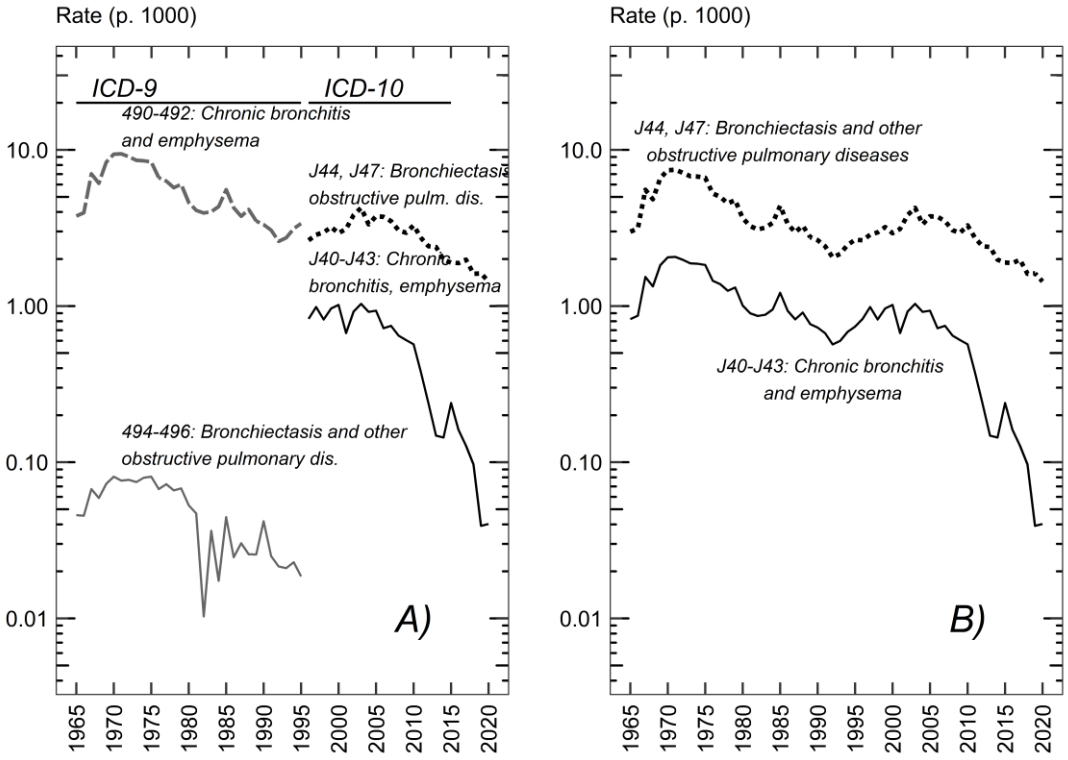


Fig. 3.17 Annual trends in standardised death rates for some obstructive pulmonary diseases codified under ICD-9 and ICD-10 before (panel A) and after (panel B) reconstruction

Source: author's calculations based on the data of TCSU of the USSR, NBS and NAPH [17]

We adjusted the transition coefficients by age for 25 of 214 ICD-9 items. Using the transition coefficients, we reconstructed the time series of deaths for the 1965-1995 period according to 212 ICD-10 items. These series were prolonged with the observed ICD-10 series for 1996-2020. In such a way, we obtained continuous mortality series under ICD-10 for 1965-2020.

3.2.2.5. Additional a posteriori corrections

Additional so-called *a posteriori* corrections were made to remove the discontinuities in the death time series resulting from changes in coding practices unrelated to the adoption of a new

classification. These changes occurred during the inter-revision period and were eliminated by *a posteriori* correction. Four rounds of *a posteriori* correction were made after every transition from an old classification to a new classification.

Figure 3.18 gives an example of *a posteriori* correction for rheumatic diseases produced after the first transition from 1965-SC to 1970-SC. The number of deaths in ages 1-59, codified as *Chronic rheumatic heart diseases* (item 85 under 1970-SC), decreased suddenly in 1974. This decline was accompanied by a symmetric increase in deaths from *Active rheumatism* (item 84 under 1970-SC). The observed exchange of deaths between the two items resulted from changes in coding practices. Working with the archived documentation, we encountered the instructions issued by the TCSU of the USSR in 1973 concerning preparing the annual forms 5 and 5b [170]. According to the new instructions, special attention had to be paid to codifying deaths from active rheumatism (item 84) in ages above 15 years old and chronic rheumatic heart diseases (item 85) in ages before 15 years old. The new rules caused an exchange in deaths between the two items in 1974. To correct this disruption, we transferred 30% of deaths codified as item 85 (item of entrance) to item 84 (item of exit) for every year in 1965-1973 in ages 1-59.

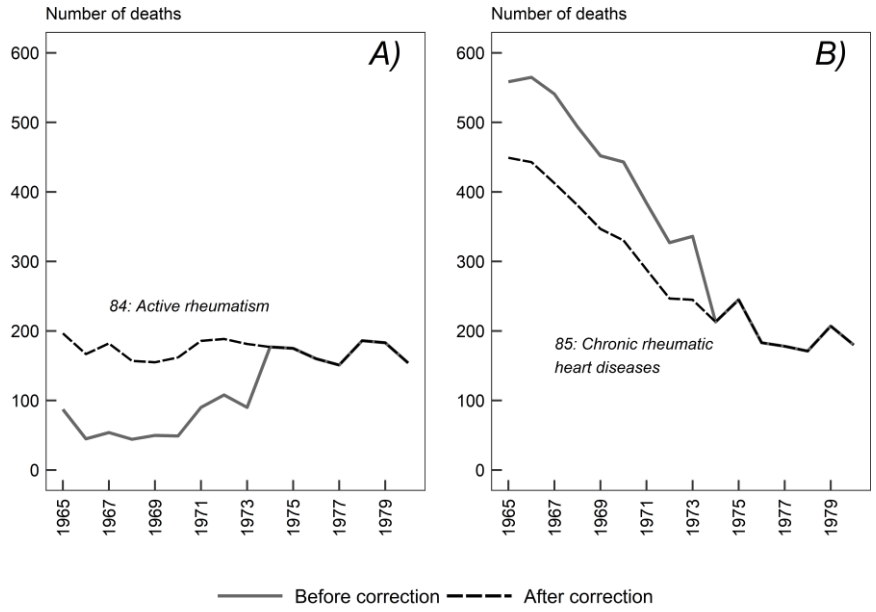


Fig. 3.18 Annual trends in deaths reconstructed under 1970-SC from items 84 and 85 (A) before and (B) after *a posteriori* correction in ages 1-59, Moldova (abs.)

Source: author's calculations based on the data of TCSU of the USSR (archived data provided by INED) [17]

Not all of the codification rules were followed by the statistical offices of each FSU republic. For example, disregarding the TCSU instructions to attribute a minimal number of medical death certificates to *Other liver cirrhosis* (item 125 under 1970-SC), the share of deaths classified under this item ranged between 60% and 70% during the Soviet period in total deaths related to digestive system diseases. The same practice continued after independence.

Totally, 45 items were corrected *a posteriori* after the first transition, 23 items after the second, six items after the third and ten items after the fourth transition. In most cases, correction coefficients were adjusted by age.

3.2.3. Redistribution of deaths from Senility and other ill-defined causes of deaths

3.2.3.1. Ill-defined causes of death at the national level

Before the end of the 1980s, very few deaths were coded as senility (item 158 under 1981-SC, 797 under ICD-9 and R54 under ICD-10) or other items referring to ill-defined causes. The situation changed thoroughly after 1989 when the Health Ministry issued new instructions about codifying deaths from circulatory system diseases among people aged 80 and over and sudden cardiac deaths in younger ages. According to new rules, any death after age 80 had to be codified as senility unless a precise cause of death could be identified based on medical documentation, an autopsy report, or the death resulting from external factors [32].

The number of deaths from senility increased drastically in Moldova when the new instructions came into force. In 1993, the number of deaths from senility was 17% of all deaths (12% in men and 21% in women). On the other hand, the number of deaths from some cardiovascular diseases, especially from *atherosclerotic cardiosclerosis*, declined sharply. The new instructions also prohibited codifying deaths from acute cardiovascular diseases in ages before 80 unless an autopsy report confirmed the diagnosis. This situation explained a high proportion of deaths from senility before 80 (20% in the age 70-79 and 2% in the age 60-69 in 1993). The reduction in deaths from senility started after 1993, with a proportion of 5% in 1997 and 3% in 2000 and less than 1% in 2020. In contrast to senility, trends in annual deaths attributed to ill-defined causes of death, except for senility (item 159 under 1981-SC; 780-796, 798, 799 under ICD-9; R00-R53, R55-R99 under ICD-10), did not follow significant changes.

Deaths from senility had to be distributed between other causes to remove discontinuities in the time series. We tested the following types of distribution of senility deaths:

1. a proportional distribution among all causes of death;
2. a proportional distribution among circulatory system diseases;
3. a special distribution among cardiovascular diseases.

The first method was rejected because of an artificial excess in cancer deaths after the distribution of senility deaths, especially among those aged 80 years and over. The second and third methods were limited to three groups of circulatory system diseases: heart, cerebrovascular and residual. According to the third method, senility deaths were distributed by specially computed coefficients. The algorithm of their calculation is presented in detail in Annexe 3).

Figure 3.19 shows the corrected trends in circulatory system diseases after distributing senility deaths according to the second (distribution 1) and third (distribution 2) methods. The results of the second method were questionable due to an artificial excess in deaths from cerebrovascular diseases and a residual group. By contrast, the new trends obtained after the third method removed the peak of deaths from cerebrovascular diseases and a residual group.

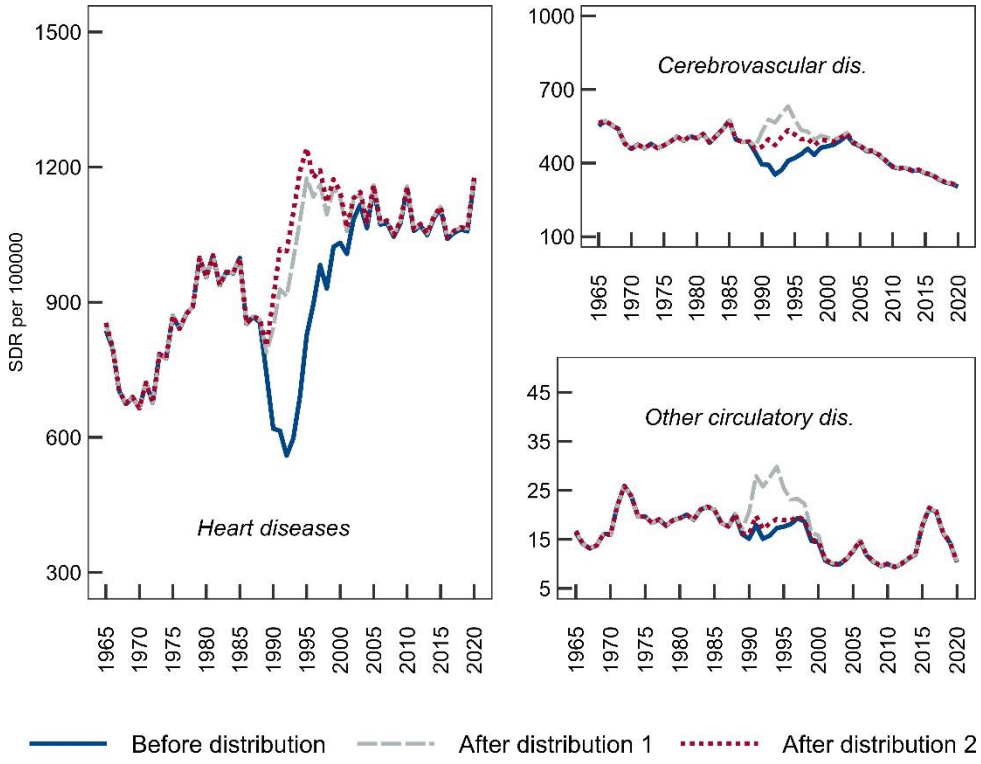


Fig. 3.19 Trends in the standardised death rate for three groups of circulatory system diseases before and after distribution of senility deaths according to limited (1) and special proportional distribution (2)

Source: author's calculations based on the data of TCSU of the USSR, NBS and NAPH [17]

The distribution of senility deaths changed the trends in mortality from circulatory system diseases in the 1990s and early 2000s. Unadjusted trends in mortality from heart diseases and cerebrovascular diseases declined considerably in the early 1990s, followed by a sharp increase from the mid-1990s until 2005. The reduction in cardiovascular mortality in the early 1990s is inconsistent with the all-cause mortality trend characterised by a steep increase in the 1990s caused by a severe socioeconomic crisis. Undoubtedly, the decrease in cardiovascular mortality in the 1990s is artificial and caused by the mortality growth from senility. Conversely, the cardiovascular mortality trends after the redistribution of senility deaths followed a dramatic rise in 1991-1995 and a moderate decline in the second half of the 1990s. The new trend corresponds entirely to the overall mortality evolution. Our study used the corrected deaths from circulatory system diseases after a special distribution of senility deaths.

3.2.3.2. Ill-defined causes of death at the sub-national and district levels

The mortality growth from senility deaths was more widespread in rural areas than urban ones, especially among the female population. In 1991, the proportion of ill-defined deaths varied between 4% in urban males and 21% in rural females, with an average of 13%. More than 98% of ill-defined deaths were attributed to item 797, "senility without mentioning of psychosis". For the 1991-1993 period, we preliminary redistributed these deaths between the three main groups of cardiovascular diseases according to the coefficients computed at the national level, as explained in section 3.2.3.1. Figure 3.20 presents the age-specific death rates from cardiovascular diseases by place of residence before and after the redistribution of senility deaths among the female population. For rural women aged 85 and older, the corrected rates in 1991-1993 should be multiplied by three for heart disease and 2.6 for cerebrovascular disease. The corresponding correction coefficients for urban females were 76% and 25%, respectively. Nationally, the residual group changed the least after corrections. For men, the adjustments of cardiovascular death rates were quite close to those estimated for women. In 2003-2005 and 2014-20, ill-defined deaths were less than 1% and were redistributed proportionally between other causes.

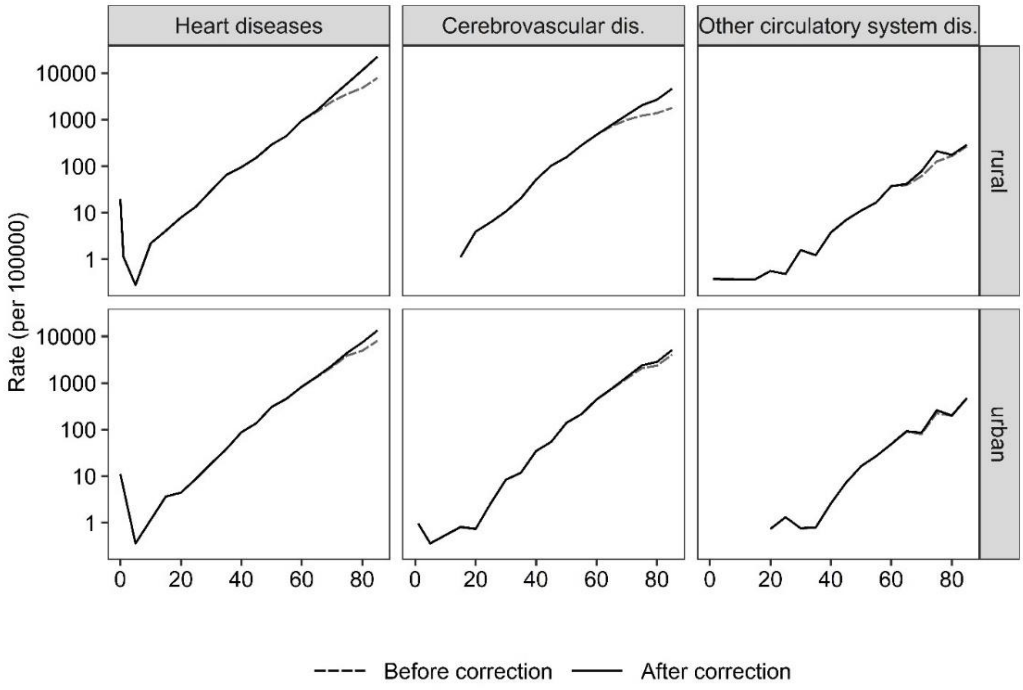


Fig. 3.20 Age-specific mortality rates from three main groups of diseases of the circulatory system by place of residence before and after the redistribution of senility deaths, Moldova, females, 1991-1993 (per 100000)

Source: author's calculations based on NAPH and NBS data.

The problem of mortality growth from senility in the 1990s was also solved at the district level. The share of ill-defined causes of death varied from less than 1% in the Orhei district to 35% in the Soldanesti district. The geographic profile of proportionate mortality and standardised death

rates from senility was almost identical in 1991-1995 (Figure 3.21). Overall, the practice of attributing deaths to senility was more prevalent in the country's north, where the intensity of population ageing is most pronounced. At the same time, in the municipalities of Chisinau and Balti, Transnistria, and some districts, the proportion of deaths attributed to senility was barely 8% in total mortality. The observed situation is due to the younger population structure in these geographical areas and better medical diagnoses of causes of death.

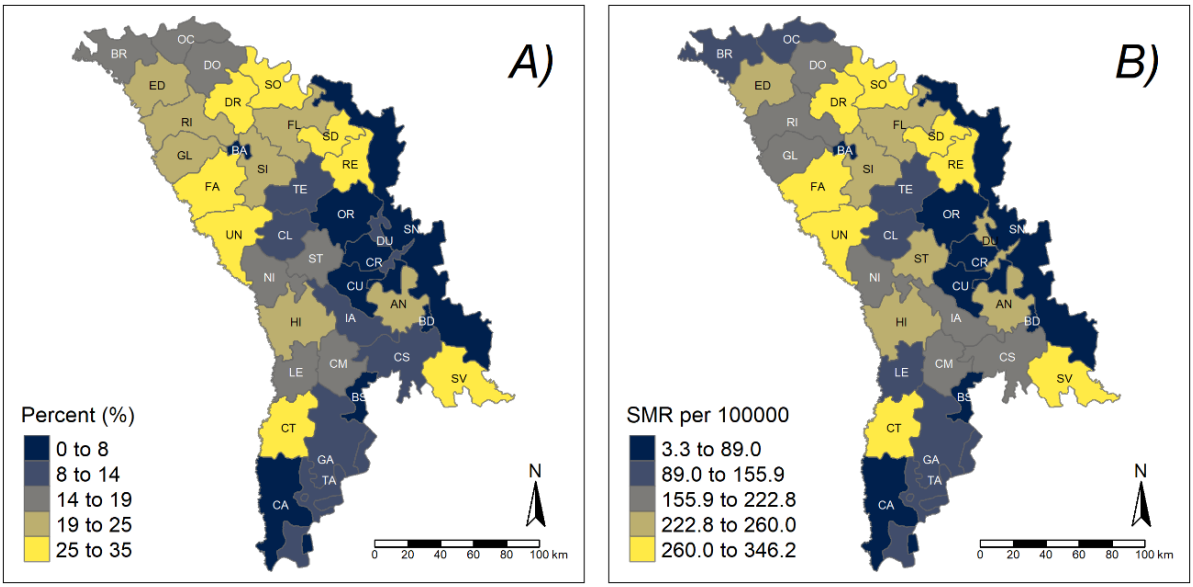


Fig. 3.21 Regional profile of proportionate mortality (A) and standardised death rates from senility (B) in 1991-1995, both sexes, Moldova

Note: "Quantile" style of classification was used
Source: author's calculations based on NAPH and NBS data.

At the district level, we used the approach applied at the national level. Deaths due to senility among those aged 80 and over were redistributed according to special coefficients among the three main cardiovascular groups (heart, cerebrovascular and a residual group). A proportional distribution was applied for old age groups before 80.

In 2012-2016, the low proportion of ill-defined causes of death (0.7%) did not affect the results. Most of the deaths due to ill-defined causes (94%) were recorded among males (74%) in the municipality of Chisinau (37%) and classified under R98-R99 (unattended death and other ill-defined and unspecified causes of mortality).

3.3. Discussion for Chapter 3

The study presented in Chapter 3 aimed to assess the quality of primary statistical data and develop the correction methods at the national, sub-national and district levels. We identified the following data quality problems for Moldova that required untrivial solutions:

1. The absence of valid intercensal population estimates for the years before 2014;

2. Incomplete registration of infant deaths and underestimation of old-age mortality in the 1960s and 1970s;
3. Discontinuities in death time series induced by periodic changes in the classification of causes of death;
4. The growth of mortality from ill-defined causes of death in the 1990s.

The data quality problems mentioned above were identified at the national level and automatically appeared at the sub-national and district levels. Further, we discuss the obtained main findings regarding these four issues.

Main findings and discussion

A) Population data quality

Reliable data on population counts by age and sex are critical for producing age-specific rates and different summarizing measures such as life expectancy. We identified different problems concerning the population counts in the Soviet period and after independence. The official annual population counts in older ages were problematic for the years preceding the 1979 census. The problem resulted from the population age heaping quite pronounced for the Soviet censuses.

For the independence period, the official intercensal estimates were not produced. Alternatively, for a very long period of independence, the population counts referring to a so-called *de jure* population were in use. These estimates were based on the 1989 census, vital statistics and highly incomplete migration statistics. Our results showed that using official *de jure* population counts leads to a severe under-registration of birth and death rates. In recent years, the official statistics underwent essential changes to be more consistent with international recommendations. In particular, the accurate post-census estimates referring to the "usually resident" population were produced by NBS for the years after 2014, including by place of residence and district.

Our study relied on the official population data only since 2014. For the previous years, we used the HMD-like population estimates produced according to the HMD methodology for 1959-2004 [121], completed with proper intercensal estimates for 2004-2014. We did not produce intercensal population estimates by place of residence or district due to the absence of reliable internal migration statistics for the independence period. Moreover, the country's administrative division was modified a few times during the independence. We relied on the census estimates for mortality analysis at the sub-national and district levels. Other researchers often use such a practice [46, 47]. The population data by social characteristics (marital status, level of education, place of residence) underwent preliminary treatment to be consistent with the population data estimated at the national level.

B) Underestimation of infant and old-age mortality

Assessing age-specific mortality rates since the late 1950s in Moldova pointed to significant data quality problems in infancy and older ages. Regarding infant mortality, we distinguished two different types of under-registration of infant deaths. The first type was linked to a genuine under-registration of infant deaths before 1973. The same problem was described for other FSU countries, but the degree of under-registration in Moldova was much more pronounced [171]. According to the correction method proposed in the study, the official infant mortality rates must be increased by 34% in 1955, 47% in 1965 and 50% in 1972 [113]. The second type of under-registration stemmed from the Soviet definition of live birth used in Moldova until 2008. The Soviet definition of live birth used in FSU countries led to the underestimation of infant death rates and their incomparability with other countries [172]. The second type of infant mortality adjustment, based on the experience of the Baltic states, had a minor effect on life expectancy at birth. From this point of view, we did not correct infant deaths at the sub-national and district levels.

Old-age mortality underestimation was considerable in the 1960s and 1970s and mainly resulted from misreporting age at death. The identified problem is common for FSU countries, where observed life expectancies at advanced ages in the 1960s and 1970s are suspiciously high compared to Western countries with high-quality population data [173]. This problem was partially solved thanks to the HMD-like old-age population estimates based on methods of extinct or almost extinct generations [174]. However, since the method of extinct generations depends on the quality of death data, old-age mortality estimates were still underestimated. Our study used a correction method based on the Coale-Demeny model life tables. The same approach was used for old-age mortality correction in the Soviet period in Ukraine [32]. After infant and old-age mortality corrections, the re-estimated trends in life expectancy at birth became more consistent over time and closer to the level observed in Ukraine, Russia and Romania (see section 4.1). The completeness of death registration in Moldova from the 1980s onwards is considered high [175].

C) Reconstruction of the continuity of the death time series

Disruptions in time series caused by changes in the classification of causes of death complicate the analysis of mortality for any country over time and between the countries. Our study used a special method to reconstruct coherent death time series according to a fixed classification developed by Vallin and Meslé [18]. The method of reconstruction was successfully applied in different countries for different periods: France [40], Russia [42], Ukraine [32, 43, 128], the Baltic countries [169], Belarus [37, 44], Armenia and Georgia [45], the Czech Republic and Western Germany [46], Poland [47].

In Moldova, the classification of causes of death was changed in 1965, 1970, 1981, 1991 and 1996. We reconstructed the continuity of the death time series in Moldova for 1965-2020 according to detailed ICD-10 groups [176, 17]. Four subsequent transitions were performed, each involving three basic steps: the correspondence tables, fundamental associations of items and transition coefficients. We checked the reconstructed series for statistical coherence after each transition at the level of fundamental associations and detailed causes of death. Additionally, *a posteriori* correction was made after each transition to eliminate disruptions caused by changes in coding practices between two revisions. The "missing" infant deaths and deaths in older ages estimated after two infant mortality and old-age mortality corrections were redistribution between all or specific causes of death. As a result, we produced a database of the reconstructed time series in 1965-2020 by sex, age and 212 ICD-10 groups of causes of death. Our database met the criteria for comparability, completeness and consistency and was integrated into the international database, The Human Cause-of-Death Database (https://www.causesofdeath.org/cgi-bin/main.php), coordinated by the French Institute for Demographic Studies and Max Planck Institute for Demographic Research [126] (Annexes 16 and 17).

We did not reconstruct the continuity of the death time series at the sub-national level due to the statistical instability in mortality data associated with relatively low death counts. Alternatively, we used the aggregated data according to the principal groups of causes of death less affected by changes in the classification of causes of death.

D) Ill-defined causes of death

The growth of senility deaths in the 1990s occurred in FSU countries due to changes in codifying causes of death at advanced ages in 1989. For example, the share of senility deaths in 1992 constituted 2.5% of total deaths in Russia and 10% in Ukraine [32]. In Moldova, these changes were much more marked and affected the trends in cardiovascular mortality among the older population. We tested three correction methods and provided an algorithm for distributing senility deaths among circulatory system diseases according to special coefficients.

Let us discuss the results of the three methods tested for Moldova compared to Russia and Ukraine, where senility deaths were redistributed. A simple proportional redistribution of senility deaths between all causes of death (method 1) was accepted for Russia [42]. However, this approach resulted in an implausible peak of deaths for some detailed causes at advanced ages in Ukraine. We observed the same situation for Moldovan data. The created excess in deaths was especially pronounced for cancer mortality, known for its insensitivity to the socioeconomic crisis of the 1990s. For Ukraine, this situation limited the proportional distribution of senility deaths to circulatory system diseases (method 2) [43]. However, we had to find another solution for

Moldovan data and redistributed senility deaths between cardiovascular items by special coefficients (method 3) [17]. The distribution of senility death between three main groups of circulatory system diseases was produced at the sub-national and district level using the coefficients computed at the national level. At the level of main groups of causes of death, senility deaths were recodified as deaths due to cardiovascular diseases.

3.4. Conclusions for Chapter 3

1. The intercensal population estimates produced according to the HMD methodology in collaboration with Max-Planck Institute for Demographic Research for the 1959-2004 period were completed with the proper intercensal estimates for the 2004-2014 period and the official post-census population estimates from 2014. Life expectancy at birth computed based on the official *de jure* population data are significantly overestimated (in 2019, 2.6 years in females and 3.2 years in males). Population data by place of residence, marital status and level of education was adjusted based on the censuses in 2004 and 2014.
2. Two types of infant mortality corrections were proposed. The first type was linked to a genuine under-registration of infant deaths in Moldova before 1973, while the second type stemmed from the Soviet definition of live birth used until 2008. According to our estimates, the infant mortality rate must be increased by 47% in 1959, 56% in 1965 and 61% in 1972. After 1973, the adjustment coefficient varied between 7% and 23%. The maximum effect of the first infant mortality correction on life expectancy at birth was 1.73 years in males and 1.9 years in females in 1959. The effect of the second infant mortality correction on life expectancy at birth was minor and varied between 0.13 and 0.25 years.
3. Based on the model regional life table, old-age mortality corrections were produced for males in 1959-68 and females in 1959-70. The underestimation of life expectancies in older ages resulted from misreporting age at death, which is typical for FSU countries. The maximum impact of old-age mortality correction on life expectancy at birth was 2.72 years in males and 3.8 years in females in 1960.
4. We reconstructed continuous death time series by sex and age according to detailed ICD-10 groups of causes of death (211 categories) for Moldova in 1965-2020. Our database met the criteria for comparability, completeness and regularity and was integrated into the international mortality database, The Human Cause-of-Death Database, coordinated by the French Institute for Demographic Studies and Max Planck Institute for Demographic Research. A special distribution method of senility deaths among cardiovascular diseases in the 1990s was proposed at the national level and accepted at the sub-national and district levels.

4. CHANGES IN MORTALITY TRENDS AND PATTERNS IN THE REPUBLIC OF MOLDOVA IN 1965-2020

Chapter 4 examines overall and cause-specific mortality trends since the mid-1960s in Moldova. First, the evolution of life expectancy at birth, age-specific and cause-specific mortality profiles in Moldova is compared to Ukraine and Romania. Next, the standardised death rates from leading and detailed causes of death in Moldova are presented across broad age groups based on the reconstructed time series. Attention was given to COVID-19 mortality in 2020. Finally, the principle age- and cause-specific risk groups responsible for excess mortality in Moldova are identified compared to the European model.

4.1. Mortality trends and patterns in Moldova compared to Romania and Ukraine

In this section, we examine the evolution of life expectancy at birth in Moldova compared to Romania and Ukraine since 1959 in the context of social and economic circumstances that occurred in these countries in the second half of the 20th century and the first two decades of the 21st century. A focus is made on the decomposition of life expectancy at birth by cause and age over the periods of deterioration and improvement in the three countries.

4.1.1. Changes in life expectancy at birth

Figure 4.1 shows the evolution of life expectancy at birth by sex in Moldova compared to Romania and Ukraine since 1959. Moldovan and Romanian populations had a similar risk of dying in the 1960s and the early 1970s, much higher than in Ukraine, especially in females. In 1959, the gap in life expectancy at birth between the two countries and Ukraine was more than 4.0 years for men and even more than 6.0 years for women. Despite the initial poor health conditions, overall mortality had fallen rapidly in Moldova and Romania by the mid-1960s. In Romania, mortality increased in males and stagnated in females during the communist regime, and the deterioration of the population's health accelerated immediately after the 1989 revolution. It was only after 1996 that the life expectancy in Romania increased steadily.

Life expectancy in Moldova and Ukraine declined continuously in the 1970s and the early 1980s, particularly among males. During the *long-term deterioration of the population's health* (1965-1984), life expectancy declined by 3.9 years in males and 1.2 years in females in Moldova, and 3.3 and 0.6 years in Ukraine, respectively. In contrast to Ukrainian women, Moldovan women experienced a deep decline in life expectancy at birth in the 1970s.

The long-term decline in population health in the two former Soviet republics was interrupted due to *the anti-alcohol campaign* (1985-1987) launched by Mikhail Gorbachev in the FSU. The campaign resulted in a considerable but short-term life expectancy growth. In Moldova,

from 1984 to 1987, life expectancy increased by 3.3 years in males and 2.4 years in females. The campaign's effect was less critical in Ukraine than in Moldova for males (2.3 years in 1984-1986) and females (0.9 years in 1984-1986).

The fading effect of the anti-alcohol campaign in the late 1980s slowed life expectancy growth and reversed the trend. Between 1987 and 1991, life expectancy in Moldova was reduced by 1.2 years in males and 0.3 years in females. The losses in Ukraine were more marked than in Moldova (respectively, 2.3 and 0.7 years).

The collapse of the USSR led to a severe *socioeconomic crisis* that hit the newly independent states due to a sudden transition to a market economy. Compared to Moldova, life expectancy losses were more striking in Ukraine, where between 1991 and 1995, males lost 3.4 years and females 1.8 years. Over the same period, Moldovan life expectancy declined by 2.1 years in males and 1.3 years in females. In the late 1990s, a short-term *post-crisis recovery* occurred in the two countries despite a continuing economic crisis. Between 1995 and 1998, life expectancy increased by 1.8 and 1.9 years in Moldovan and Ukrainian males and 1.6 and 1.3 years in Moldovan and Ukrainian females.

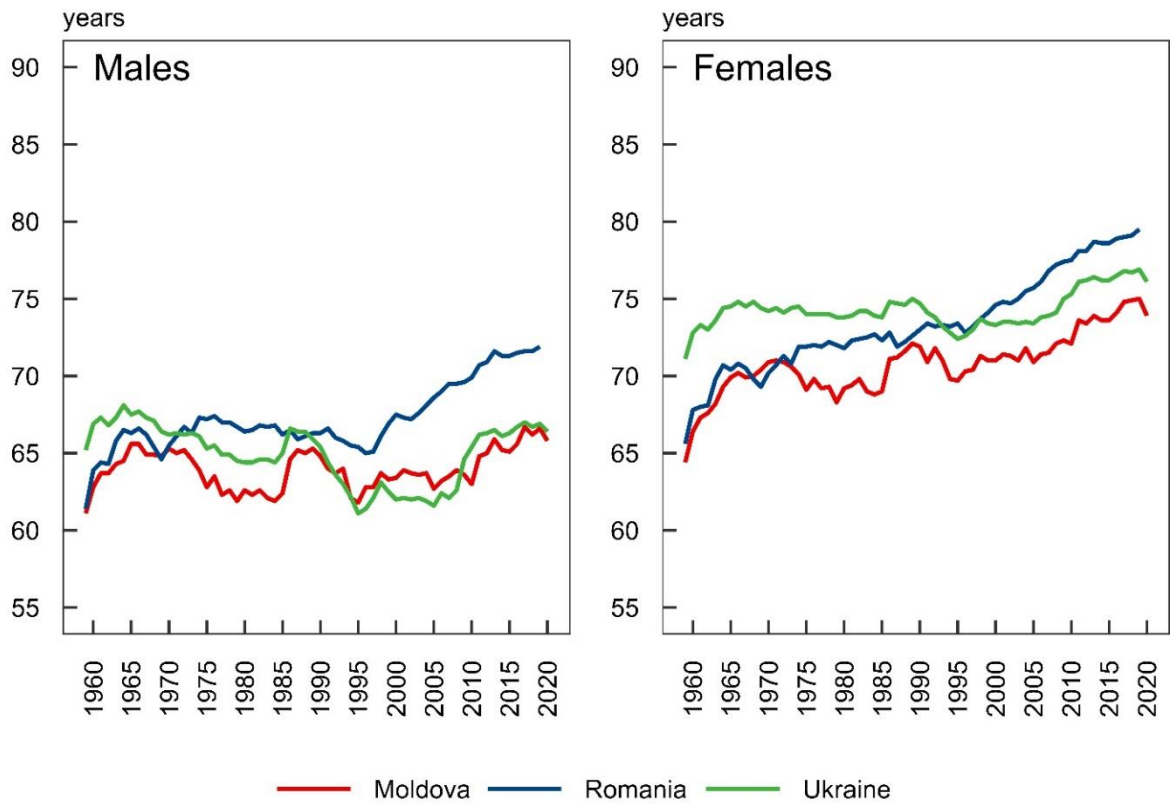


Fig. 4.1 The evolution of life expectancy at birth by sex in Moldova compared to Ukraine and Romania by sex since 1959

Note: For Ukraine in 2014-2020, the data exclude the temporarily occupied territory of the Autonomous Republic of Crimea, the regions of Donetsk and Luhansk. The last year of observation was 2020 for Moldova and Ukraine and 2019 for Romania.
Source: author's calculations based on the HCD database, the Romanian National Institute of Statistics data and the State Statistics Service of Ukraine data.

Following wide fluctuations in the late 1980s and the 1990s, life expectancy mainly stagnated until 2005, followed by visible *improvements*. Between 1998 and 2019, men gained 2.1 years of life expectancy in Moldova and 3.4 years in Ukraine. In women, the recent progress was the same in both countries (2.6 years). Between 2019 and 2020, life expectancy declined by 0.8 years in men and 1.1 years in women in Moldova and by 0.6 years and 0.8 years in Ukraine. The COVID-19 pandemic in 2020 stopped these moderate advances.

4.1.2. Changes in age-specific mortality profiles

Figure 4.2 presents the ratio of age-specific mortality rates in 1965 (baseline year) to death rates registered in several years with a 10-year interval. In all three countries, the changes in mortality patterns were not consistent across age, with middle-aged males being the most affected group. In 1975, mortality rates among males aged 40 to 54 were close to the 1965 reference year (Romania) or increased by 30% (Ukraine) or 60% (Moldova). Men's health worsened gradually a decade later, and the deterioration accelerated through the 1990s. In 1995, the risk of dying among men in the aforementioned age group was already more than double that of the reference year in the three countries. At the same time, infant mortality in Moldova and Romania, which experienced much higher levels than in Ukraine in the 1960s and 1970s, declined considerably, nearly twice between 1965 and 1995. The improvements in child mortality were much less evident than in infant mortality. In Romania, the situation was exacerbated by a dramatic outbreak of HIV infection among children in the late 1980s.

In Romania, in 2005 and 2010, the age profile of male mortality showed significant improvements across all age groups. Mortality rates were below the 1965 reference level for the under-40s and over-60s and fell to the 1985 level for the middle-aged. Progress has continued over the last decade for the latter, though still staying above the 1965 threshold in 2019. In 2005, the curves for Moldovan and Ukrainian males were nearly identical to those in 1995. In 2010, death rates in Ukraine declined substantially across all age groups, particularly among young and middle-aged men. In Moldova, due to a jump in mortality in 2010, it remained at the 2005 level. Finally, in 2019, mortality rates in these two former Soviet republics were below the 1965 reference year only for those under 30. At the same time, adult mortality remained at the 1985 level, particularly among middle-aged men.

The age-specific mortality pattern of women is characterized by much lower mortality growth in Ukraine and stagnation in Romania during the period of deterioration. The mortality increase among middle-aged Moldovan women in the 1970s and 1980s was as marked as among men. However, in contrast to men, women showed a much more marked decline in adult mortality during the improvement period. Romanian women had lower mortality rates in all age groups in

2019 compared to 1965, while among Moldovan and Ukrainian women, the situation ameliorated only for ages up to 30.

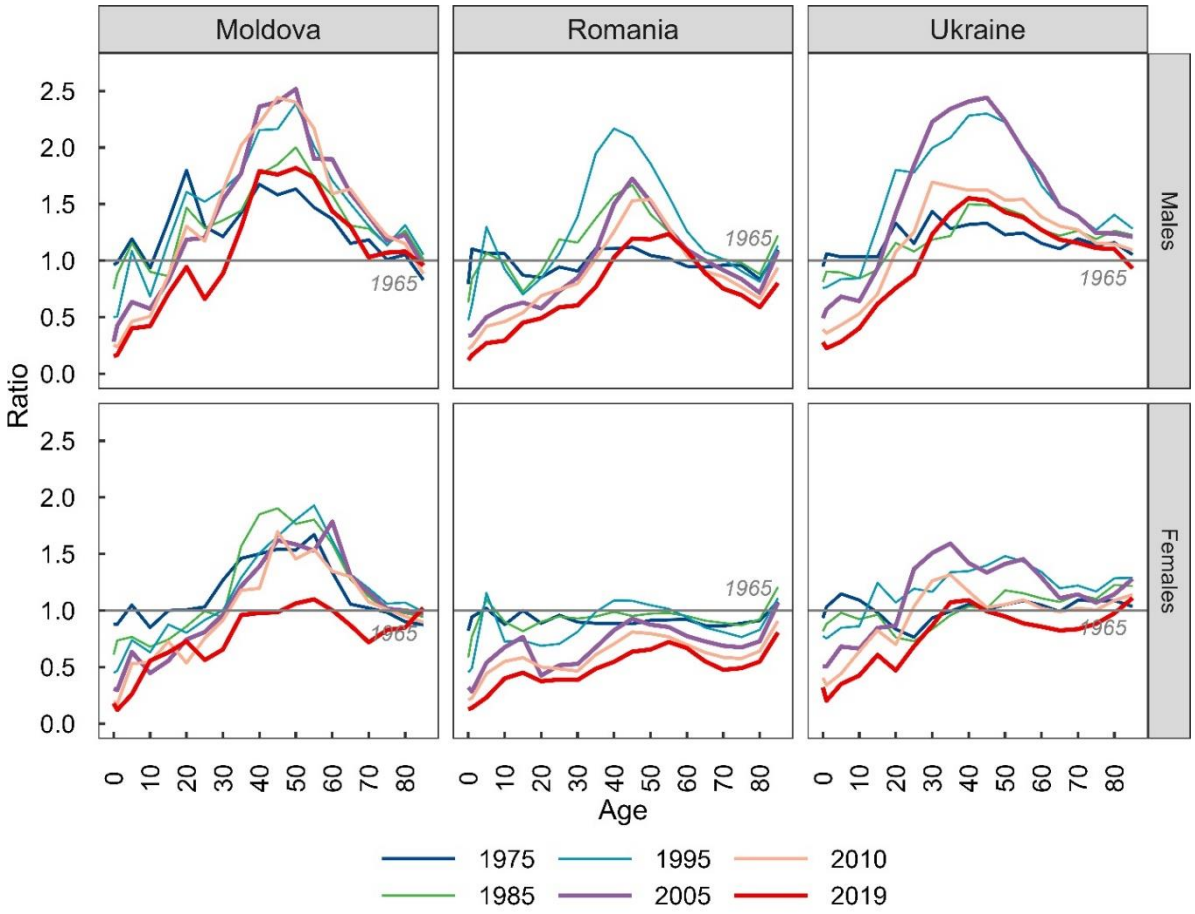


Fig. 4.2 Changes in age-specific mortality rates relative to 1965 in Moldova, Romania and Ukraine, males

Note: see Fig 4.1. The reference year is 1965 (The ratio is equal to 1.0).
Source: author's calculations based on the HCD database, the Romanian National Institute of Statistics data and the State Statistics Service of Ukraine data.

4.1.3. Decomposition of the difference in life expectancy

Figure 4.3 illustrates the decomposition of the difference in male life expectancy at birth by age and cause of death over the deterioration and improvement periods in Moldova, Romania and Ukraine. The first period lasted from 1965 to 2005 in Moldova and Ukraine and from 1965 to 1996 in Romania. Consequently, the second period was from 2005 to 2019 in the FSU countries and from 1996 to 2018 in Romania.

During the deterioration period, the loss of male life expectancy at birth was higher in Ukraine (6 years) than in Moldova and Romania (2.3 years and 1.3 years, respectively). However, in the latter two countries, the rise in adult mortality was offset by a reduction in infant mortality. In Moldova, the contribution of infant mortality reduction to the overall changes in male life expectancy at birth between 1965 and 2005 was 2.5 years (versus 1.7 years in Romania and 0.8 years in Ukraine). These improvements were made primarily through the control of respiratory

diseases. If under-15 mortality is not considered, male life expectancy decreased by seven years in Ukraine, by 5.3 years in Moldova in 1965-2005 and by 3.2 years in Romania in 1965-96. Cardiovascular disease was the primary component in deteriorating adult health, accounting for 1.6 years of the decline in life expectancy at birth in Moldova, 3.8 years in Ukraine and 2.3 years in Romania. The other two causes of death that had a major impact on men's health over the deterioration period were external causes of death and digestive diseases. Their combined adverse effect on men's life expectancy at birth was 2.5 years in Ukraine, 2.3 years in Moldova and 1.0 years in Romania. If external causes played a more critical role than digestive diseases in Ukraine and Romania, then in Moldova, the influence of these two categories of alcohol-related deaths was the same.

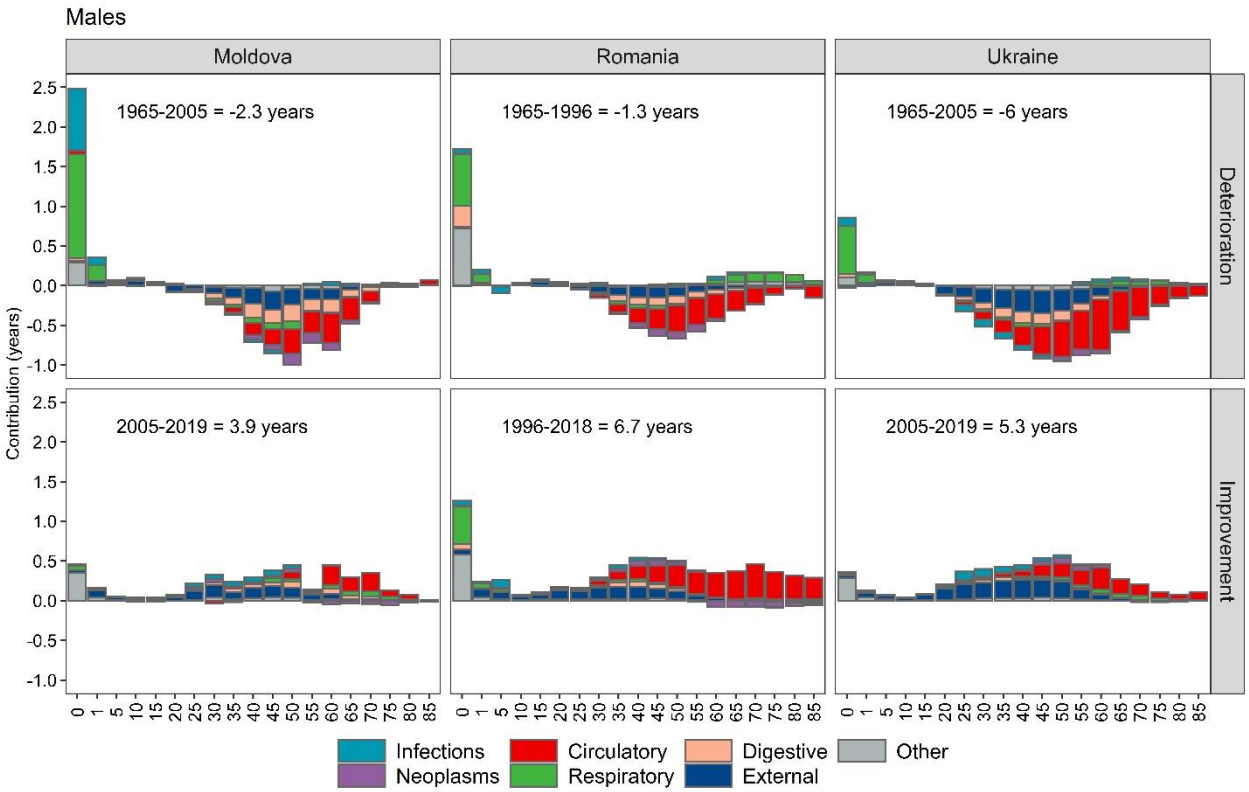


Fig. 4.3 Contributions to the changes in life expectancy at birth by age and cause of death during a period of deterioration and a period of improvement in Moldova, Romania and Ukraine, males

Note: see Figure 4.1.
Source: author's calculations based on the HCD database, the Romanian National Institute of Statistics data and the State Statistics Service of Ukraine data.

From 2005 to 2019, men from Moldova and Ukraine gained 3.9 years and 5.3 years of life expectancy at birth, while the increase in Romania was 6.7 years from 1996 to 2018. For Moldovan and Ukrainian men, progress was chiefly linked to a reduction in mortality due to external causes of death among young men and middle-aged men (1.1 years and 1.9 years, respectively). Cardiovascular mortality reduction had less impact in these countries (0.9 years and 1.5 years,

respectively). On the contrary, the period of improvement in Romania was marked by a substantial decrease in cardiovascular mortality in the middle-aged and the elderly (3.1 years) and external causes of death in young men (1.3 years). In all three countries, life expectancy growth was also associated with a further drop in infant mortality from a residual group of causes of death represented in infancy by conditions originating in the perinatal period.

Similar to males, the loss of life expectancy at birth in females over the deterioration period was partially counterbalanced by essential improvements in infant mortality (Figure 4.4). In Moldova, the increase in adult female mortality was mainly related to diseases of the digestive system. The worsening of women's health in Ukraine was mainly due to increased cardiovascular mortality among older adults, while mortality among Romanian women was stagnant with a moderate positive contribution from respiratory system diseases. The improvement period saw a significant decrease in cardiovascular mortality among middle and older women in Romania (4.0 years of the total increase of 6.4 years). The exact cause of death contributed to female life expectancy growth in Moldova and Ukraine (2.0 years of life expectancy growth of 4.1 years and 3.6 years, respectively).

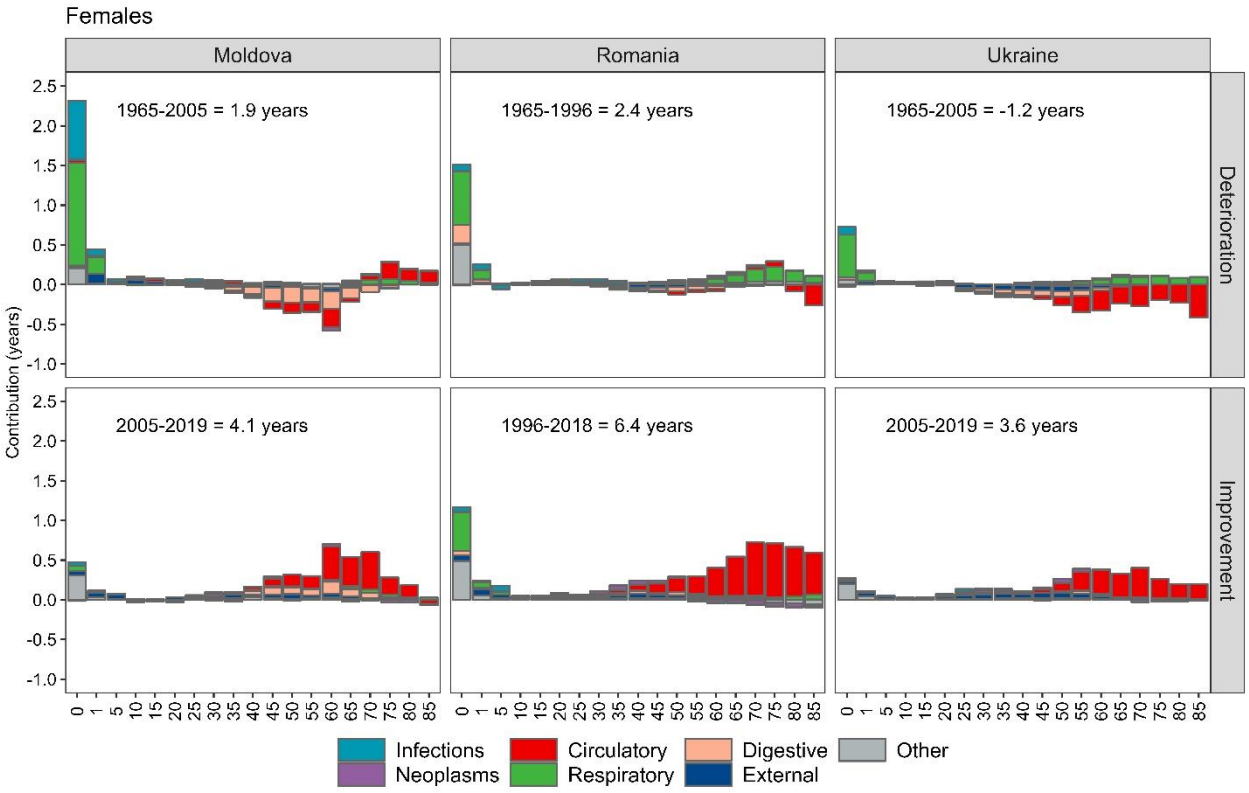


Fig. 4.4 Contributions to the changes in life expectancy at birth by age and cause of death during a period of deterioration and a period of improvement in Moldova, Romania and Ukraine, females

Note: see Figure 4.1.
Source: author's calculations based on the HCD database, the Romanian National Institute of Statistics data and the State Statistics Service of Ukraine data.

4.1.4. Changes in standardised death rates from main causes of death

Trends in standardised death rates by sex for the seven leading causes of death since 1965 are presented in Figure 4.5. In all three countries, *circulatory system diseases* accounted for 55% - 60% of all male deaths over the whole period. The cardiovascular mortality increase in 1969 in Romania may be partly linked to the transition from ICD-7 to ICD-8. In the early 1970s, men in the three countries experienced a similar risk of death from cardiovascular disease, but subsequent growth in the 1980s was more pronounced in Moldova and Ukraine than in Romania. In both FSU republics, the 1985 anti-alcohol campaign resulted in a rapid but brief reduction in cardiovascular mortality, followed by a very steep rise caused by the socioeconomic crisis of the 1990s. Between 1989 and 1995, the standardised death rates in these countries rose by about 30%. After a short decline in the late 1990s, cardiovascular mortality resumed growth in Ukraine and stagnated/decreased in Moldova, followed by a decline after 2005. In Romania, mortality growth from circulatory system diseases accelerated immediately after the 1989 revolution, increasing by 15% between 1989 and 1996. Since then, a continuous decline in cardiovascular mortality has been registered in this country, with the current level of mortality corresponding to the early 1960s. Trends in cardiovascular mortality in females were pretty similar to those in males. During the period of deterioration, cardiovascular mortality in women stagnated in Romania or experienced less acute growth than in men in Moldova and Ukraine. Furthermore, the influence of the anti-alcohol campaign followed by the crisis of the 1990s was stronger among women in Moldova than in Ukraine.

Mortality from *neoplasms*, the second most common cause of death since the late 1970s in Ukraine and the late 1980s in Moldova and Romania, tends very differently before and after the collapse of the communist system. In Romania, the stagnation period of the 1970s gave way to a steady increase from the late-1980s onwards. In Moldova and Ukraine, the situation worsened rapidly throughout the 1980s; however, the 1990s marked a marked decline in these countries. Nevertheless, since the beginning of the millennium, a rapid increase in cancer mortality has resumed in Moldova, while in Ukraine, the decline/stagnation continues to date.

Respiratory system diseases, with standardised mortality rates higher than cancer rates in the 1970s and even in the 1980s in Moldova and Romania, have dropped significantly over the entire period. The downward trend halted during the social turmoil of the 1990s in Ukraine and even reversed in Moldova. In Romania, the recent period has been marked by stagnation in mortality caused by respiratory diseases and even by the start of a new upward trend.

External causes have been the third leading cause of death among Ukrainian men since the mid-1990s, while this cause of death has the same or a very close level of mortality as respiratory

and digestive diseases among Moldovan men (since the mid-1980s) and Romanian men (since the early the 2000s). External causes of death, like cardiovascular disease, were susceptible to socioeconomic and political upheavals in the three countries, particularly Ukraine. In the two FSU countries, the mortality curves for men followed the same trajectory up to the beginning of the 1990s, but the socioeconomic crisis caused a much more significant increase in Ukraine than in Moldova. Between 1965 and 1995, mortality from external causes of death more than doubled in Ukraine and went up by 80% in Moldova and 70% in Romania. In Ukraine, after a temporary amelioration in the late 1990s, a new upsurge in external deaths occurred, followed by a deep decline after 2002, which accelerated in 2009-10. In Moldova, after 1992, the year of the military conflict, male mortality remained stagnant until 2005, followed by an improvement. In Romania, violent deaths among males began to fall steadily after 1996. Females in Moldova had consistently higher death rates from external causes than in Romania over the whole period or in Ukraine over the Soviet period. Moldovan women were twice more likely to die of violent causes than Romanian women in the 1980s or the first decade of the millennium. Even in 1977, when a 7.5 earthquake hit Romania, standardised mortality rates were 50% higher in Moldova than in Romania. At the same time, the general trend in female mortality from external causes in Moldova has been downward since the mid-1980s, without an upsurge in the 1990s observed in the case of Ukrainian women.

Mortality from *digestive system diseases* experienced a very unfavourable evolution in the countries analysed. Moldovan and Romanian men had a similar level at the beginning of the period, about 70% higher than that for Ukrainian men. In Moldova, the mortality increase for this cause of death was robust before the anti-alcohol campaign; the standardised rates were multiplied by 2.5 from 1965 to 1984. This spectacular increase enormously widened the gap between Moldova and the other two countries (more than twice with Romania and three times with Ukraine in 1984), where the situation worsened considerably less. After the abolition of restrictive anti-alcoholic measures, mortality growth was less severe (50% from 1989 to 2005), followed by a moderate decline after 2005.

In contrast to Moldova, Ukraine saw the fastest growth after independence, while a sharp decline occurred only in 2009 and 2010, followed by stagnation. In Romania, the increase in mortality from digestive diseases began in the 1980s and escalated after the 1989 revolution, with no marked improvement over the last two decades. Trends in female mortality from digestive diseases were very close to those in males but with lower values except for Moldova, where the sex ratio was 1.1 to 1.4 (only in the 1960s and the last decade, it was 1.5 and more). Like men, Moldovan women experienced impressive growth in mortality due to digestive diseases in the

1970s, with a multiplication of standardised rates by 3.7 times between 1965 and 1984. Since Romanian and Ukrainian women mainly experienced stagnation or a moderate increase in mortality in the Soviet period, the gap with Moldova in the mid-1980s rose to 3.5 times for Romania and 6.6 times for Ukraine.

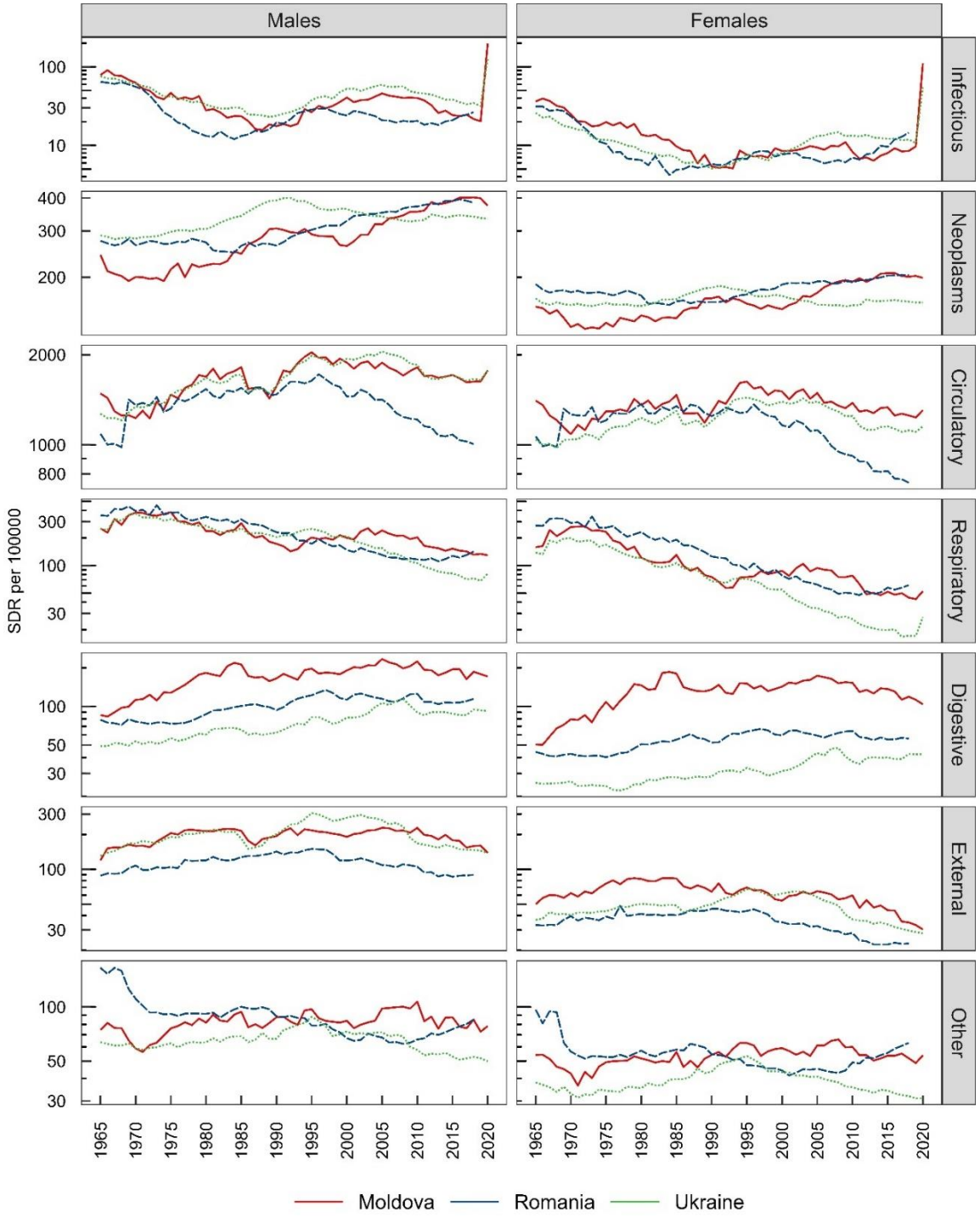


Fig. 4.5 Standardised death rates from seven main groups of causes of death in Moldova, Romania and Ukraine, males (per 100000, semi-logarithmic scale)

Note: see Figure 4.1.
Source: author's calculations based on the HCD database, the Romanian National Institute of Statistics data and the State Statistics Service of Ukraine data.

Mortality from *infectious diseases* had declined more than four times in Moldova and Romania and more than three times in Ukraine by the late 1980s. The subsequent period of social upheaval was associated with a reversal in the mortality trend for this pathology. Male mortality attributable to infectious diseases increased 2.5-fold between 1989 and 2005 in both FSU countries and 80% between 1989 and 1996 in Romania. Subsequent reductions in mortality from infectious diseases were as strong as the previous growth, but the recent trend in Romania points to a new upward trend. The same increasing trend for the recent period has been observed in Romania and for the residual group of causes of death.

4.2. Mortality trends by age and cause of death in Moldova

In this section, based on the continuous time series reconstructed under ICD-10, cause-specific mortality trends are analysed by main age groups: less than one year, children and adolescents aged 1-14 years old, young adults aged 15-39 years old, mature adults aged 40-64 years old and older adults aged 65 years and over. First, the mortality profile for each age group is presented for seven main causes of death and then for selected detailed causes. The selection of the main group for the detailed analysis varies according to the age category. Annexe 4 presents supplementary figures and data on standardised death rates in 1965 and 2020 by age and selected groups of ICD-10 items. Detailed information on cause-specific mortality trends by age can also be found in the annexes to our monograph on mortality trends in Moldova since 1965 [17].

4.2.1. Infant mortality and mortality among children and adolescents aged 1-14

Throughout the study period, the *infant mortality* profile was dominated by infectious and respiratory diseases and the "other diseases" group, which is represented in this age group mainly by perinatal conditions (Figure 4.6, panel A). At the start of the study period, 65% of infant deaths were attributed to respiratory and infectious diseases, while only one-third resulted from "other diseases". Conversely, the latter category currently accounts for more than two-thirds of deaths under one year, while the proportion of the other two conditions is around 20%. Mortality from respiratory and infectious diseases declined dramatically during the study period, especially in the 1980s. Between 1965 and 2020, there was a 40-fold infant mortality reduction for infectious diseases and a 25-fold for respiratory diseases (Annexe 4, A4.1). The declining trend in infant mortality from infectious and respiratory diseases was interrupted in the 1970s and 1990s. Mortality from injury and poisoning remained largely stagnant until 2010, followed by moderate improvements. The relative stagnation in all-cause infant mortality observed in recent years has been primarily related to the "other diseases" group. The impact of other causes on infant mortality is of minor importance.

The *"other diseases"* group includes conditions originating in the perinatal period and congenital anomalies. In panel B of Figure 4.6, perinatal diseases are presented by obstetrical trauma, congenital pneumonia, other respiratory diseases of the new-born and other perinatal diseases. Infant mortality from these detailed perinatal conditions has long been unchanged, with no marked improvement. Noticeable progress has been made for perinatal diseases, especially for obstetrical trauma, since the early 2000s. The recent amelioration is also marked for congenital pneumonia and other respiratory diseases of the new-born but at a much lower level in contrast to obstetrical trauma. The neonatal mortality trend associated with other perinatal conditions has maintained the level during the last two decades. The recent trend in infant mortality from congenital heart anomalies showed a better trend than other anomalies.

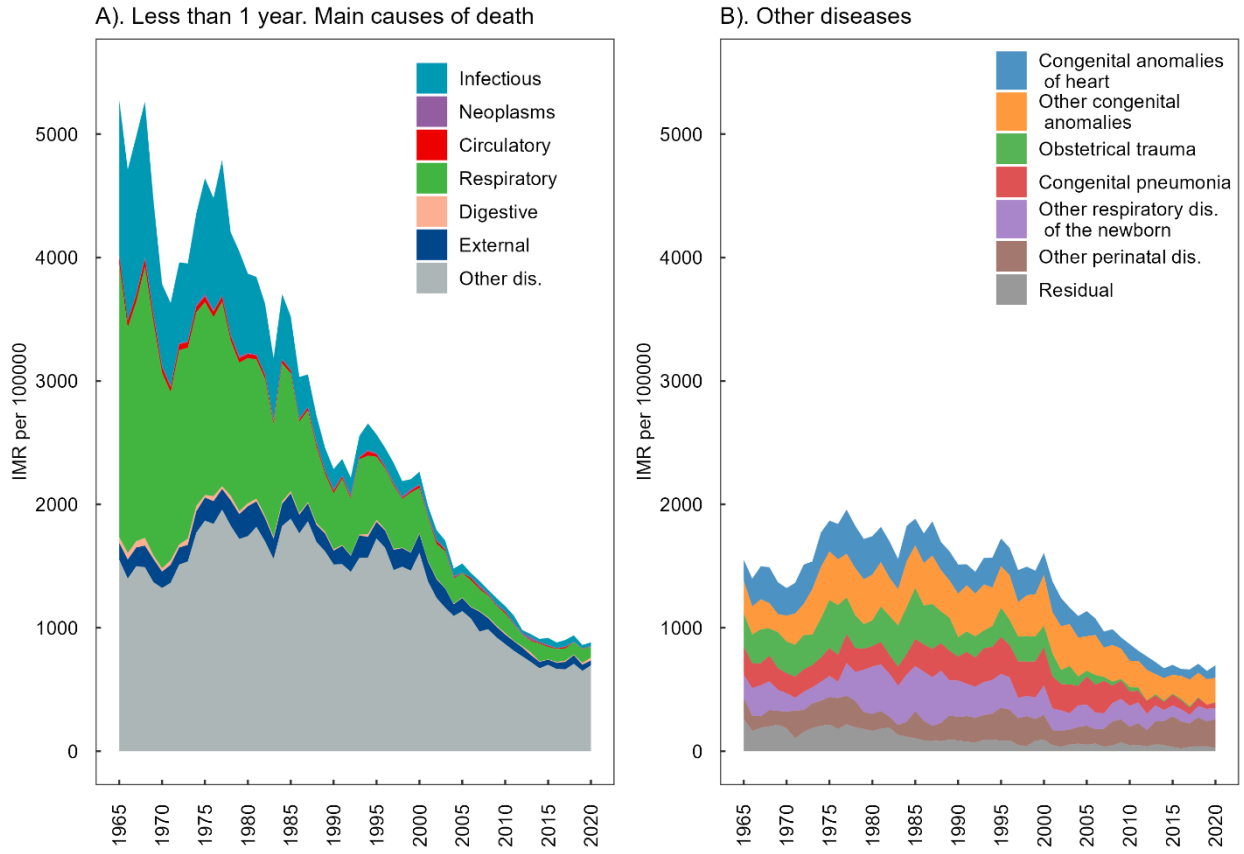


Fig. 4.6 1965-2020 trends in infant mortality by main causes of death (panel A) and detailed causes of the "Other diseases" group (panel B) in Moldova (per 100000 live births)

Source: author's calculations based on NBS and NAPH data.

Mortality from injury and poisoning among *children and adolescents* aged 1-14 was ranked first and has substantially decreased since the mid-1980s (Figure 4.7, panel A). Between 1965 and 2020, mortality from external causes of death in this age group decreased more than four times. Accidental falls, drowning, and transport accidents played a crucial role in violent deaths among children and adolescents, accounting for 45-55% of all deaths from external causes (Annexe 4,

A4.2). Mortality from respiratory system diseases, the second most common cause of death at the start of the period, has been considerably reduced since the late 1970s, interrupted by the socioeconomic crisis of the 1990s. Over the study period, the risk of dying from respiratory system disease was reduced more than seven times in this age category (Annexe 4, A4.2). The evolution of *respiratory system diseases* and *infectious diseases* at a more detailed level is presented in panel B of Figure 4.7. Mortality from pneumonia was the major contributor to the overall trend in mortality from respiratory system diseases. The long-term improvement for this cause of death stopped in the 1990s and resumed at the turn of the century. Fluctuations in mortality from influenza were especially marked in the 1960s and 1970s but became almost invisible after the 1990s.

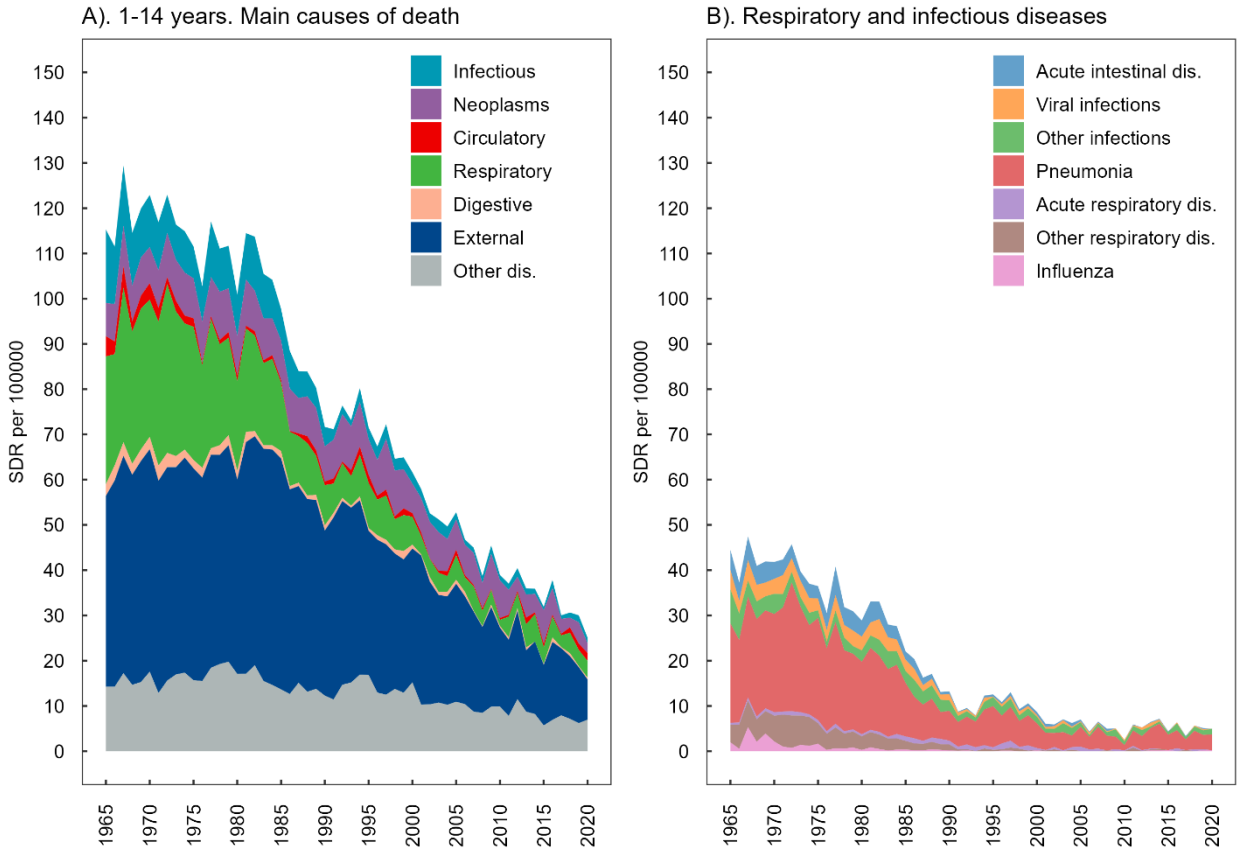


Fig. 4.7 1965-2020 trends in standardised death rates at age 1-14 for main causes of death (panel A) and detailed respiratory and infectious diseases (panel B) in Moldova (per 100000)

Source: author's calculations based on NBS and NAPH data.

Mortality associated with the "other diseases" group remained relatively stable over the study period and has been the second leading cause of death since the turn of the millennium. Among children and adolescents, this residual group of causes of death is represented by diseases of the nervous system and congenital anomalies (Annexe 4, A4.2). After a long stagnation, neoplasm mortality has started declining moderately since the early 2000s and is currently in third

place after “other diseases”. This recent improvement in cancer mortality was mainly related to the mortality decline from leukaemia and lymphomas (Annexe 4, A4.2). As with infant mortality, a steady decline in mortality from infectious diseases was halted in the late 1970s and the early 1990s. In the 1960s and 1970s, deaths from infectious diseases were chiefly related to acute intestinal infections and viral infections. Mortality related to circulatory and digestive system diseases was reduced rapidly until the late 1980s and is of minor importance nowadays.

4.2.2. Mortality among young adults aged 15-39 years old

4.2.2.1. Main causes of death among young adults

Among young adult males aged 15 to 39, *external causes of death* dominate the mortality profile, representing 55% of total mortality (Figure 4.8). The male-to-female ratio for this cause of death is the most pronounced, up to 5 times. Among young adult females, external causes of death account for 25% of all deaths, close to neoplasms and digestive system diseases (Annexe 4, A4.3). For this age group, we can identify the *socially sensitive groups of causes of death* subject to wide fluctuations in mortality provoked by the anti-alcohol campaign in 1985-1987 and the socioeconomic crisis of the 1990s. These groups comprise external causes of death, circulatory, digestive and respiratory system diseases, infectious diseases and the “other diseases” group, represented among young people by mental disorders and nervous system diseases. Regarding *neoplasms*, mortality is not susceptible to these social and economic factors. The fluctuations in mortality from socially sensitive groups of causes of death were particularly pronounced in young men and much less in young women.

During the long-term deterioration of population health (1965-84), the mortality trends for the main causes of death, excluding neoplasms and infectious diseases, were quite unfavourable among young adults (increase or stagnation). Before the 1985 anti-alcohol campaign, the worsening of the situation was especially marked for the groups of socially sensitive causes of death, except for *infectious* diseases. For the latter, noticeable improvements were achieved, particularly in the 1970s, although male mortality has stagnated since the 1980s. The rise in mortality from 1965 to 1984 was particularly marked for *digestive system diseases*: from 1965 to 1984, the standardised indicators tripled in young men and rose fivefold in young women.

Once the antialcohol campaign was suddenly launched in 1985, the situation ameliorated for all socially sensitive groups of causes of death, except for infectious diseases. The unfavourable trends resumed very quickly, especially for infectious diseases, with the misuse of the anti-alcohol measures in 1987. The response was particularly pronounced for external causes of death among young males. As a result, in 1989, the standardised death rates for this cause of death came back to the level recorded in 1984, before the anti-alcohol campaign. In the 1990s, the mortality trend

for external causes of death among young males mainly stagnated, followed by a steady decline since the late 1990s. The peak in mortality in 1992 is explained by the war conflict in Transnistria (code Y36 under ICD-10).

In 2020 compared to 1965, standardised indicators for external causes of death in young men reached the level registered in the mid-1960s and fell by only 35% among young women (Annexe 4, A4.3). On the contrary, mortality from digestive system diseases showed a further moderate increase in the 1990s, followed by fluctuations without much progress. The unfavourable trend during the period of independence occurred for respiratory system diseases, more in young males than females. Mortality from *infectious diseases* increased in the late 1980s and accelerated its growth in the 1990s. At the turn of the millennium, this type of mortality, primarily associated with tuberculosis among young adults, began to decline steadily. The impact of COVID-19 in 2020 on all-cause mortality and mortality from infectious diseases was insignificant among young adults.

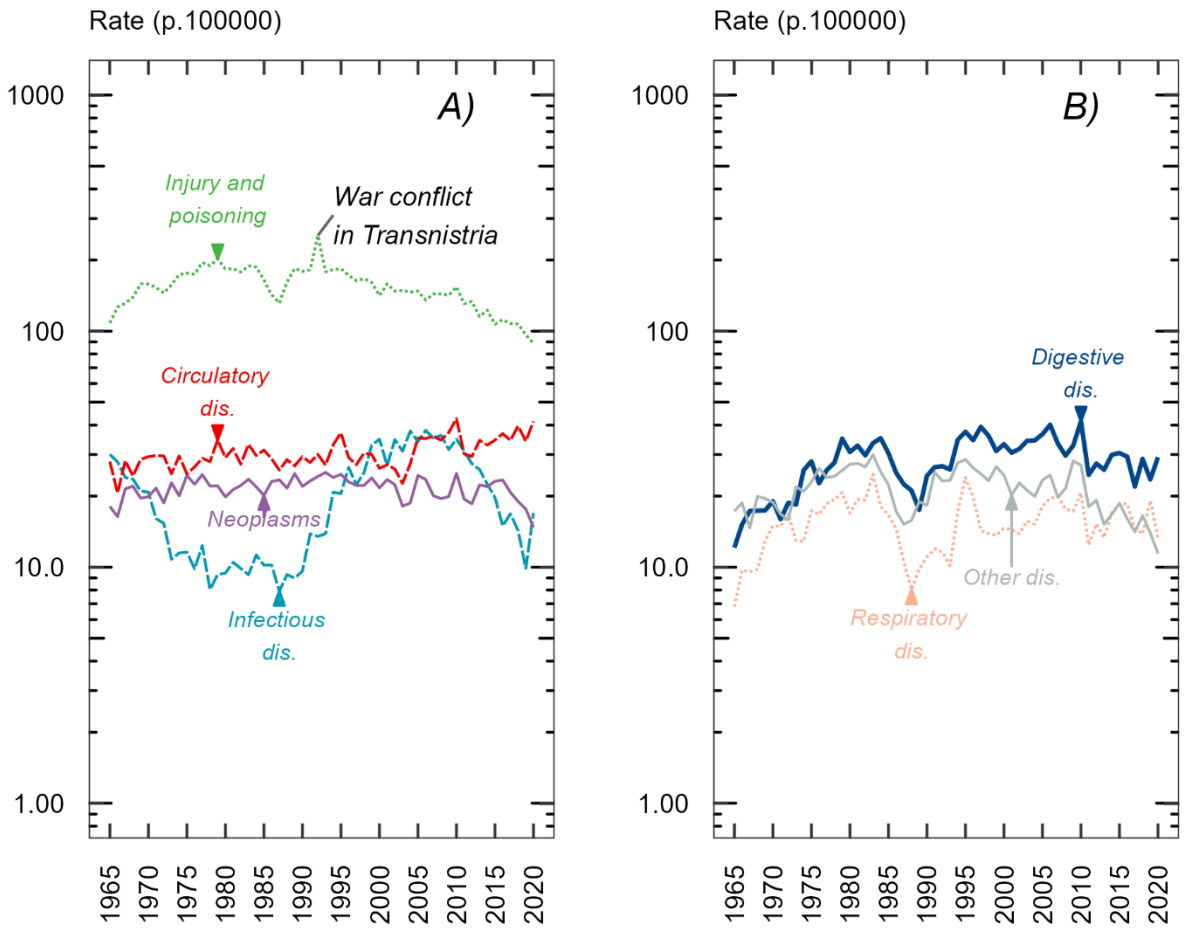


Fig. 4.8 1965-2020 trends in standardised death rates in males at age 15-39 for main causes of death in Moldova (per 100000, semi-logarithmic scale)

Source: author's calculations based on NBS and NAPH data.

4.2.2.2. External causes of death among young adults

Among young males, *transport accidents* and *suicide* were the two leading causes of death responsible for about 70% of external mortality throughout the study period (Figure 4.9). The period of population health deterioration in 1965-84 was accompanied by mortality growth for different categories of external causes of death. Before the launch of the anti-alcohol campaign in 1985, standardised death rates tripled for suicide and *injury, undetermined whether accidentally or purposely inflicted* (or undetermined injury).

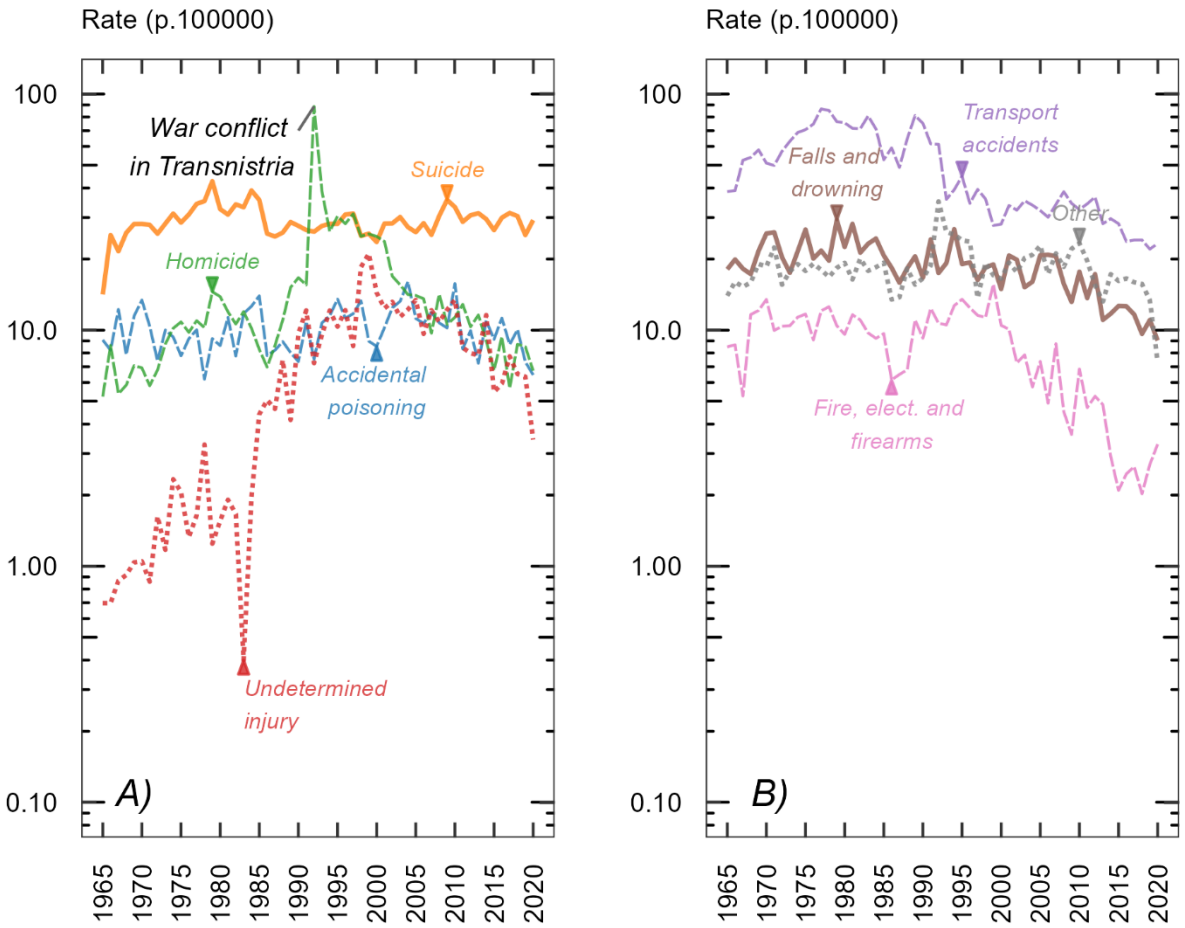


Fig. 4.9 1965-2020 trends in standardised death rates in males at age 15-39 for detailed external causes of death in Moldova (per 100000, semi-logarithmic scale)

Source: author's calculations based on NBS and NAPH data.

Different categories of external causes of death reacted differently to the 1985 anti-alcohol campaign. The anti-alcohol campaign significantly impacted mortality from *falls*, *accidental poisoning*, *drowning* for both sexes, suicide in young males and homicide in young females. The most marked effect was found for the *homicide* rate in females (death rates decreased by 80% from 1984 to 1987), while in males, it was pretty modest (17%). Mortality continued the growth for undetermined injury for both sexes despite restrictions on alcohol consumption in 1985-87. This fact can be attributable to the gradual changes in coding practice for external causes of death. This

"undetermined injury" group, with a minor effect on external mortality before 1985 (less than 1%), was likely to serve as a substitute for any specific subcategory such as accidents, suicide or homicide. As a result, deaths associated with "undetermined injury" increased to 10% for both sexes in the late 1990s.

When the restrictive anti-alcohol measures were relaxed, the adverse trend in mortality from external causes of death resumed among young adults, with the most robust growth for transport accidents and homicide (70% increase between 1987 and 1989). In 1989, male mortality from transport accidents corresponded to the level registered before the anti-alcohol campaign, but standardised rates for homicides had the values registered at the end of the 1970s. At the same time, the growth in mortality from other violent causes was less evident.

The socioeconomic crisis of the 1990s accelerated the growth of mortality from homicide, which continued until 1995, followed by a steady decline. On the contrary, the mortality trend in transport accidents followed a marked decline throughout the 1990s. Once the country's economic situation ameliorated, mortality from transport accidents ceased to decline and fell to stagnation.

Since the mid-1990s, mortality from external causes of death among young men has decreased moderately, followed by stagnation in recent years. Over the last decade, some progress was recorded in mortality from homicide, undetermined injury and accidents provoked by fire, electricity and firearms. On the other hand, stagnating mortality for other external causes of death, including transport accidents and suicide, puts into question the sustainability of these fragile improvements among young males in Moldova.

4.2.3. Mortality among mature adults aged 40-64 years old

4.2.3.1. Main causes of death among mature adults

Circulatory system diseases, the most common cause of death among mature adults aged 40-64, account for 30% of total mortality in males and 35% in females (Figure 4.10, Annexe 4, A4.4). The continuous mortality growth for this pathology was interrupted only by the 1985 anti-alcohol campaign. However, the misuse of the anti-alcohol measures, followed by the severe crisis of the 1990s, caused an upsurge in cardiovascular mortality. After wide fluctuations, mortality from circulatory system diseases among the middle-aged resumed growth among males and stagnated among females until 2005, followed by a moderate decline. The recent improvements were more marked in females than males.

Neoplasms rank second in the overall mortality pattern in mature adults, with about 20% of total mortality over the whole period. Depending on the period, neoplasms share second place with external causes of death in men and digestive system diseases in women. Among middle-aged men, mortality from this cause of death rose rapidly through the late 1980s, followed by

stagnation or a moderate reduction in the 1990s. Among women, mortality from neoplasms was relatively steady compared to men during the entire period.

Digestive system diseases have a marked effect on the Moldovan mortality profile, particularly among females. In the mid-1980s, the risk of dying from digestive system diseases was very close to that from circulatory system diseases among middle-aged women. Between 1965 and 2020, the share of this pathology rose from 8% to 14% in men and from 7% to 18% in women. The mortality growth was especially striking in 1965-1984, when the standardised death rates rose seven-fold in females and four-fold in males (Annexe 4, A4.4). After a brief improvement related to the 1985 anti-alcohol campaign, mortality from digestive diseases resumed an upward trend in men and stagnated in women. Only since 2010 has this type of mortality started declining slowly after a few decades of negative evolution.

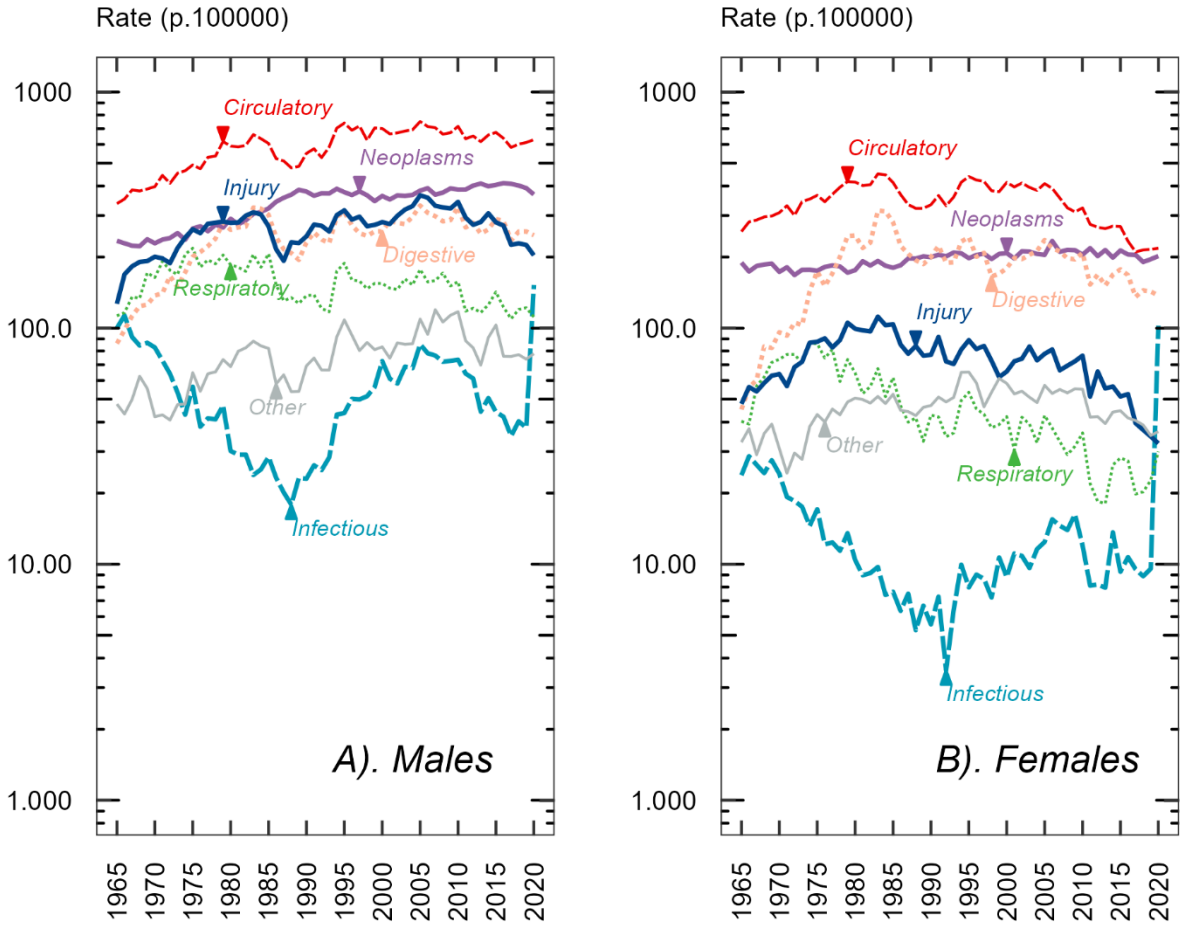


Fig. 4.10 1965-2020 trends in standardised death rates at age 40-64 for main causes of death in Moldova by sex (per 100000, semi-logarithmic scale)

Source: author's calculations based on NBS and NAPH data.

The evolution of mortality from *external causes of death* in middle-aged men closely correlates to that from digestive system diseases. Similar to digestive system diseases, moderate progress in deaths from injuries and poisonings became visible only over the last decade. Among

females aged 40 to 64, the reduction in mortality from injury and poisoning began in the mid-1980s and continues until now.

The long-term upward trend in mortality from *respiratory system diseases* among males only reversed during the anti-alcohol campaign, followed by stagnation in the 1990s and a modest decline in the past decade. In females, progress in respiratory disease mortality started in the 1970s, although it ceased during the socioeconomic crisis of the 1990s. After a sharp decline in the 1970s and 1980s, mortality from *infectious diseases* increased continuously in the 1990s. However, since 2010, it has been declining steadily until the COVID-19 pandemic in 2020. Mortality increase from infections in 2020 compared to 2019 was much greater in women than men (11 times and four times).

4.2.3.2. Mortality from neoplasms among mature adults

Figure 4.11 illustrates trends in cancer mortality for different locations by sex. Among adults aged 40-64, neoplasms play a crucial role compared to young adults (especially males) and the older population, where external causes of death and circulatory system diseases, respectively, are mainly prevalent. *Lung cancer* is a principal cause of neoplasm deaths in men, with a share varying between 30% and 40%. Male mortality related to this cause of death rose continuously through the late 1980s, then it levelled off and even decreased in the second half of the 1990s. At the turn of the new millennium, the male lung cancer mortality trend resumed its slow growth, followed by a stagnation that has persisted.

Cancer of *the upper aerodigestive tract* (the lip, oral cavity, pharynx and oesophagus) has a relatively moderate impact (10% in 2020) on overall neoplasm mortality, but the mortality growth was the most rapid during the study period. Between 1965 and 2020, its standardised indicators increased seven times in men and doubled in women. Like lung cancer, mortality from cancer of the upper aerodigestive tract increased rapidly in the 1980s, followed by stagnation in the 1990s and a further upsurge in the new millennium. The same evolution can be found in men for *urinary system* cancer, dominated by bladder cancer, with a 3–5% share in total cancer mortality. Mortality from lung cancer and cancer of the upper aerodigestive tract and the urinary system was lower in women than in men between three (urinary system) and 15 times (upper aerodigestive tract) and was relatively stable over the whole period.

Breast cancer, the leading cause of death from malignant tumours in middle-aged females, tended upwards during the study period, with standardised rates doubling in 1965-2020 (Annexe 4, A4.4). In contrast, mortality from *uterus* cancer decreased, particularly in the 1970s and 1980s; but the progress ceased after independence. The opposite trends in breast and uterus cancer mortality led to a crossover between the two conditions in the early 1980s. Although *prostate*

cancer had a relatively modest effect on total cancer mortality (3% in 2020), mortality from cancer of this site followed an increasing trend during the entire period.

Mortality trends for digestive system cancer vary substantially depending on the location. Between 1965 to 2020, the risk of dying from *stomach* cancer was reduced more than three times for both sexes (Annexe 4, A4.4). On the other hand, mortality from cancer of the *intestine* and *other digestive organs*, mainly represented by liver cancer, showed a constant growth over five decades. The trends in mortality from stomach and intestine overlapped in the early 1980s among women and the early 2000s among men.

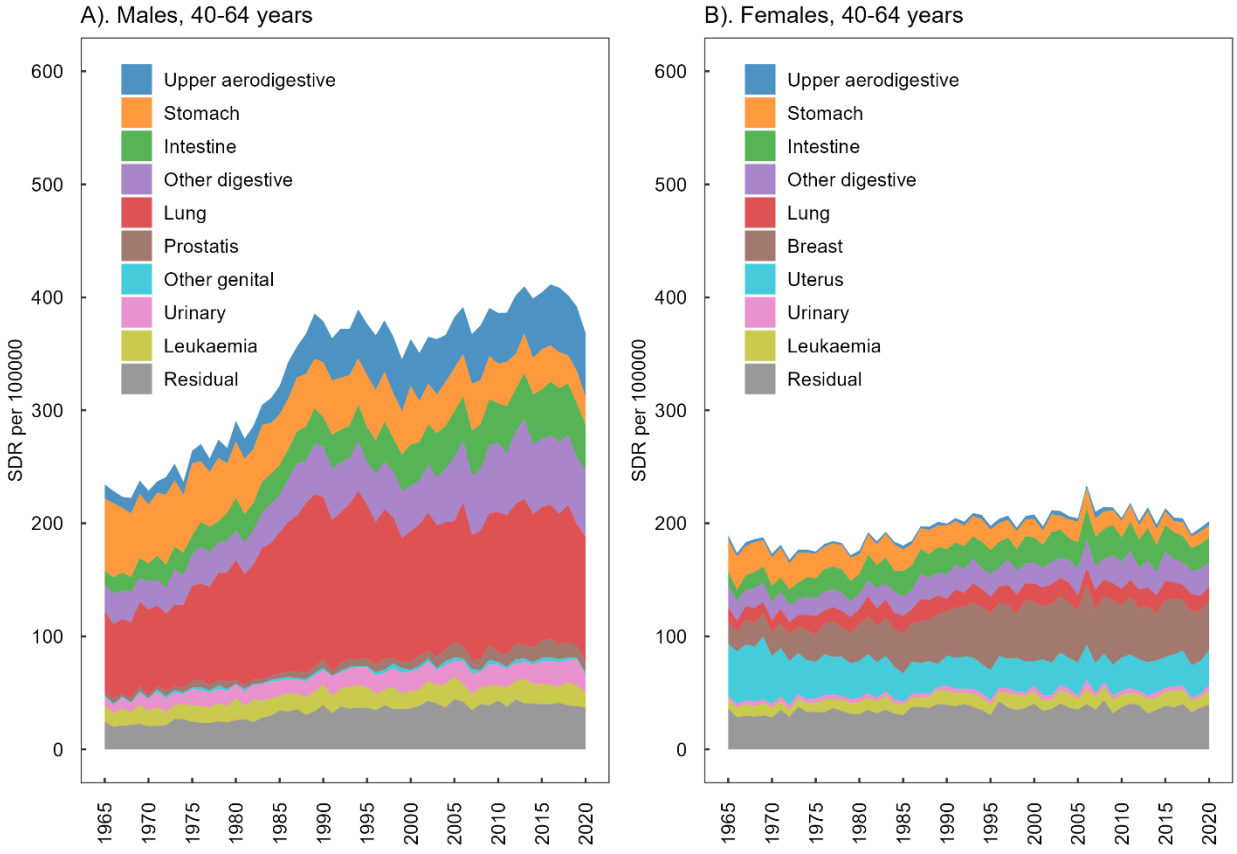


Fig. 4.11 1965-2020 trends in standardised death rates at age 40-64 for neoplasms of different locations in Moldova by sex (per 100000)

Source: author's calculations based on NBS and NAPH data.

Mortality from *leukaemia and lymphomas* has not changed much over the study period, unlike children and adolescents, who experienced some improvements in recent years. Finally, the residual group of malignant neoplasms demonstrated a reasonably rapid growth: the share in total cancer mortality rose from 5% in 1965 to 10% in 2020. Malignant neoplasms of other sites were primarily represented by two causes: cancer of the brain and other parts of the central nervous system and cancer of other and unspecified sites (70% in 2020, respectively).

4.2.3.3. Mortality from digestive system diseases among mature adults

Cirrhosis of the liver is the principal cause of death from digestive system diseases (Figure 4.12). The proportion of this pathology rose from 50% in men and 60% in women in 1965 to 80% and 90% in 2020. The evolution of mortality was more adverse in women than men, particularly before the 1985 anti-alcohol campaign. For instance, from 1965 to 1984, the standardised mortality indicator for this disease rose 5-fold in males and 10-fold in females. The male-to-female ratio was close to one for alcoholic liver cirrhosis (1.3 in 1970, 0.9 in 1985, 1.2 in 2000), although the ratio increased during the past two decades but still was less than two (1.6 in 2020). The contribution of alcoholic liver cirrhosis was small (less than 10%) due to a considerable under-registration of deaths from this pathology.

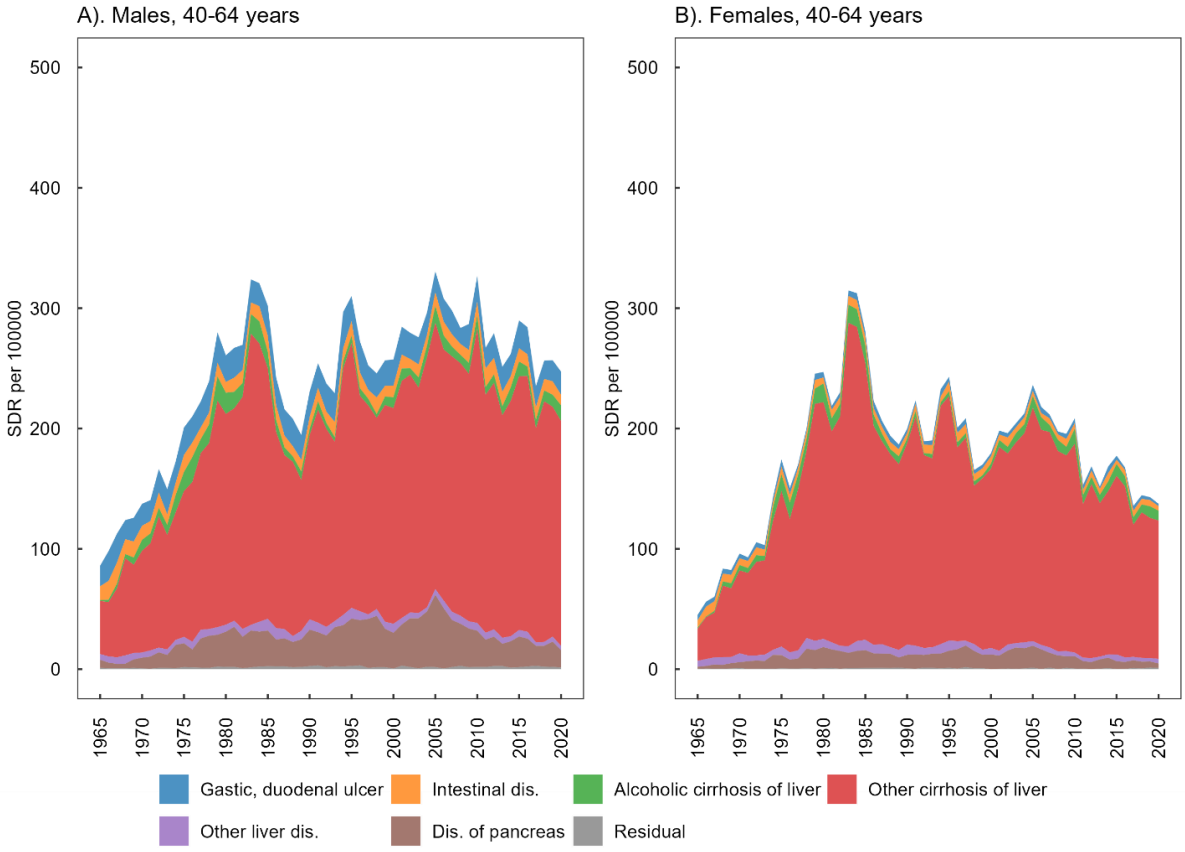


Fig. 4.12 1965-2020 trends in standardised death rates at age 40-64 for detailed digestive system diseases in Moldova by sex (per 100000)

Source: author's calculations based on NBS and NAPH data.

The sudden launch of the anti-alcohol campaign by the Soviets in 1985 showed the dependence of mortality among the adult population on alcohol consumption for different causes of death, including liver cirrhosis. The sharp restriction of alcohol consumption during Gorbachev's anti-alcohol campaign appeared to delay many deaths, significantly reducing mortality from liver cirrhosis. Soon after the withdrawal of the restrictive measures, mortality growth recommenced, but it was more moderate compared to the Soviet period. In Moldova,

between 1984, the year before the anti-alcohol campaign, and 1989, the last year when mortality declined, standardised mortality rates decreased by 90% in men and 70% in women.

A similar unfavourable mortality trend was found for *pancreas diseases*, closely related to alcohol abuse, specifically strong alcoholic beverages. Mortality from *gastric* and *duodenal ulcers*, also closely related to alcohol use, remained largely stagnant during the whole period. The downward trend occurred for *diseases of the intestine*.

4.2.3.4. Mortality from infectious diseases among mature adults

Among middle-aged adults, like young adults, *tuberculosis* is the principal cause of death from infectious diseases, excluding the COVID-19 outbreak in 2020. Mortality from tuberculosis among the adult population declined significantly in the 1970s, especially among males. However, the improvements halted in the late 1980s, followed by a dramatic rise during the socioeconomic crisis of the 1990s. The growth continued in the first decade of the 21st century. The long-term unfavourable trend in mortality from tuberculosis reversed after 2010, and the decline persists until now. In 2020, the standardised death rates from tuberculosis corresponded to the level observed in the late 1980s. (tuberculosis).

Fig. 4.13 1965-2020 trends in standardised death rates at age 40-64 for detailed infectious diseases in Moldova by sex (per 100000)

Source: author's calculations based on NBS and NAPH data.

Mortality associated with AIDS followed a dramatic rise since the mid-1990s. In 2020, mortality from the COVID-19 infection was the highest ever observed for infectious diseases over

the past half a century. The male-to-female ratio for COVID-19 was 1.3, much less than the sex ratio for any other infection, varying between 2.0 (other infections) to 10.0

4.2.4. Mortality among older adults aged 65 years old and over

4.2.4.1. Mortality from main causes of death among older adults

Before analysing cause-specific mortality trends among older adults, it is essential to point out two issues related to data quality. First, the old-age mortality was adjusted for the years until the late 1960s in males and the mid-1970s in females due to inaccurate population data and significant underestimation of official death counts. Second, deaths recorded as Senility were redistributed by a special method between detailed circulatory system diseases (see Chapter 3).

The predominance of *circulatory system diseases* in the cause-specific mortality profile is much more marked in the elderly than in the middle-aged, especially in females (Figure 4.16). The share of cardiovascular diseases in total mortality ranged from 65% to 80% in males and 75% to 85% in females (Annexe 4, A4.5). The magnitude of mortality fluctuations for circulatory system diseases and other socially sensitive causes of death was considerably lower among older people than young and mature adults. After the socioeconomic perturbations of the 1990s, older women have been experiencing a moderate reduction in cardiovascular mortality from 2005 onwards. Among older men, the recent improvements are much less marked. Before the early 1980s, *respiratory system disease*s were the second most common cause of death among the older population, followed by neoplasms. Old-age mortality from this condition rose moderately in the late 1960s, followed by a considerable decline observed for other age groups of the adult population. From 1967 to 1992, the corresponding standardised death rates were reduced by almost three times in males and five times in females. The socioeconomic crisis of the 1990s caused the reversal of this declining trend. Like in the previous age group, the negative trend continued into the new millennium, although it has improved slightly for both sexes since 2010.

Neoplasms constitute 11% of all deaths in men and 8% in women in 2020. Among older men, neoplasm mortality increased continuously in the 1980s, followed by stagnation or decline in the 1990s, already observed among adults aged 40 to 64. However, the trend has been upward for both sexes at the beginning of the millennium.

Mortality from *digestive system diseases* among the older population has followed an adverse trend, especially in women, although the deterioration was much less marked compared to mature adults. Between 1965 and 2020, the standardised death rates for this condition doubled among older males and rose by 50% among older females. Like for the preceding two age groups, the situation mainly worsened before the launch of the 1985 anti-alcohol campaign. Since then, however, old-age mortality caused by digestive system diseases remained relatively stagnant until

2010, followed by a moderate reduction. Like in the two previous age groups, the absence of sex differentiation in mortality from digestive diseases was found for older people.

Among older men, mortality from *injury and poisoning* was relatively constant during the entire period, while a downward trend can be seen since the mid-1980s among older women. Mortality from *infectious diseases* decreased considerably in the 1970s and 1980s, followed by a long stagnation until 2020, when the COVID-19 pandemic triggered a colossal jump in deaths. In the last year of observation, infectious diseases, which had always been at the bottom since the mid-1980s, ranked third.

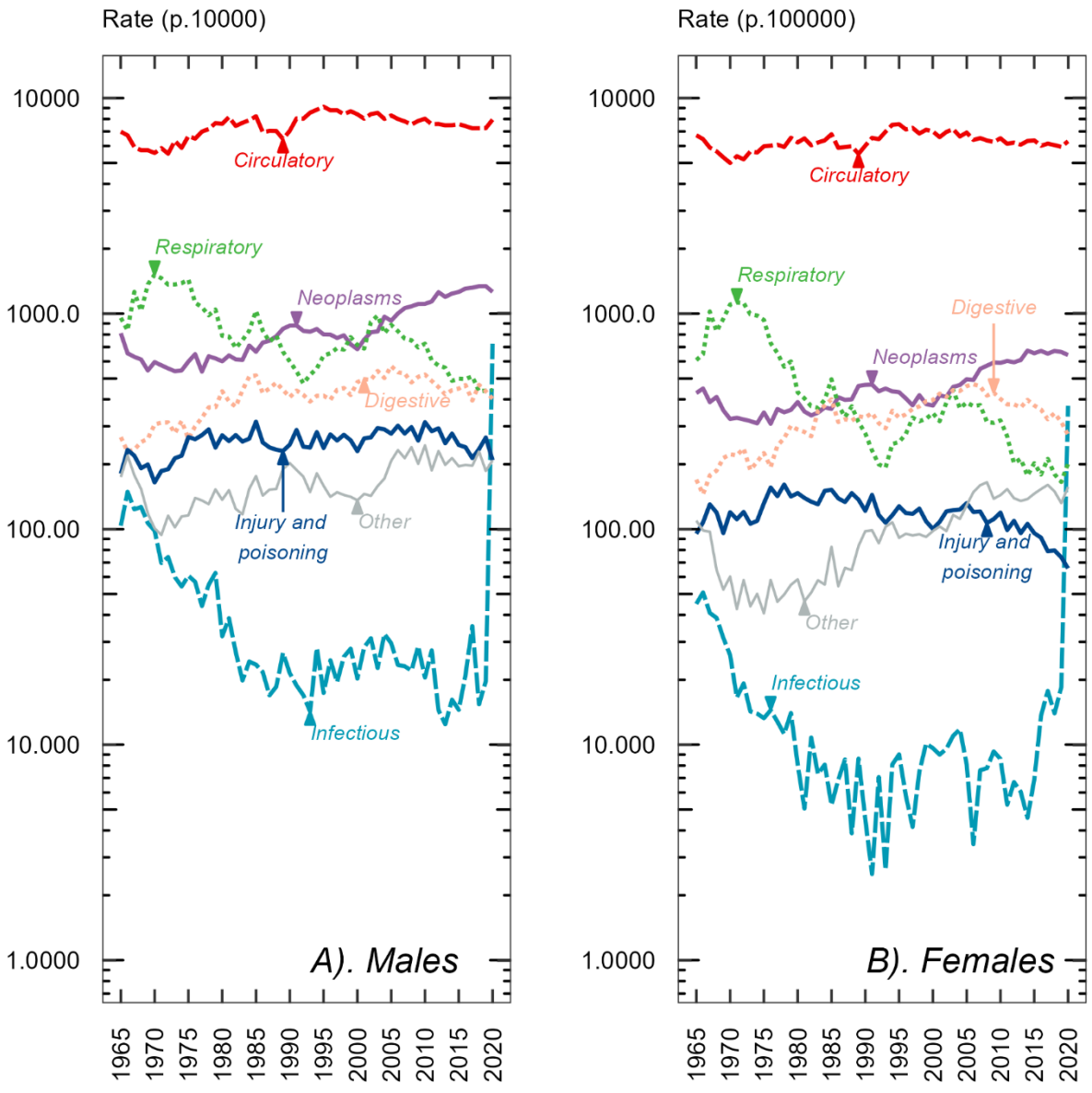


Fig. 4.14 1965-2020 trends in standardised death rates for main causes of death at age 65 and over, by sex (per 100000, semi-logarithmic scale)

Source: author's calculations based on NBS and NAPH data.

4.2.4.2. Mortality from circulatory system diseases among older adults

Figure 4.15 shows the evolution of mortality by sex and principal components of circulatory system diseases represented by heart diseases, cerebrovascular disorders and the residual group of cardiovascular diseases. The sex gap in cardiovascular mortality among the elderly was much narrower than among the middle-aged and was even absent in the late 1960s and early 1970s, mainly due to data quality problems (see Chapter 3).

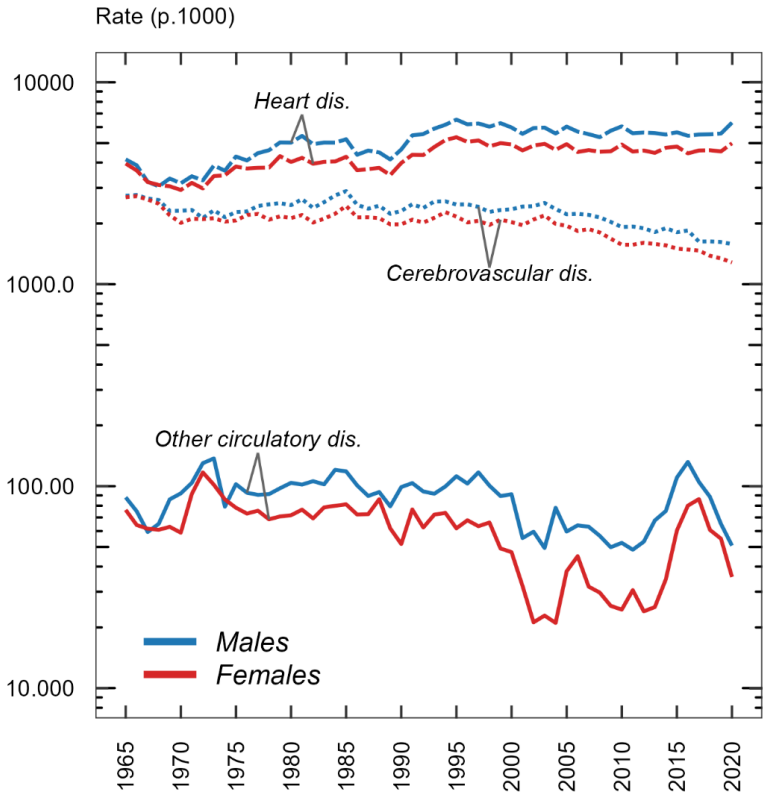


Fig. 4.15 1965-2020 trends in standardised death rates for main components of cardiovascular mortality at age 65 and over, by sex (per 100000, semi-logarithmic scale)
Source: author's calculations based on NBS and NAPH data.

The impact of the 1985 anti-alcohol campaign on old-age mortality from *heart disease* and cerebrovascular disorders was much less pronounced compared to the previous age group. By contrast, the socioeconomic crisis of the 1990s led to considerable growth in mortality from heart diseases; the standardised rates increased by 60% between 1991 and 1995 for both males and females. The increase was even higher when compared to corresponding changes among mature adults (50% and 40%, respectively). The response of old-age mortality caused by *cerebrovascular disorders* to the social and economic perturbations of the 1990s was much less marked.

Recent trends in old-age mortality from heart diseases and cerebrovascular diseases had no visible signs of amelioration until 2005, followed by a marked decline in mortality from cerebrovascular diseases more pronounced in women than men. On the other hand, old-age

mortality associated with heart diseases has continued the long-term deterioration until now. *Other circulatory system diseases* had a minor influence on cardiovascular mortality during the entire period. The proportion of the residual group of cardiovascular deaths barely exceeded 2%.

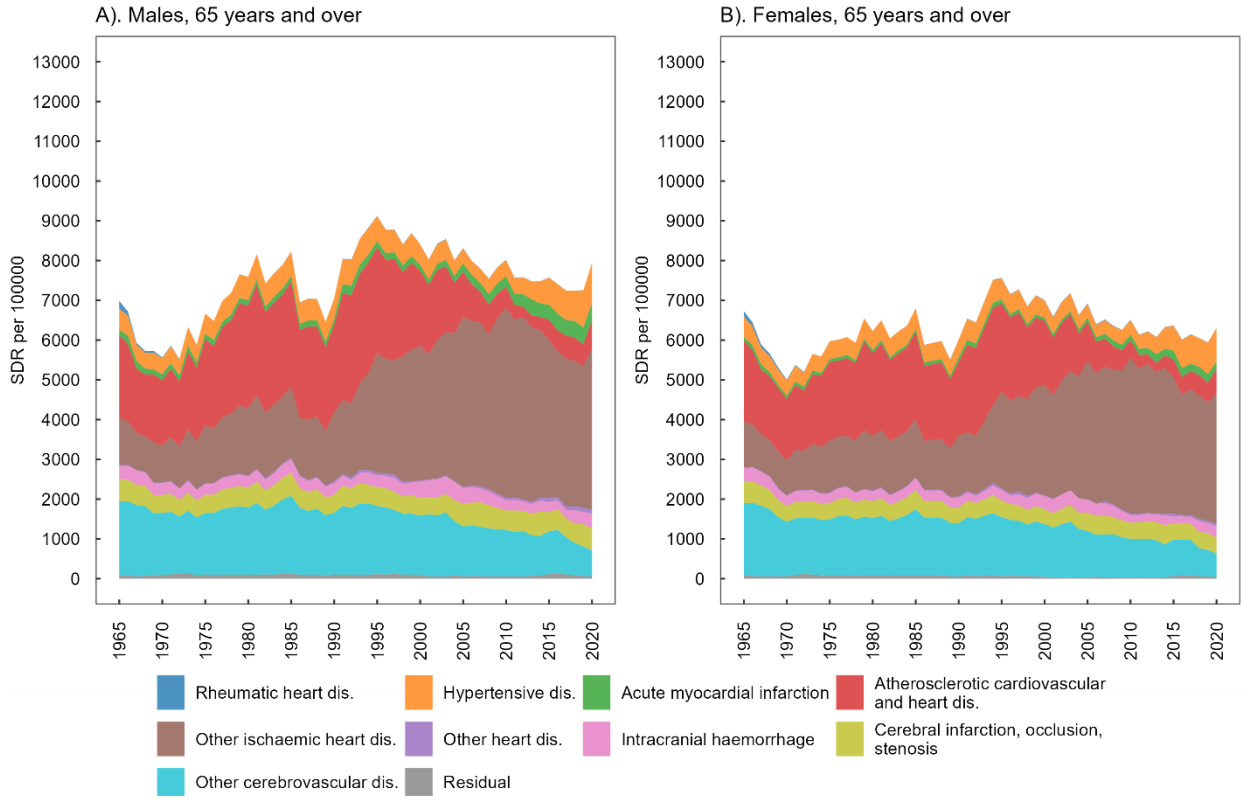


Fig. 4.16 1965-2020 trends in standardised death rates for detailed circulatory system diseases at age 65 and over, by sex (per 100000)

Source: author's calculations based on NBS and NAPH data.

Figure 4.16 shows the evolution of mortality from different nosological forms of circulatory system diseases among older adults. *Atherosclerotic cardiosclerosis* played a notable role in the Soviet codification system of heart diseases, particularly in older ages. In the early 1990s, 65% of deaths from heart diseases were attributed to *atherosclerotic cardiosclerosis* (I25.0-I25.1 under ICD-10). The introduction of the International Classification of Diseases and Causes of Death in 1991 caused a gradual reduction in deaths from cardiosclerosis. This decline was accompanied by a symmetric increase in deaths codified as *other ischemic heart diseases*, represented mainly by item I25.8 – *Other forms of chronic ischaemic heart disease*. In 2020, the share of deaths from atherosclerotic cardiosclerosis represented less than 10% of deaths from heart diseases, while the lion's share was attributed to other chronic ischaemic heart diseases. The reconstruction method cannot eliminate the gradual changes in coding practice for chronic ischaemic heart diseases, and the observed trends for the independence period should be interpreted with caution. At the same time, the contribution of more specific heart diseases, such

as *acute myocardial infarction* or *hypertensive heart diseases*, was relatively small but increasing over the past decade.

4.2.4.3. Mortality from respiratory system diseases among older adults

Among older adults, *chronic obstructive pulmonary diseases* are the most common cause of death from respiratory system diseases (Figure 4.17). This group accounts for 70% to 80% of all deaths from respiratory system diseases at different times. Following a marked reduction in the 1980s, old-age mortality from this pathology increased sharply during the socioeconomic crisis of the 1990s. From 2005 onwards, mortality from chronic pulmonary diseases has been on a steady downward path. However, an increase in *pneumonia* mortality has offset this recent progress in chronic obstructive pulmonary disease. *Other respiratory system diseases* were represented mainly by the "other affections of the respiratory system" widely used during the Soviet period to codify ill-defined respiratory system diseases. During the period of independence, this practice became progressively less frequent. In 2020, 1% of deaths from pulmonary diseases were attributed to this ill-defined pulmonary condition, compared to 15% in 1970 and 8% in 1985. This reduction can be explained by the more accurate diagnosis of pulmonary disorders and their less frequent codification under ill-defined conditions. Mortality from *pulmonary empyema and lung abscess* among older adults has decreased considerably since the mid-1970s.

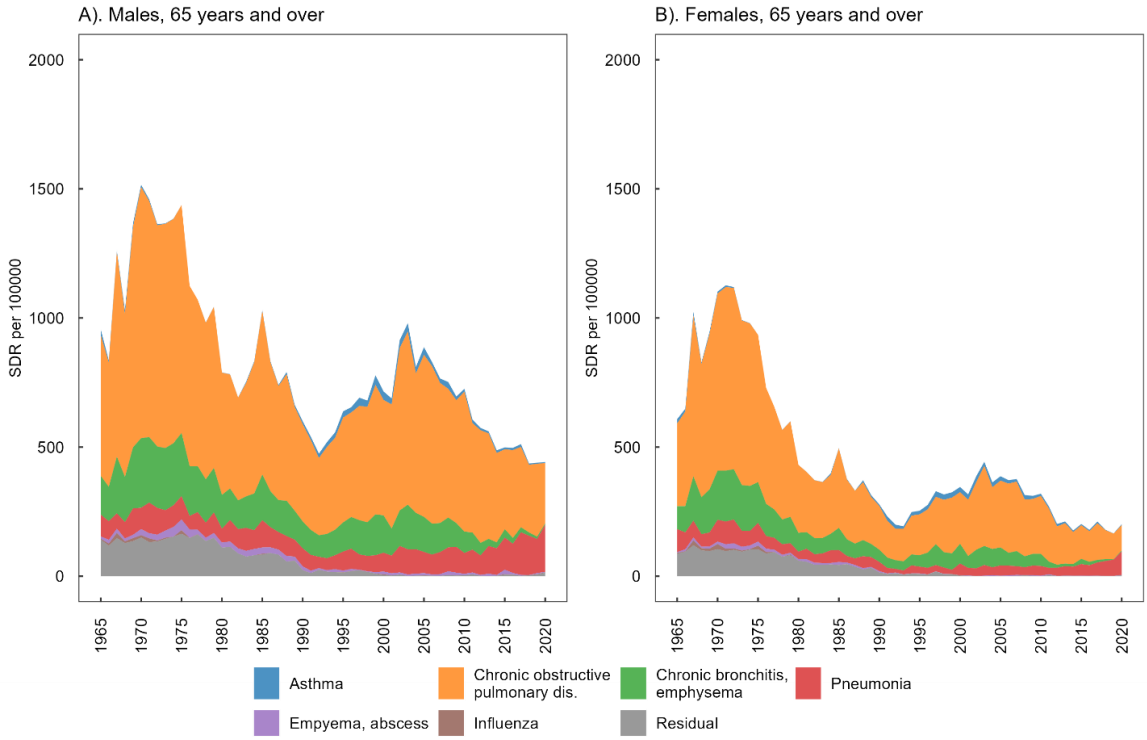
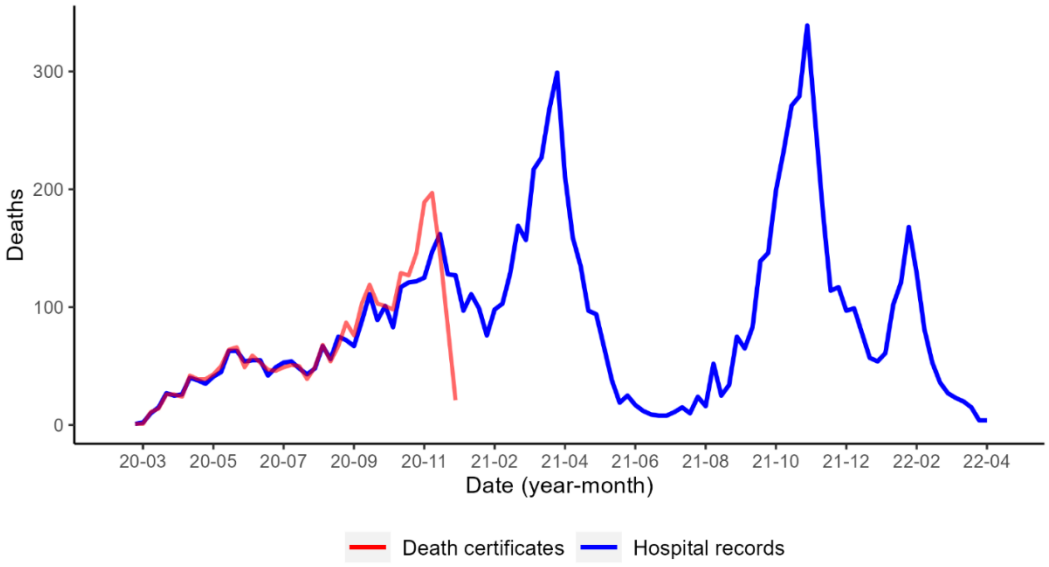


Fig. 4.17 1965-2020 trends in standardised death rates for detailed respiratory system diseases at age 65 and over, by sex (per 100000)

Source: author's calculations based on NBS and NAPH data.

4.3. COVID-19 mortality in Moldova

Figure 4.18 shows the evolution of COVID-19 deaths by week between 18/03/2020 and 19/04/2022 in Moldova based on two data sources. The first refers to hospital death records of laboratory-confirmed COVID-19 cases, while the second refers to medical death certificates with U07.1 as an underlying cause of death (see section 2.1.2.2). The date of hospital death records is the date of publication by the Ministry of Health. The date of death based on the medical certificate is the date of occurrence.



Death certificates, n = 2819 from 18/03/2020 to 31/12/2021
Hospital records, n = 2790 from 18/03/2020 to 31/12/2021
Hospital records, n = 9655 from 18/03/2020 to 19/04/2022

Fig. 4.18 COVID-19 deaths based on hospital death records between 18/03/2020 and 19/04/2022 and death certificate records between 18/03/220 and 31/12/2021 in Moldova by week (abs.)

Note: 1832 hospital death records were excluded (see section 2.1.2).
Source: author's calculations based on the MH and NAPH data

From 18/03/2020 to 19/04/2022 (762 days of the observation), at least four waves of the COVID-19 pandemic can be detected in Moldova, according to hospital death records. After a constant increase in COVID-19 deaths, the first wave took place in late 2020. The second wave occurred between early March and late April 2021, and its magnitude was much higher than the first wave. Following the improvement in the late spring/summer, the third wave was recorded in autumn 2021. Finally, the fourth wave occurred at the beginning of 2022, with a peak in February. The intensity of the last wave was much weaker than the second and third waves, but the duration was shorter than all three previous waves. The period between the second and third waves was much more extended (warm season) than between the first and second or the third and fourth (cold season). The maximum number of death (339 deaths) was recorded on the 87th week of the pandemic, between 08/11/2021 and 15/11/2021.

According to medical death certificates and hospital death records, the cumulative number of COVID-19 deaths was quite similar in 2020 (2819 vs 2790). Until the start of the first wave, weekly changes in COVID-19 deaths have almost coincided for both sources, i.e., the date of publication corresponded to the date of death. However, during the first wave, the publication of hospital death records was somewhat delayed over time relative to certificate death records. Medical institutions overburdened during the pandemic sent the data to the NAPH daily with an inevitable delay. Furthermore, according to medical death certificates, weekly deaths dropped sharply at the end of 2020, while hospital death records fell smoothly until mid-January 2021. A certain proportion of medical death certificates issued at the end of December are processed by the NAPH at the beginning of the following year.

Standardised death rates from COVID-19 for all ages (Figure 4.19) were somewhat higher in males than females during the four waves, especially in the first and last. On the other hand, during the periods between waves, the level of mortality did not differ considerably by sex. The maximum weekly standardised mortality associated with COVID-19 was 129 deaths per 1 million among males during the third wave.

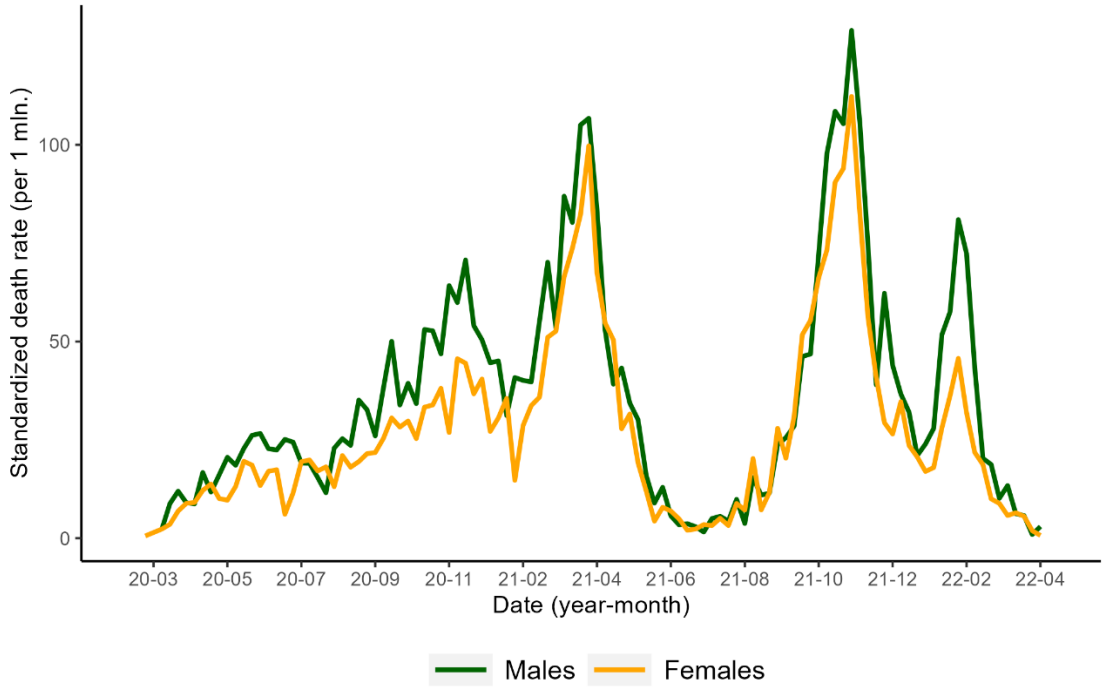


Fig. 4.19 Weekly standardised death rates by sex from COVID-19 based on hospital death records in Moldova between 18/03/2020 and 19/04/2022 (per 1 million)

Source: author's calculations based on the MH data

The same or close results were found for the two broad age groups, before and after 70 years old. The maximum weekly standardised death rate among adults aged 70 years and over was more than 550 deaths per 1 million among males during the third period. Moreover, an additional mortality peak was identified among men younger than 70 in May 2020 (Annexe 5).

Figure 4.20 shows the distribution of cumulative COVID-19 deaths by sex and age as of 31/12/2020 and 19/04/2022. As of 31/12/2020, the maximum number of deaths was registered in the 65-69 age group for both men and women. At that time, the median age at death was 67.0 years (IQR=60-73) for men and 67.5 years (IQR=61-74) for women, without statistically significant difference (p>0.05, Wilcoxon rank sum test). As of 19/04/2022, the maximum cumulative deaths related to COVID-19 occurred in the same age group for both sexes. However, there have been some changes in the distribution of deaths. The share of deaths among older males, particularly in the 70-74 and 85+ age groups, has risen markedly. Among females, the distribution of COVID-19-related deaths was essentially the same at both points in time, even though the contribution of the oldest age group rose. These structural changes probably reflect an improved diagnosis of COVID-19 infection in older adults. Consequently, as of 19/04/2022, the median age at death rose in males (69.0 years; IQR = 62-76) and females (70.0 years; IQR=63-77). However, like for the first time point, the difference in the median age at death among men and women was not statistically significant for the second time point (p>0.05, Wilcoxon rank sum test).

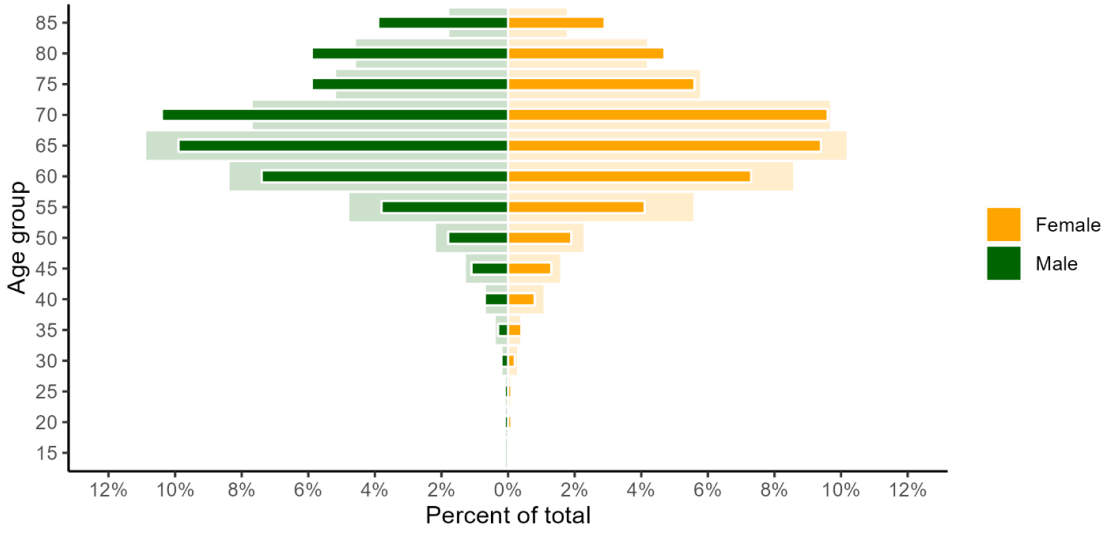


Fig. 4.20 Age and sex distribution of COVID-19 deaths as of 31/12/2020 and 19/04/2022 in Moldova (%)

Source: author's calculations based on the MH data

Excess mortality was analysed as the ratio of weekly probabilities of dying in 2020 to the average in the previous three years (2017-2019). The ratio computed for overall mortality followed an upward trend throughout the year since March and varied between 2.0 and 2.5 times in late 2020, when the first wave occurred (Figure 4.21).

Figure 4.22 shows excess mortality in 2020 by week and age for all causes of death and circulatory system diseases. Excess all-cause mortality among the population aged 40 years and

over at the end of 2020 was attributable to the COVID-19 pandemic. The results also pointed to the excess of deaths from circulatory system diseases among the population aged 85 and older in late 2020. This observation is most likely related to misdiagnosis and attribution of undiagnosed COVID-19 deaths to circulatory system diseases.

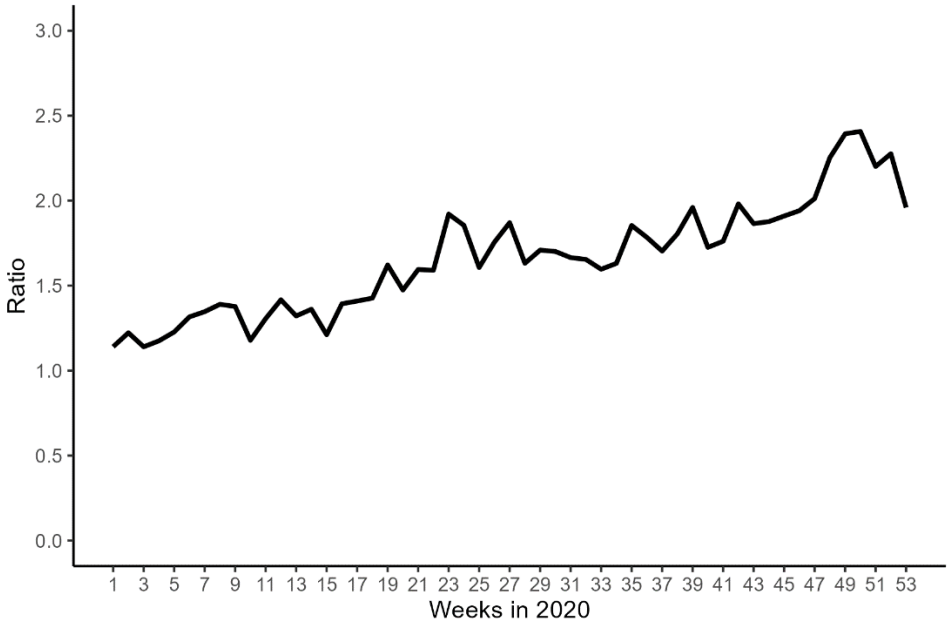


Fig. 4.21 Ratio of weekly probabilities of dying in 2020 to the 2017-2019 average for all ages and causes of death in Moldova, both sexes (times)

Source: author's calculations based on the MH and NAPH data

Between 2019 and 2020, life expectancy at birth dropped by 0.8 years in men (from 66.6 to 65.8 years) and 1.1 years in women (from 75 to 73.9 years). Figure 4.23 illustrates the results of the decomposition of the difference in life expectancy at birth between two years. Among men, the reduction in life expectancy was primarily attributed to infectious diseases (-0.6 years) and circulatory system diseases (-0.2 years). Among women, the rise in mortality from infectious diseases was also the principal component of the life expectancy decline (-0.8 years), but the impact of circulatory system diseases was less noticeable (-0.2 years). The most considerable growth in mortality from infectious diseases in 2020 occurred between 50 and 79 years in men and between 45 and 79 years in women. The increase in cardiovascular mortality in 2020 was most significant in older age groups. As mentioned before (see section 4.2.4.2), positive trends in old-age mortality from circulatory system diseases have been observed since 2005. The excess deaths from cardiovascular diseases among the older population during the first COVID-19 wave resulted from the under-registration of COVID-19 deaths.

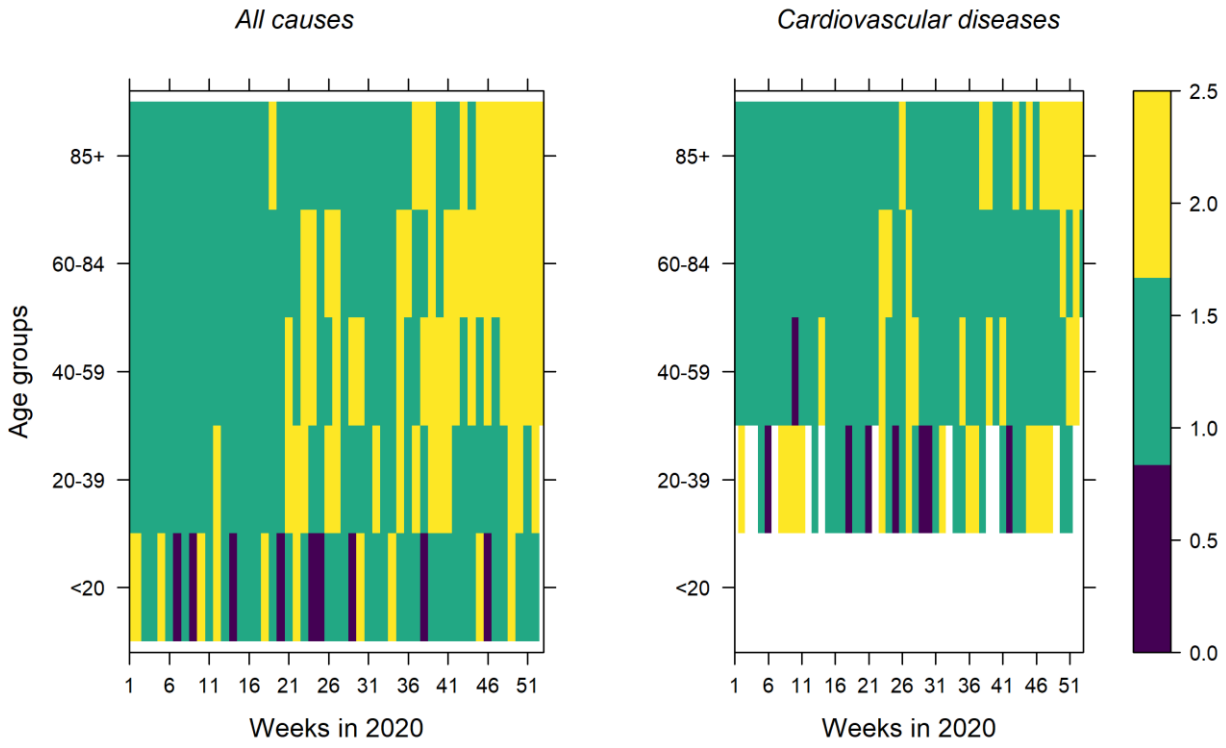


Fig. 4.22 Ratio of weekly probabilities of dying in 2020 to the 2017-2019 average by age for all causes of death and circulatory system diseases in Moldova, both sexes (times)

Source: author's calculations based on the MH and NAPH data

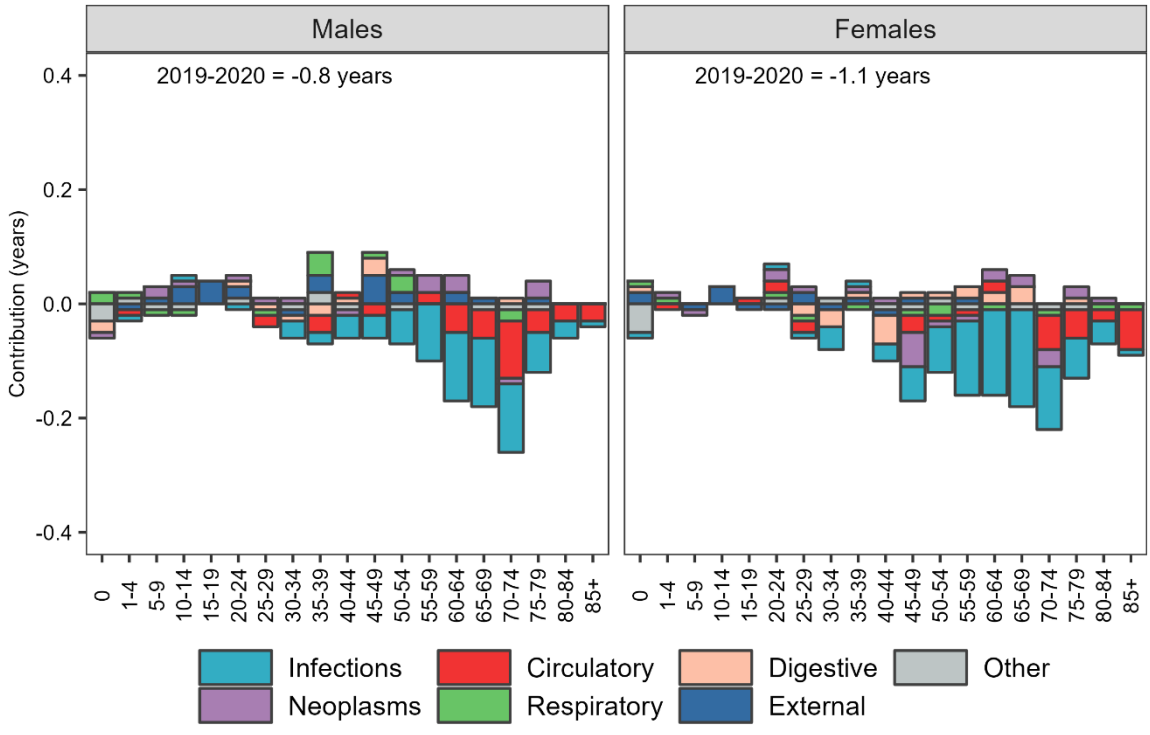


Fig. 4.23 Decomposition of the changes in life expectancy at birth between 2019 and 2020 by age and cause of death in Moldova, by sex (years)

Source: author's calculations based on the MH and NAPH data

4.4. Excess mortality in Moldova compared to the European model

This section is devoted to analysing excess (excessive) mortality in Moldova compared to the European model. The study defines excess mortality as the difference between life table deaths in Moldova and the European model ($d_x^{Moldova} - d_x^{Model}$). Life table deaths by sex, age and cause (d_x) were computed based on the multiple decrement life tables. The sum of life table deaths for all ages and causes of death is equal to the life table radix (100000 deaths). The radix can also be interpreted as a hypothetical cohort (100000 new-borns). The European model represents the average death rates for two Central (the Czech Republic and Poland) and Western (Germany and England and Wales) European countries (see Chapter 2). The study covers the 2001-2019 period, omitting the COVID-19 pandemic.

Figure 4.24 illustrates the evolution of life expectancy at birth in Moldova, the four selected European countries and the European model since 2001. The differentiation in life expectancies between the four European countries in females is much less marked than in males. In Moldova, the indicator remained unchanged until 2005, followed by modest progress. Between 2001 and 2019, life expectancy at birth increased by 2.7 years for males (from 63.9 years to 66.6 years) and 3.6 years for females (from 71.4 years to 75.0 years).

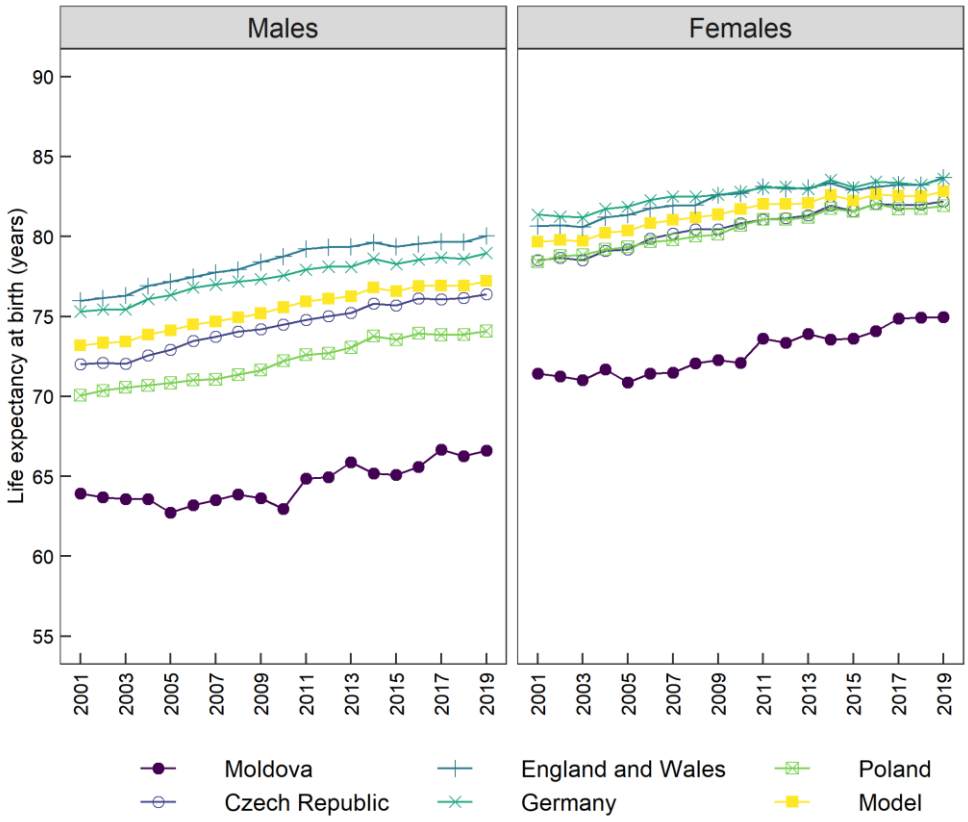


Fig. 4.24 Life expectancy at birth in Moldova as compared to European countries and their average model, 2001-19, by sex

Source: author's calculations based on NBS and NAPH data.

In 2019, Moldovan women lived 9.0 years less than women from England and Wales and 7.0 years less than women from Poland and the Czech Republic. Among men, this gap varied between 7.0 years (Poland) and 13 years (England and Wales). The gap in life expectancy between Moldova and the average model rose until 2010 for both sexes. Between 2001 and 2010, it increased from 9.0 to 13.0 years in males and from 8.0 to 10.0 years in females. As a result of some progress in life expectancy over the past decade, Moldova has narrowed this gap, but it remained large, representing 11 years for men and eight years for women.

Figure 4.25 illustrates the age-specific distribution of life table deaths from all causes combined in Moldova and the European model. In the model, life table deaths were shifted to older ages, particularly to the age group of 85 years and over. In the model, the life table deaths concentration in the age groups of 75 years and over was 64% in males and 80% in females. At the same time, in Moldova, these figures were 36% and 62%, respectively. The contribution of the age group of 85 years and over was especially marked in females. For example, in 2019, over half of the female life table deaths were attributable to this age group in the model and 25% in Moldova. Life table deaths in Moldova were considered excessive compared to the European model when the difference between Moldova and the model was more than zero. Excess deaths for all causes of death concentrated predominantly in men aged 30 to 70 and women aged 50 to 80.

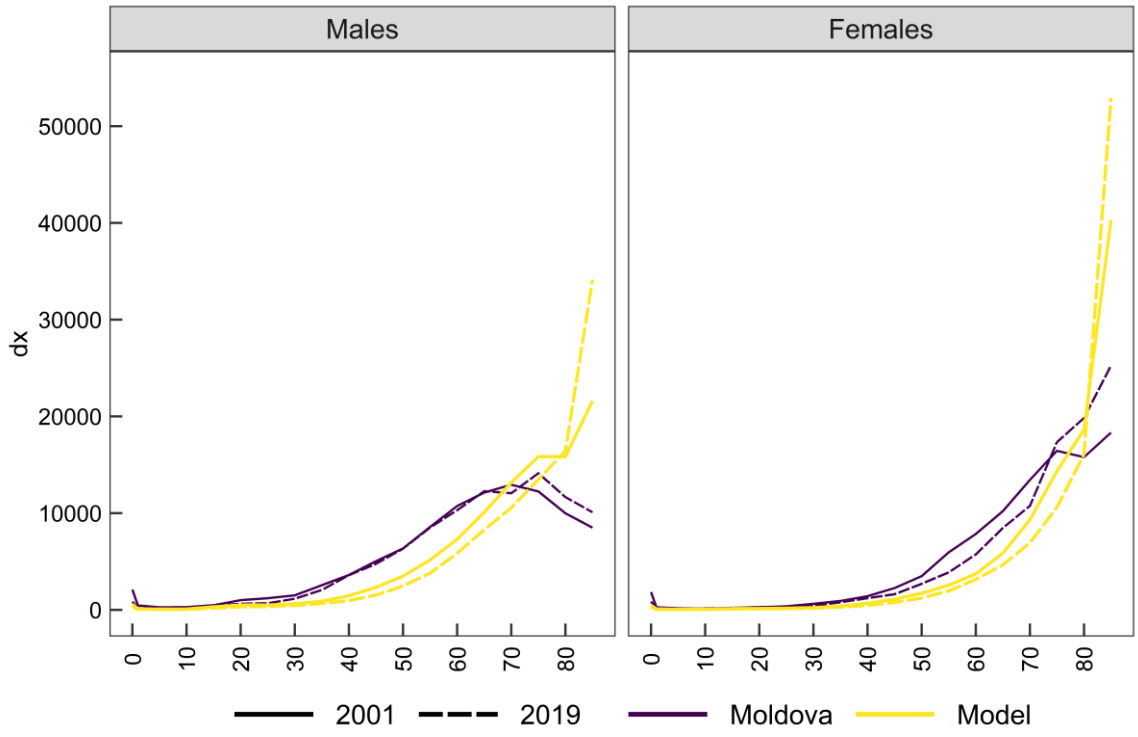


Fig. 4.25 Distribution of life table deaths from all causes in Moldova and the model in 2001 and 2019 by age and sex

Note: The sum of life table deaths is equal to the radix of the life table (100000)
Source: author's calculations based on NBS and NAPH data.

In the model, between 2001 and 2019, life table deaths were redistributed from older age groups (60 years and over) to more advanced ages, especially 85 years and over. Similar changes, though much less pronounced, have occurred in Moldovan women. At the same time, no significant changes were observed in Moldovan men, for whom the two lines in 2001 and 2019 nearly overlapped in the figure above.

Table 4.1 shows the distribution of life table deaths and excess life table deaths by leading cause in the age groups before 70 in 2001 and 2019. The number of life table deaths fell marginally among men: from 56 thousand in 2001 to 52 thousand in 2019, or by 8%. In other words, out of 100 male new-borns, 56% would die under 70 years old in 2001 and 52% in 2019 if age-specific death rates were the same as in the corresponding years during their life. Among females, life table deaths under 70 declined from 36 thousand in 2001 to 27 thousand in 2019. In such a way, in 2019, 27% of female deaths occurred under 70.

Table 4.1 Life table deaths and excess deaths under 70 in Moldova compared to the European model by cause of death in 2001 and 2019, males, per 100000 deaths (abs., %)

Cause of death	Life table deaths		Excess life table deaths	
	2001	2019	2001	2019
Males				
Infectious diseases	1983 (4%)	1093 (2%)	1661 (7%)	827 (3%)
Neoplasms	9120 (16%)	10966 (21%)	-1905 (-8%)	2620 (10%)
Circulatory system diseases	19623 (35%)	19039 (37%)	7963 (35%)	11964 (45%)
Respiratory system diseases	4384 (8%)	3680 (7%)	2841 (12%)	2026 (8%)
Digestive system diseases	7187 (13%)	6694 (13%)	5163 (23%)	4575 (17%)
External causes of death	10358 (13%)	7755 (15%)	6472 (28%)	4465 (17%)
Other diseases	3674 (7%)	2829 (5%)	589 (3%)	210 (1%)
All causes of death	*56328 (100%)*	*52057 (100%)*	*22782 (100%)*	*26686 (100%)*
Females				
Infectious diseases	525 (1%)	472 (2%)	348 (2%)	323 (2%)
Neoplasms	6419 (18%)	7031 (26%)	-1197 (-6%)	708 (5%)
Circulatory system diseases	15242 (42%)	9991 (37%)	10273 (55%)	7391 (55%)
Respiratory system diseases	1456 (4%)	1020 (4%)	659 (4%)	67 (0%)
Digestive system diseases	6010 (17%)	4523 (17%)	5055 (27%)	3537 (26%)
External causes of death	3044 (8%)	1571 (6%)	2088 (11%)	696 (5%)
Other diseases	3303 (9%)	2205 (8%)	1384 (7%)	630 (5%)
All causes of death	*35998 (100%)*	*26813 (100%)*	*18610 (100%)*	*13352 (100%)*

Source: author's calculations based on NBS and NAPH data.

The distribution of life table deaths under the age of 70 by leading cause in 2019 was characterized by the predominance of circulatory system diseases (37%) followed by neoplasms

(21% in males and 26% in females), external causes of death in males (15%) and digestive system diseases (13% in males and 17% in females). The cause-specific mortality pattern in 2001 was quite close, with an increasing contribution of neoplasms and a declining impact of circulatory system diseases. This pattern corresponds to the mortality patterns observed based on standardised death rates (see section 4.2).

Excess life table deaths accounted for 27 thousand deaths per 100 thousand deaths among men and 13 thousand deaths among women. In other words, for every 100 thousand deaths in Moldova, 27 thousand deaths in males and 13 thousand in females are considered excessive compared to the European model. Since the life table radix is the size of a hypothetical cohort (100%), one can ascertain that 27% of male and 13% of female new-borns die under 70 excessively compared to the model.

The cause-specific mortality pattern of excess life table deaths differs from that observed for life table deaths. In 2019, circulatory system diseases were responsible for about one in two excess deaths in males (45%) and females (55%) under 70. Among men, the other two main causes were digestive system diseases (17%) and external causes (17%). Among women, excess deaths from digestive system diseases accounted for 26% of the overall excess mortality under 70. The influence of other causes, including neoplasms, was 10% or less.

During the study period, excess life table deaths rose by 17% in men (from 22782 to 26686 table deaths), while in women, the corresponding figures were reduced by 28% (from 18610 to 13352 table deaths). Excess life table deaths for both sexes declined for all main causes except for neoplasms and circulatory system diseases in men. At the start of the period, excess deaths under 70 related to neoplasms were even negative due to lower cancer mortality than in the European model. Neoplasm excess morality was negative until 2008 for both sexes.

Figure 4.26 shows the age-specific distribution of life table deaths in males for circulatory and digestive system diseases, external causes of death and neoplasms in Moldova and the European model. Among Moldovan men, the life table deaths from circulatory system diseases started rising after 30-40 years, with a peak of deaths around the age group 70-74 years, followed by a fall. Among European men, the life table deaths from circulatory system diseases began to increase after 40-50 years, and the increase was smoother, with a peak of deaths in the last age group.

For digestive system diseases, the divergence in male life table deaths between Moldova and the European model started even after 20 years, while for external causes from age 0. The increase in life table deaths in Moldova was abrupt for these two conditions, peaking at age 50. At the same time, in the model, male life table deaths were shifted to the age group of 85 years and

over, though two classical waves around 20 and 50 years were noted for external causes. The distribution of life table deaths attributed to neoplasms among Moldovan and European males aged under 60 years old was almost identical. However, in old age groups, the concentration of deaths decreased abruptly in Moldova but continued to increase in the model.

In 2001 and 2019, life table deaths from circulatory and digestive system diseases among Moldovan men followed the same age pattern. Life table deaths from external causes declined in young and middle-aged adults, while neoplasm deaths increased after the age of 50 in 2019 compared to 2001 without altering the age profile.

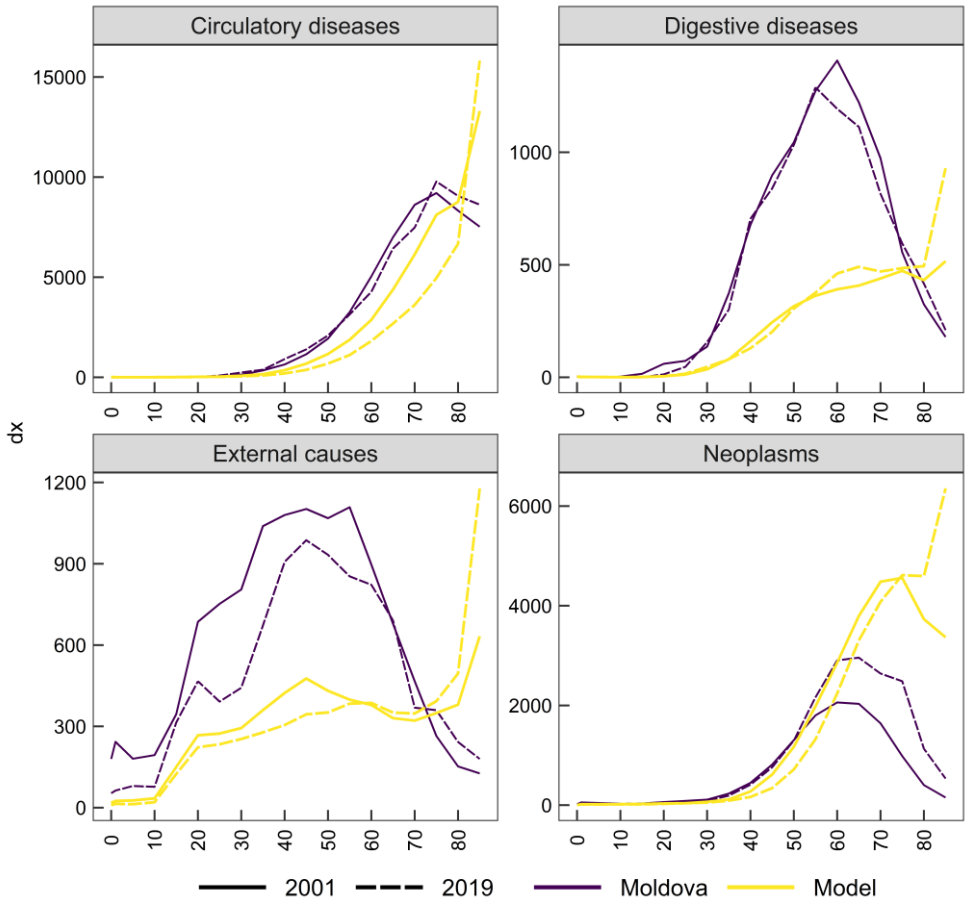


Fig. 4.26 Distribution of life table deaths by age from circulatory diseases, digestive diseases, external causes of death and neoplasms in Moldova and the model in 2001 and 2019, males

Source: author's calculations based on NBS and NAPH data.

4.5. Discussion for Chapter 4

The study presented in Chapter 4 aimed to examine the long-term trends in overall and cause-specific mortality and to identify the major risk groups responsible for excess mortality in Moldova, relative to the European model.

We hypothesized that the absence of marked progress in life expectancy at birth over the last 55 years in Moldova resulted from different trends in age and cause-specific mortality.

Different age groups reacted differently in terms of medical causes of death to the socioeconomic perturbations that affected the country. Although unfavourable mortality trends have been observed for a wide range of causes of death, the historical lag between Moldova and the Western countries is attributable to a restricted number of causes of death and age groups.

The continuous time series of deaths reconstructed for Moldova according to the groups of ICD-10 items for the 1965-2020 period were used. The data were adjusted for incomplete death registration in infancy and older ages, especially in the 1960s and 1970s (see section 3.2). We also relied on the reconstructed mortality series for Ukraine, Romania and the countries selected for the European model [128, 177]. The reconstructed series available in the HCD database made it possible to compare mortality trends safely across the three countries and time. The author reconstructed the time series of deaths for Moldova and Romania implemented in the HCD database (Annexes 16 and 17). COVID-19 deaths published daily by the MH as individual death records during the pandemic were collected by the author and processed according to the international database "The Demography of COVID-19 Deaths" protocol (Annexe 18).

The study's main *limitation* was the availability of the reconstructed mortality series. For Ukraine, the 1965-2014 reconstructed mortality series were prolonged with crude data after excluding the temporarily occupied territories of the Autonomous Republic of Crimea, the regions of Donetsk and Luhansk. For Romania, the unreconstructed data were used for the 1965-1979 period. However, the comparative analysis for the three countries was done by leading causes of death, excluding the discontinuity problem in the time series induced by periodic changes in classification.

Main findings and discussion

A) Mortality trends and patterns in Moldova compared to Romania and Ukraine

In the three countries, life expectancy at birth over the past five decades has evolved under different social, economic and political conditions. In Moldova and Ukraine, the FSU republics, the overall downward trend in life expectancy was punctuated by the 1985 antialcohol campaign and the severe socioeconomic crisis of the 1990s. In Romania, the 1989 revolution and the collapse of the communist regime significantly impacted the population's health.

The Soviet government started implementing specific measures to combat alcoholism at the beginning of the 1980s; the most dramatic results were achieved during the campaign launched by Mikhail Gorbachev in May 1985 [178]. The two-year campaign featured harsh administrative measures to limit public access to alcohol. Production and sales of alcoholic beverages were cut nearly three times in the State sector, the price of alcohol was increased, severe penalties were imposed for home alcohol production, and networks of narcological facilities for the compulsory

treatment of alcoholism, known as medical-labour dispensaries, were expanded [16]. In Moldova, a traditional wine-making and wine-consuming country, massive areas of vineyards were cut off. Between 1984 and 1987, areas under vines declined by 20%, and the annual gross harvest of grapes decreased by a third [179, 180]. The collapse of the USSR and an abrupt transition to a market economy caused a severe socioeconomic crisis in the FSU countries. In 1993, the soaring inflation reached 1183% in Moldova and 3691% in Ukraine [181].

Based on the analysis of age-specific mortality trends relative to 1965, periods of deterioration and improvement were detected for the three countries. In Moldova and Ukraine, the long-term deterioration in population health continued through 2005, followed by moderate improvements. After decades of stagnation in Romania, life expectancy has consistently increased since 1997. In the three countries, the increase in mortality from circulatory system diseases and external causes of death among adults was responsible for the long-term deterioration in population health. Middle-aged males were the most affected age and sex group. The same medical conditions accounted for the life expectancy increase during the improvement period. In Moldova, the impact of digestive system diseases on a decrease in life expectancy until 2005 was pronounced for both sexes.

In the three countries, mortality from *circulatory system diseases* had very similar values in the early 1970s, at the start of a long period of deterioration in population health, and in the late 1980s, at the height of the anti-alcoholic campaign launched by the Soviets. The mortality growth during the Soviet period and the reaction to the social perturbations after the political transition were much more potent in Moldova and Ukraine than in Romania. Furthermore, the harsh anti-alcohol measures of the mid-1980s showed that cardiovascular mortality was highly dependent on alcohol consumption in the FSU. Improvements in cardiovascular mortality in Romania after 1997 were observed for the three major components: heart diseases, cerebrovascular diseases and other circulatory system diseases. At the same time, in Ukraine and Moldova, recent advances have been mainly associated with declining mortality from cerebrovascular diseases, while heart disease remains the major public health challenge [182].

Unlike cardiovascular mortality, mortality from *neoplasms* was insensitive to the socioeconomic perturbations in the three countries in the late 1980s and 1990s [183]. The effect of cancer mortality on life expectancy at birth during the deterioration and improvement periods was nearly invisible. The recent upward trend in cancer mortality in Moldova is more similar to Romania, which contrasts with the situation in Ukraine, where a decline or stagnation occurred since independence.

In Moldova and Ukraine, the rapid rise in cancer mortality among males in the 1980s and a steep decline in the 1990s were mainly related to lung cancer [32, 183]. In the FSU countries, the rise in cancer mortality in the 1980s was directly connected to the growing spread of tobacco consumption and environmental pollution due to rapid industry and agricultural development. By contrast, the economic recession at the end of the 1980s, followed by the socioeconomic crisis of the 1990s, reduced industrial and agricultural pollution and tobacco consumption in these countries [32].

Shkolnokov et al. suggested several hypotheses to explain the rapid increase in cancer mortality in the 1980s, followed by the sharp decline in the 1990s in Russia and Ukraine [184, 185]. The authors pointed to considerable under-registration of cancer deaths in the older population, particularly in rural settings, and new coding practices in the 1980s. According to a directive issued by the Soviet Ministry of Health in 1989, if a cardiovascular disease was a co-morbidity to malignant neoplasm, the latter had to be codified as an underlying cause of death. The development of territorial networks of cancer dispensaries in the former republics, including Moldova, could also partially explain the increase in cancer mortality in the 1980s. Shkolnokov et al. also attributed the reduction in lung cancer mortality in the 1990s among middle-aged males to a cohort effect and a simultaneous sharp rise in mortality from competing causes of death like circulatory system diseases and violent deaths [184, 185].

External causes of death and *digestive diseases* are two health conditions closely related to excessive alcohol consumption. The influence of alcohol-related mortality during a period of deterioration had a more considerable effect on men's health in Moldova and Ukraine than in Romania. The increase in mortality from external causes among men during the socioeconomic crisis of the 1990s was much more significant in Ukraine than in Moldova. At the same time, exceptionally high mortality due to liver disease distinguishes Moldovan mortality pattern from that of the other two countries. Women's health was much more vulnerable to alcohol-related mortality in Moldova than in Romania or Ukraine. The rapid decline in life expectancy among Moldovan women in the 1970s was mainly attributable to an unprecedented increase in liver cirrhosis mortality. The maintenance of high values for this cause of death explains the poor health of Moldovan women compared to the women of Romania or Ukraine [186].

Differences in drinking behaviour reflect differences in alcohol-related mortality in the countries studied. Romania and Moldova have the characteristics of a Mediterranean alcohol consumption pattern, in which the daily use of wine is customary. However, unlike Romania, Moldova experiences a hazardous variation of the Mediterranean culture of alcohol consumption, with a high proportion of unregistered alcohol largely represented by homemade wine [187].

Ukraine is closer Northern European drinking pattern with the predominance of beverages that contain a high percentage of alcohol [188]. Further, Ukraine is one of the countries experiencing the riskiest drinking patterns, such as binge drinking [189]. These traditional regional patterns were mixed with other patterns of alcohol consumption in the Soviet era and after the collapse of the communist regime. For example, in Moldova, the transitional period of the 1990s was accompanied by an increasing proportion of spirits in recorded alcohol consumption. In recent decades, beer has gradually substituted wine in Romania and spirits in Ukraine [189, 190]. These incremental changes in drinking patterns, accompanied by a decline in total alcohol consumption, have led to changes in external causes of death throughout the improvement period in the three countries.

The elevated prevalence of hepatitis B and C in the FSU countries is also critical in high mortality rates for liver cirrhosis. The prevalence of hepatitis B carriers in the 1990s had similar values in Moldova (8-12%) and Ukraine (8.3%) [191–193]. Before introducing the compulsory immunization of infants in Moldova in 1994 [194], viral hepatitis played a significant role in the public health system, particularly in children and pregnant women [195].

B) Mortality trends by age and cause of death in Moldova

This section focused on analysing mortality trends by detailed causes of death and sex across five broad age groups. Improvements in *infant mortality* over the period are quite considerable and primarily related to advances in post-neonatal mortality from various exogenous factors, first and foremost pneumonia and acute intestinal infections. On the other hand, perinatal conditions, primarily related to endogenous risk factors, stagnated until the beginning of the millennium, followed by improvements. These advances in neonatal mortality, especially obstetrical trauma, can be explained by implementing national perinatal programmes [196]. In *children and adolescents*, the overall downward trend in mortality is also reflected in the detailed causes of death, such as transport accidents, pneumonia, and acute respiratory conditions.

Mortality among *young adult* males, dominated by external causes of death, was sensitive to the 1985 anti-alcohol campaign. The pattern of external mortality in this age group was strongly influenced by suicide and transport accidents. The socioeconomic crisis of the 1990s did not accelerate the growth in mortality caused by injury and poisoning among young adults in Moldova as it did in Ukraine [32] or Russia [42]. On the contrary, since the early 1990s, mortality associated with violent deaths among young Moldovan men has declined moderately, except for the war conflict in Transnistria in 1992. The socioeconomic crisis caused a deep decline in mortality from transport accidents. Lower incomes and gasoline shortages in the 1990s reduced the risk of fatalities in motor vehicle accidents. Similar findings were observed in other post-Soviet countries

[42, 43]. Recent improvements in mortality among young adults focused on different conditions associated with external causes of death without progress in suicide mortality.

Mortality among *mature adult males* was most susceptible to the socio-economic factors of the 1980s and 1990s. Among middle-aged men, the long-term deterioration in population health (1965-2004) was associated with mortality growth or stagnation for leading causes of death. The exception was mortality from infectious diseases, which declined continuously during the Soviet period, followed by growth after independence. Between 2005 and 2019, some moderate improvements occurred in mortality from respiratory and digestive system diseases, external causes of death and infectious diseases. However, the mortality level was higher or the same in 2019 compared to 1965. The long-term trend in cardiovascular mortality among middle-aged males, disregarding the fluctuations induced by the anti-alcohol campaign and the socioeconomic crisis, has maintained an elevated level until now.

More attention was paid to *cancer mortality* among middle-aged adults. In Moldova, like in Ukraine, a decline in lung cancer mortality among middle-aged males in the 1990s contrasts with an immense rise in deaths from circulatory system diseases and external causes of death. To explain this phenomenon, we accepted the hypothesis on competing risks proposed by Shkolnokov et al. The rapid increase in mortality from circulatory system diseases and accidents caused by the socioeconomic crisis of the 1990s increased the risk of dying from these causes among people with cancer [185, 197]. When the crisis ended, the upward trend in lung cancer mortality resumed. The lack of progress in mortality from *uterus cancer* since the mid-1980s and the rapid increase in *breast cancer* mortality are related mainly to insufficient screening programmes and diagnostic capacities. Moldova has the highest proportion of cervical cancer (>50%) among the FSU countries diagnosed at late stages (II-IV) [198].

The opposite trends in mortality from *stomach* and *intestine cancer* can be observed in all industrial countries and are attributable to changing traditions regarding food preparation and eating habits. Other studies demonstrated that the reduction in stomach cancer mortality was closely related to increasing variety in a diet. On the other hand, the growth in mortality from intestine cancer was positively correlated with meat and animal fat consumption [199].

Cirrhosis of the liver is a significant burden to the health of the Moldovan population, especially women. A dramatic increase in mortality from this cause of death, especially before the 1985 anti-alcohol campaign, explains a striking divergence in female life expectancy trends between Moldova and other former Soviet republics, like Ukraine or Russia, which have been significantly less affected by this disease [17]. The lack of sex difference in mortality from liver diseases is a characteristic that distinguishes Moldova from other countries where this pathology

had a high impact on the total mortality pattern in the past, such as France [18] or Hungary [27]. At the same time, for diseases of the pancreas and gastric and duodenal ulcers, whose mortality is associated with excessive consumption of strong alcoholic beverages, the differences between the sexes are clearly stated.

Trends in mortality among *older adults* were much less affected by the events of the 1980s and 1990s, although the socioeconomic crisis of the 1990s had a considerable impact on mortality from circulatory system diseases. Since 2005, the situation has improved for old-age mortality from several causes of death, such as cerebrovascular diseases, chronic obstructive pulmonary diseases, liver cirrhosis and some external causes of death. Again, like among middle-aged adults, the progress was more marked in women than men.

Among older adults, the recent progress in cardiovascular mortality was related to a decline in mortality from cerebrovascular disorders. At the same time, mortality due to heart disease and other circulatory system diseases among older adults has remained high for several decades. The low differentiation of cardiovascular mortality in Moldova, particularly heart diseases, can be found in Ukraine and other FSU countries. The cardiovascular mortality pattern in these countries is characterized by a relatively small share of deaths related to the residual group of circulatory system diseases [182]. Other studies showed a wide-ranging practice of attributing ill-defined heart diseases in the older population to so-called "atherosclerotic cardiosclerosis" (I25.1 under ICD-10) [32]. In Ukraine, this practice continues, with the proportion of atherosclerotic cardiosclerosis in more than 50% of all cardiovascular and 70% of ischaemic heart diseases. In Moldova, with the adoption of ICD-9 in 1991, deaths earlier codified as atherosclerotic cardiosclerosis have been attributed to unspecified ischaemic heart disease (I25.8 under ICD-8). However, the unsatisfactory diagnosis of heart disease does not detract from the general perception of the epidemiological situation in Moldova. Moreover, similar mortality from circulatory system diseases in Moldova and Ukraine and some Central European countries like Poland or Romania in the 1970s indirectly points to a relatively satisfactory registration of cardiovascular deaths as a whole class [182].

C) COVID-19 mortality in Moldova

During the pandemic, the COVID-19 deaths registration system in Moldova was limited to laboratory-confirmed cases recorded in hospitals or at home. In 2020, the hospital death records statistics were consistent with medical death certificate data where COVID-19 was indicated as an underlying cause of death. However, the study demonstrated that in 2020, COVID-19 deaths were under-registered, especially among the elderly. In particular, excess mortality at older ages during the first wave in late 2020 was attributed to cardiovascular disease. In 2021, the registration of COVID-19 deaths improved due to better testing capacities. The male-to-female ratio for COVID-

19 mortality increased among older adults. The pandemic markedly affected life expectancy at birth for both sexes. The impact of COVID-19 is expected to be much higher in 2021 than in 2020, considering the magnitude of the infection in 2021.

D) Excess mortality in Moldova compared to the European model

This section examined excess mortality in Moldova compared to the European model from 2001 to 2019. The model let us consider not only the experience of Western Europe, which benefited from the cardiovascular revolution in the 1970s [21] but also that of Central Europe, where the health improvements started much later [28]. We compared the distribution of life table deaths in Moldova to the selected model to identify excess deaths by age and cause. These age and cause-specific groups are considered *risk groups of excess mortality* since they account for Moldova's lag behind the European model. Despite recent progress in population health, the gap in life expectancy between Moldova and the model widened in males and stagnated in females.

The distribution of life table deaths by cause corresponded to the cause-specific mortality pattern in the country, with circulatory system diseases and neoplasms as the two main causes of death. On the other hand, the distribution of excess life table deaths had another profile. The lion's share of excess mortality was attributable to circulatory and digestive system diseases in both sexes and external causes of death in males [200]. The decomposition results detected these causes of death as the principal causes contributing to long-term unfavourable trends in life expectancy in Moldova. Neoplasms did not significantly impact the excess mortality in Moldova compared to the model, even though this disease is the second most frequent cause of death. The negative contribution of neoplasms to excess mortality has increased over the past decade and will accelerate in the future, as unfavourable trends in Moldova contrast with progress in advanced countries [198, 201].

Our study showed that the recent increase in life expectancy at birth in the country was accompanied by a decline in excess mortality in females but not males. Among females, the cardiovascular component had a fundamental impact on this progress. Excess mortality in males decreased mainly from external causes of death, while long-term adverse trends in cardiovascular mortality continue to widen the gap between Moldova and European countries. The shift in the distribution of life table deaths towards older ages is considered a good sign of sustainable future growth in female life expectancy.

4.6. Conclusions for Chapter 4

1. Based on the analysis of life expectancies at birth and age-specific death rates since 1965, the periods of long-term deterioration and improvement in population health were identified for Moldova, Romania and Ukraine. In Moldova and Ukraine, disregarding the wide fluctuations in

mortality induced by the 1985 anti-alcohol campaign and the socioeconomic crisis of the 1990s, life expectancy declined or stagnated from the mid-1960s until 2005, followed by moderate improvements. In Romania, under the Communist regime, life expectancy followed a downward trend that accelerated after the 1989 revolution. Constant progress in life expectancy has started in this country since 1997.

2. The period of long-term deterioration in population health was associated with an immense rise in cardiovascular mortality among adults, particularly in Moldovan and Ukrainian males. External causes of death were another critical contributor to the decline in population health. In Moldova, where a hazardous type of Mediterranean drinking culture is widespread, digestive system diseases significantly negatively impacted life expectancy during the Soviet period, especially in middle-aged women. In Ukraine, a traditional spirits-drinking country, the effect of external causes of death was far more considerable than in Moldova and Romania, especially after independence. A reduction in infant mortality from infectious and respiratory diseases has partially offset the general deterioration in population health.

3. The recent improvement period in Moldova, like in Ukraine, was primarily associated with a decline in mortality from cardiovascular diseases among middle-aged and older women and external causes of death among young male adults. Unlike Romania, in the two FSU countries, there was no notable improvement in cardiovascular mortality among middle-aged and older males. In Moldova and pre-war Ukraine, elevated cardiovascular mortality remains the major component of low life expectancy.

4. Substantial progress in mortality from respiratory and infectious diseases (pneumonia, acute respiratory diseases, acute intestinal infections), on the one hand, and a prolonged stagnation in mortality from some perinatal conditions stand behind the overall decline in infant mortality over the past 55 years. The decline in neonatal mortality component in the new millennium was mainly associated with a reduction in deaths from obstetrical trauma. Over the past half a century, the decline in mortality among children and adolescents was attributable to transport accidents, falls, drowning, pneumonia and leukaemia.

5. Mortality among young male adults following the rise or stagnation in the Soviet period has continuously declined, except for the war conflict in 1992. This progress was chiefly attributable to different external causes of death, such as transport accidents, accidental poisoning, falls and drowning, and accidents due to fire, electricity and firearms. Suicide mortality, the main component of violent deaths in the youth, has been stagnant for several decades.

6. Mortality among middle-aged adults has been increasing for several decades for ischaemic heart diseases, cerebrovascular diseases, different external causes of death, liver cirrhosis,

malignant neoplasms of specific sites (lung, breast and intestine cancer), pneumonia and chronic obstructive pulmonary diseases. At the same time, during the Soviet period, visible progress was achieved in mortality from stomach cancer, uterus cancer and tuberculosis. The effect of the 1985 anti-alcohol campaign demonstrated the dependence of adult mortality from different causes of death on alcohol consumption. During the period of independence, the unfavourable mortality trends observed in the Soviet era continued. The socioeconomic crisis of the 1990s accelerated the increase in mortality from cardiovascular diseases and external causes and reversed the trend in mortality from infections. Cancer mortality was insensitive to the crisis of the 1990s. The moderate decline in lung cancer mortality in middle-aged men in the 1990s is due to the competing risks of dying from causes more sensitive to socioeconomic unrest, such as cardiovascular diseases and violent deaths, among those with cancer.

7. Old-age mortality was much less sensitive to the socioeconomic crisis of the 1990s. The recent progress was mainly attributable to decreased mortality from cerebrovascular disorders, while mortality associated with heart diseases continues to follow the long-term unfavourable trend.

8. The COVID-19 pandemic reduced life expectancy at birth by about one year and significantly impacted the cause-of-death mortality pattern in 2020. In Moldova, mortality from COVID-19 was limited to laboratory-confirmed cases, which did not meet the WHO recommendations. The weekly evolution of COVID-19 mortality, according to hospital death records and medical death certificate data, was mainly the same in 2020. Based on standardised weekly death rates, four waves were detected with peak values in mid-December 2020, March 2021, October 2021 and February 2022. Weekly excess mortality among older adults in Wave 1 was partially attributed to cardiovascular disease. The male-to-female ratio for COVID-19-related mortality was higher among the elderly and much lower among the middle-aged.

9. Elevated adult mortality from circulatory and digestive systems diseases in both sexes and external causes of death in men accounted for excess mortality in Moldova compared to the European model. Excess life table deaths from these causes were concentrated between 30 and 70 years in males and 50 and 80 years in females. In the period 2001-2019, excess mortality in women under 70 declined due to reducing cardiovascular mortality. In men, excess mortality increased at the expense of the cardiovascular component, offsetting improvements in mortality from external causes of death.

5. SOCIAL DISPARITIES IN MORTALITY BY PLACE OF RESIDENCE, MARITAL STATUS AND LEVEL OF EDUCATION

5.1. Mortality disparities by place of residence

5.1.1. Urban-rural differences in all-cause mortality

Table 5.1 shows life expectancy at birth for men and by place of residence since 1991. The gap in life expectancy between urban and rural areas was statistically significant ($p<0.05$) in all periods under study, considering the 95% confidence intervals. The difference for both sexes was the largest in 1991-1993 (about three years), while it declined substantially at the turn of the millennium. Between 1991-1993 and 2003-2005, the decrease in life expectancy was the most marked for urban men (1.3 years), whereas the figure declined moderately for urban women (0.5 years) and remained almost unchanged for the rural population. In 2014-2016 and 2017-2019, life expectancy increased in both settings, and the urban-rural differential persisted at 2.5-2.7 years for both sexes.

Table 5.1 Life expectancy at birth and 95% confidence intervals by sex and place of residence in Moldova after independence (years)

Period	Urban	Rural	Total	Urban-rural difference
Males				
1991-1993[1]	65.79 (65.6-65.97)	62.82 (62.66-63)	64.22 (64.1-64.35)	2.96*
2003-2005	64.53 (64.3-64.75)	63.41 (63.24-63.58)	63.82 (63.69-63.96)	1.12*
2014-2016	66.92 (66.71-67.13)	64.25 (64.08-64.41)	65.24 (65.1-65.37)	2.67*
2017-2019	68.18 (67.97-68.38)	65.61 (65.43-65.78)	66.57 (66.43-66.71)	2.57*
2020	66.86 (66.54-67.21)	65.2 (64.92-65.51)	65.89 (65.65-66.13)	1.67*
Females				
1991-1993[1]	73.24 (73.08-73.42)	70.26 (70.09-70.42)	71.5 (71.39-71.61)	2.98*
2003-2005	72.79 (72.58-73)	70.74 (70.58-70.9)	71.48 (71.35-71.62)	2.05*
2014-2016	75.39 (75.18-75.58)	72.74 (72.58-72.9)	73.73 (73.61-73.86)	2.64*
2017-2019	76.52 (76.32-76.7)	73.98 (73.82-74.14)	74.99 (74.86-75.11)	2.53*
2020	74.81 (74.49-75.15)	73.22 (72.9-73.52)	73.9 (73.69-74.11)	1.59*

[1]With Transnistria. * p-value < 0.05.

Source: author's calculations based on NBS and NAPH data.

From 1991-1993 to 2017-2019, life expectancy rose slightly more rapidly in rural than urban areas. Life expectancy at birth for women increased by 3.73 years (3.41-3.74) in rural settings and by 3.28 years (2.92-3.28) in urban settings. The corresponding gains among men were 2.79 years (2.46-2.82) and 2.40 years (1.99-2.44). This increase was statistically significant for both sexes ($p<0.05$). In the pandemic year 2020, life expectancy at birth in urban areas was reduced

by 1.32 years ($p<0.05$) in males and 1.71 years ($p<0.05$) in females. By contrast, changes in life expectancy in rural settings were not statistically significant ($p>0.05$). Different changes in life expectancy by place of residence in 2020 resulted in a decrease in the difference in all-cause mortality between urban and rural areas from 2.53 years ($p<0.05$) to 1.59 years ($p<0.05$). The situation in 2020, however, was still better in urban than rural areas.

Figure 5.1 illustrates the ratio of probabilities of death by age group (q_x) between rural and urban populations for the periods studied. Children and adults between the ages of 15 to 59 had higher probabilities of dying for both sexes in rural than urban areas. For people over age 60, the disparities in urban-rural mortality were much less visible, if not absent. The largest excess in rural mortality was among men aged 15-29 and women aged 30-44 in 1991-1993 (1.6 times). The rural-urban mortality gap narrowed in all age groups in 2003-2005, and in men, it became insignificant, except for ages 15-29. As a result of the COVID-19 pandemic in 2020, differences in mortality declined considerably in the age groups of 45-59 years and 60 years and older. Similarly, in 2020, the risk of child mortality in rural settings became more pronounced compared to other periods.

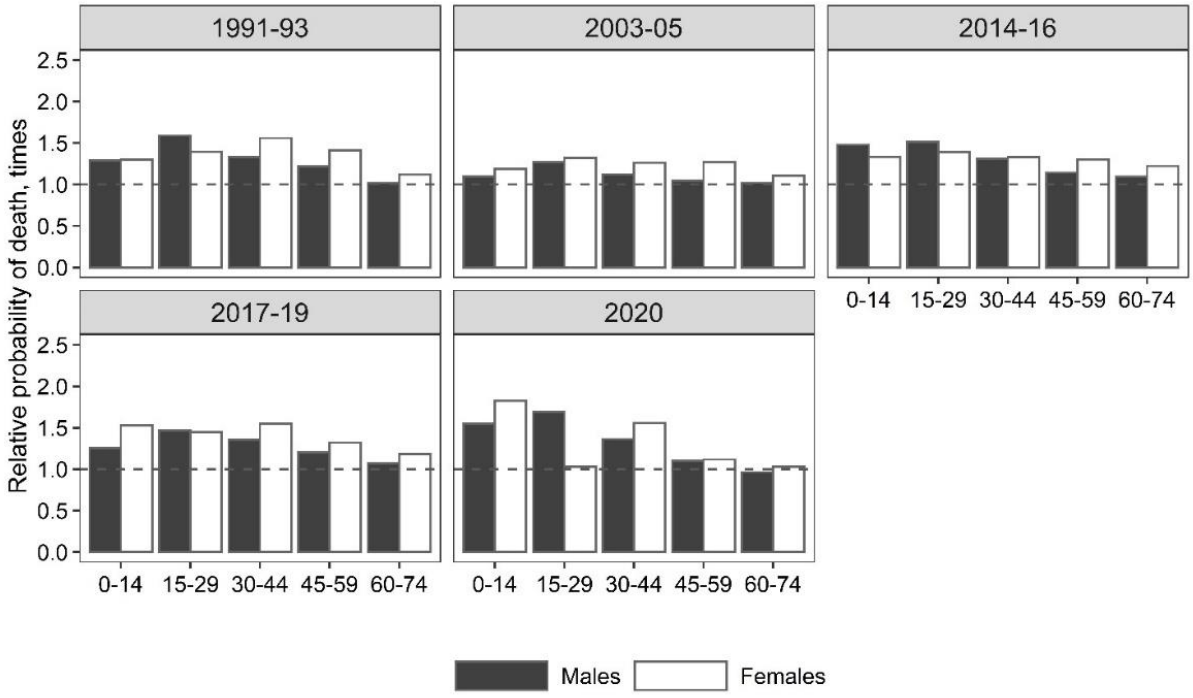


Fig. 5.1 Age-specific ratios between the probabilities of dying by urban-rural residence and sex in 1991-1993, 2003-2005, 2014-2016 and 2017-2019 in Moldova (times)

Note: reference group – urban population.
Source: author's calculations based on NBS and NAPH data.

5.1.2. Urban-rural differences by cause of death

5.1.2.1. Urban-rural differences in mortality between 1991-1993 and 2017-2019

Considering the dramatic impact of COVID-19 infection on mortality rates in 2020, the 1991-1993 period was compared with the 2017-2019 period. Table 5.2 presents standardised death

rates calculated for the two periods for all causes of death combined, the seven main causes of death by place of residence, and changes in mortality differences between rural and urban populations.

Table 5.2 Standardised death rates by place of residence, sex and cause with 95%CIs in 1991-1993 and 2017-2019 and change in mortality differences between rural and urban areas in Moldova

	1991-1993		2017-2019		Change (per 100000)[1]
	SDR, rural (95% CI)	SDR, urban (95% CI)	SDR, rural (95% CI)	SDR, urban (95% CI)	
Males					
Infectious diseases	18.87 (17.16; 20.69)	18.28 (15.89; 20.84)	21.62 (19.64; 23.73)	23.53 (20.48; 26.86)	-2.51
Neoplasms	260.3 (252.75; 268)*	375.47 (361.64; 389.62)	**370.8** (360.79; 380.99)*	**448.32** (433.03; 463.95)	37.65
Circulatory system diseases	1930.74 (1900.27; 1961.52)*	1518.88 (1481.99; 1556.3)	**1719.45** (1692.14; 1747.05)*	**1428.49** (1394.39; 1463.11)	-120.91
Respiratory system diseases	163.4 (156.64; 170.34)*	137.41 (127.71; 147.5)	154.43 (147.2; 161.87)*	**101.23** (93.51; 109.32)	27.21
Digestive system diseases	188.02 (181.78; 194.4)*	148.33 (140.18; 156.76)	191.9 (185.13; 198.83)*	147.45 (139; 156.22)	4.76
External causes	225.51 (219.18; 231.96)*	203.46 (195.03; 212.08)	**175.47** (169.47; 181.62)*	**128.45** (121.17; 136.01)	24.97
Other diseases	72.42 (68.64; 76.32)*	98.51 (91.57; 105.7)	78.86 (74.33; 83.56)	**75.26** (69.29; 81.54)	29.69
All causes	2859.25 (2825.62; 2893.13)*	2500.34 (2457.35; 2543.73)	**2712.52** (2680.75; 2744.52)*	**2352.74** (2312.3; 2393.62)	0.86
Females					
Infectious diseases	5.39 (4.67; 6.19)	4.89 (4; 5.9)	**7.28** (6.21; 8.48)*	**11.44** (9.69; 13.38)	-4.66
Neoplasms	137.16 (132.82; 141.61)*	212.83 (205.44; 220.4)	**179.68** (174.08; 185.4)*	**237.78** (229.35; 246.42)	17.56
Circulatory system diseases	1536.62 (1517.79; 1555.62)*	1211.53 (1189.64; 1233.69)	**1334.26** (1316.59; 1352.09)*	**1112.67** (1090.63; 1135.03)	-103.52
Respiratory system diseases	66.64 (63.37; 70.01)*	51.29 (47.39; 55.39)	**52.65** (49.29; 56.17)*	**34.2** (30.72; 37.93)	3.10
Digestive system diseases	155.56 (150.95; 160.27)*	102.15 (97.06; 107.42)	**134.24** (129.46; 139.15)*	**86.87** (81.78; 92.17)	-6.03
External causes	70.33 (67.2; 73.56)*	62.31 (58.51; 66.25)	**38.57** (36; 41.27)*	**28.34** (25.52; 31.36)	2.20
Other diseases	47.7 (45.33; 50.16)*	63.59 (59.95; 67.37)	51.21 (48.24; 54.31)	**52.4** (48.57; 56.43)	14.70
All causes	2019.41 (1998.85; 2040.12)*	1708.58 (1683.96; 1733.44)	**1797.88** (1777.99; 1817.93)*	**1563.69** (1538.71; 1588.96)	-76.65

SDR - age-standardised death rate per 100000 population. CI - confidence interval. * p-value < 0.05 compared to urban areas. Statistically significant differences compared to 1991-1993 are marked in bold (p<0.05).

[1]Change in mortality difference between rural and urban areas was calculated as follows: ($SDR_{2017\text{-}2019,\ rural}$ - $SDR_{1991\text{-}1993,\ rural}$) - ($SDR_{2017\text{-}2019,\ urban}$ - $SDR_{1991\text{-}1993,\ urban}$). If mortality decreases between 1991-1993 and 2017-2019 (green cells), a negative value means a decline is greater in rural than urban areas. If mortality increases (red cells), a positive value means an increase is higher in rural than urban areas. Values near zero indicate similar changes in rural and urban areas.

Source: author's calculations based on NBS and NAPH data.

In 1991-1993, among men and women, standardised death rates from all causes of death, circulatory, respiratory and digestive systems diseases and external causes of death were higher in

rural than urban areas ($p<0.05$). Mortality attributable to neoplasms and other diseases was higher among urban men and women ($p<0.05$). Differences in mortality from infectious diseases were not statistically significant between rural and urban areas in 1991-1993. In 2017-2019, standardised death rates from neoplasms in both sexes and infectious diseases in women were higher in urban settings than in rural ones ($p<0.05$). Differences in mortality from other diseases among males and females and infectious diseases among males were not statistically significant in 2017-2019 ($p>0.05$). In males, in 2017-2019 compared to 1991-1993, standardised death rates were significantly reduced for all causes, circulatory system diseases and external causes in urban and rural areas and respiratory system diseases in urban areas ($p<0.05$). In females, the mortality decline between 1991-1993 and 2017-2019 was statistically significant for all causes of death, circulatory, respiratory and digestive systems diseases, external causes of death in rural and urban areas and other diseases in urban areas ($p<0.05$). Progress in cardiovascular mortality for both sexes was more pronounced in rural than urban areas (the change in mortality difference presented in Table 5.2 is a negative value). In contrast, the reduction in mortality from external causes in males was more notable in urban than rural areas (the change in mortality difference presented in Table 5.2 is a positive value). In both places of residence, mortality associated with neoplasms increased statistically significantly throughout independence, at a faster rate in rural areas than in urban ones (the change in mortality difference presented in Table 5.2 is a positive value).

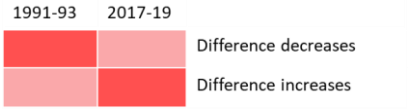
Table 5.3 shows the absolute (RD, rate difference) and relative (RR, rate ratio) differences in standardised death rates between the rural and urban areas in 1991-1993 and 2017-2019. In males, absolute and relative disparities in mortality decreased for circulatory system diseases in 2017-2019 compared to 1991-1993 ($p<0.05$). Conversely, the rural-urban mortality disparities increased for respiratory diseases and external causes of death ($p<0.05$). There was also a decrease in a negative rural-urban gradient in neoplasm mortality ($p<0.05$). Because of these opposite changes in different causes of death between rural and urban males, absolute and relative differences in all-cause mortality did not change statistically significantly. Among females, the rate difference for all-cause mortality decreased from 311 deaths to 234 deaths per 100000 population or 25% ($p<0.05$). As for males, absolute and relative differences in mortality between rural and urban female populations were reduced for circulatory system diseases ($p<0.05$). The growth in relative differences among women was statistically significant for neoplasms, respiratory system diseases and external causes of death ($p<0.05$). Mortality from infectious diseases did not have statistically significant differences by place of residence in 1991-1993 and 2017-2019. On the other hand, the risk of dying from “other diseases” was more frequent in urban settings at the start of the period (RR in males = 0.74; RR in females = 0.75; $p<0.05$) but had a rate

ratio close to one by the end of the study period. The impact of differences in mortality by cause of death between rural and urban populations on differences in all-cause mortality in 1991-1993 and 2017-2019 is shown in Table 5.4.

Table 5.3 Absolute and relative differences in mortality by main cause of death and sex between rural and urban areas in 1991-1993 and 2017-2019 and their changes between 1991-1993 and 2017-2019 in Moldova

	1991-1993		2017-2019		Change (%)	
	RD (95% CI)	RR (95% CI)	RD (95% CI)	RR (95% CI)	RD[1]	RR[2]
Males						
Infectious diseases	0.59 (-2.41;3.6)	1.03 (0.87;1.2)	-1.92 (-5.65;1.82)	0.92 (0.76;1.08)	-423.6	-11
Neoplasms	-115.17 (-131.04;-99.3)*	0.69 (0.65;0.74)*	-77.53 (-95.93;-59.12)*	0.83 (0.78;0.87)*	-32.7**	19.3**
Circulatory system diseases	411.86 (363.82;459.9)*	1.27 (1.24;1.3)*	290.95 (247.08;334.83)*	1.2 (1.17;1.23)*	-29.4**	-5.3**
Respiratory system diseases	25.99 (14.02;37.95)*	1.19 (1.11;1.27)*	53.2 (42.49;63.9)*	1.53 (1.43;1.62)*	104.7**	28.3**
Digestive system diseases	39.69 (29.32;50.05)*	1.27 (1.2;1.33)*	44.45 (33.51;55.38)*	1.3 (1.23;1.37)*	12	2.7
External causes	22.05 (11.44;32.67)	1.11 (1.06;1.16)	47.02 (37.49;56.55)*	1.37 (1.3;1.43)*	113.2**	23.2**
Other diseases	-26.09 (-34.08;-18.1)*	0.74 (0.65;0.82)*	3.6 (-4.01;11.2)	1.05 (0.95;1.15)	-113.8**	42.5**
All causes	358.92 (304.18;413.65)*	1.14 (1.12;1.16)*	359.77 (308.19;411.36)*	1.15 (1.13;1.17)*	0.2	0.8
Females						
Infectious diseases	0.5 (-0.69;1.69)	1.1 (0.87;1.34)	-4.16 (-6.28;-2.03)	0.64 (0.42;0.86)	-927.5**	-42.3**
Neoplasms	-75.67 (-84.31;-67.03)*	0.64 (0.6;0.69)*	-58.1 (-68.3;-47.91)*	0.76 (0.71;0.8)*	-23.2	17.2**
Circulatory system diseases	325.1 (296.12;354.08)*	1.27 (1.25;1.29)*	221.58 (193.22;249.95)*	1.2 (1.18;1.22)*	-31.8**	-5.5**
Respiratory system diseases	15.35 (10.19;20.51)*	1.3 (1.21;1.39)*	18.45 (13.52;23.38)*	1.54 (1.42;1.66)*	20.2	18.5**
Digestive system diseases	53.41 (46.48;60.34)*	1.52 (1.46;1.58)*	47.38 (40.32;54.43)*	1.55 (1.48;1.61)*	-11.3	1.5
External causes	8.03 (3.05;13.01)	1.13 (1.05;1.21)	10.23 (6.34;14.12)*	1.36 (1.24;1.48)*	27.4	20.6**
Other diseases	-15.89 (-20.29;-11.49)*	0.75 (0.67;0.83)*	-1.19 (-6.11;3.74)	0.98 (0.88;1.07)	-92.5**	30.3**
All causes	310.83 (278.67;343)*	1.18 (1.16;1.2)*	234.19 (202.15;266.23)*	1.15 (1.13;1.17)*	-24.7**	-2.7

RD - rate difference (rural-urban) per 100000 population. RR - rate ratio (rural/urban), times. CI - confidence interval.
* the difference is statistically significant compared to the urban population ($p<0.05$). ** the difference is statistically significant compared to the previous period ($p<0.05$).
[1]Change in RD was calculated: (RD 2017-2019 - RD 1991-1993/RD 1991-1993 x100
[2]Change in RR was calculated: (RR 2017-2019 - RR 1991-1993/RR 1991-1993 x100
Source: author's calculations based on NBS and NAPH data.



Among men, differences in mortality from circulatory system diseases had the greatest effect on differences in all-cause mortality during the two periods (114.75% and 80.87%). The influence of respiratory system diseases and external causes of death on all-cause mortality differences between rural and urban men almost doubled between 1991-1993 and 2017-2019. On the other hand, the impact of digestive system diseases remained unchanged. The combined effect of respiratory and digestive diseases and external causes of death on differences in all-cause mortality between rural and urban men increased from 24% in 1991-1993 to 40% in 2017-2019.

Among females, at the beginning and by the end of the study period, differences in mortality between rural and urban areas were mainly explained by differences in mortality from circulatory system diseases (104.95% and 94.62%) and digestive system diseases (17.18% and 20.23%). Differences in mortality from neoplasms had a minor influence among men (-32.09% in 1991-1993; -21.55% in 2017-2019) and women (-24.34% in 1991-1993; -24.81% in 2017-2019).

Table 5.4 Absolute difference in mortality by main cause of death and sex between rural and urban areas and their impact on the absolute difference in all-cause mortality in 1991-1993 and 2017-2019 in Moldova

	1991-1993		2017-2019	
	RD	%[1]	RD	%[1]
Males				
Infectious diseases	0.59	0.16	-1.92	-0.53
Neoplasms	-115.17	-32.09	-77.53	-21.55
Circulatory system diseases	411.86	114.75	290.95	80.87
Respiratory system diseases	25.99	7.24	53.20	14.79
Digestive system diseases	39.69	11.06	44.45	12.36
External causes	22.05	6.14	47.02	13.07
Other diseases	-26.09	-7.27	3.60	1.00
All causes	358.92	100.00	359.77	100.00
Females				
Infectious diseases	0.50	0.16	-4.16	-1.78
Neoplasms	-75.67	-24.34	-58.10	-24.81
Circulatory system diseases	325.10	104.59	221.58	94.62
Respiratory system diseases	15.35	4.94	18.45	7.88
Digestive system diseases	53.41	17.18	47.38	20.23
External causes	8.03	2.58	10.23	4.37
Other diseases	-15.89	-5.11	-1.19	-0.51
All causes	310.83	100.00	234.19	100.00

RD - rate difference (rural-urban) per 100000 population.
[1]the impact of RD in mortality from a cause *i* on RD in all-cause mortality was calculated:
RD for a cause i / RD for all causes x 100
Source: author's calculations based on NBS and NAPH data.

5.1.2.2. Urban-rural differences in mortality over four different periods

Standardised death rates by cause of death and place of residence with 95% confidence intervals in 1991-1993, 2003-2005, 2014-2016, 2017-2019 and 2020 are shown in Figures 5.2 for men and 5.3 for women. Annexe 6 provides the corresponding detailed data. Figure 5.4 shows the absolute or rate difference (RD) in standardised death rates between rural and urban populations by sex, cause and period. Figure 5.5 illustrates the relative mortality difference or rate ratio (RR) by place of residence, sex, cause and period. More detailed information on RD and RR can be found in Annexe 7.

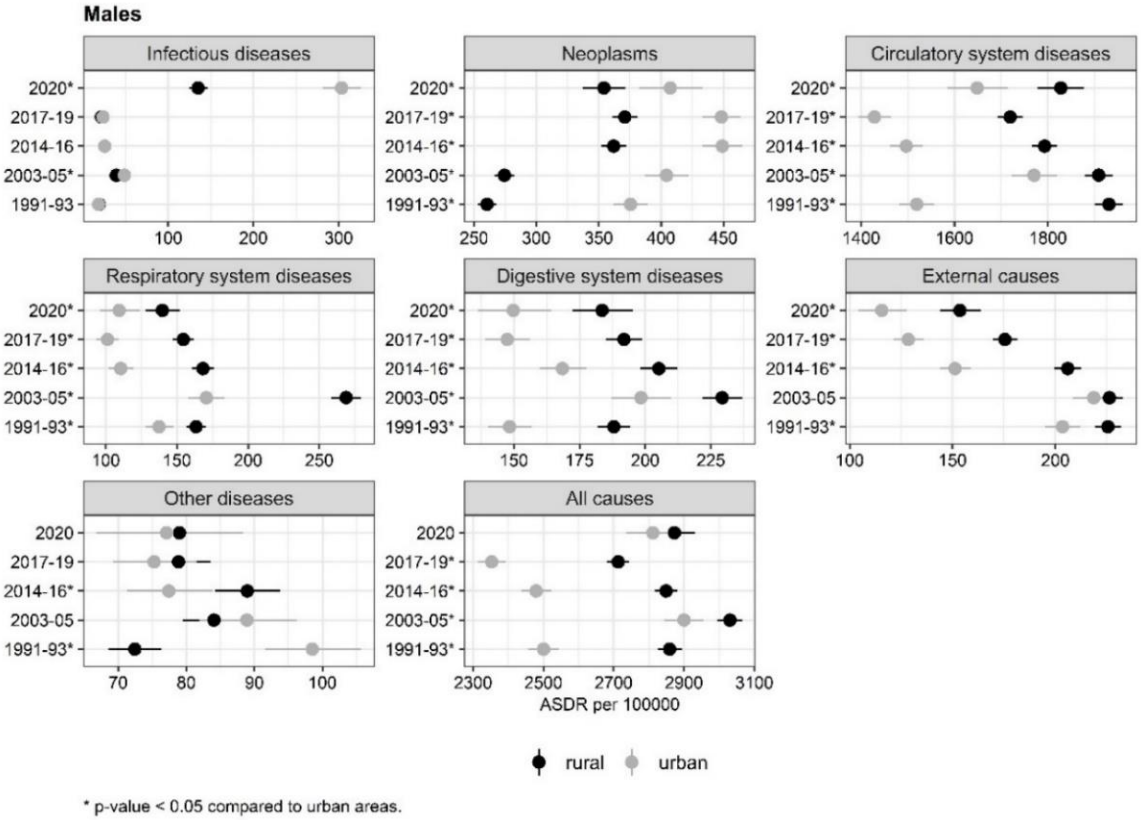


Fig. 5.2 Standardised death rates by main cause of death and place of residence among Moldovan males in 1991-1993, 2003-2005, 2014-2016, 2017-2019 and 2020 (per 100000)

Source: author's calculations based on NBS and NAPH data.

The impact of COVID-19 was analysed separately because of the specificity of the mortality pattern in 2020. All-cause mortality was higher in rural than urban areas for all periods ($p<0.05$), except for males in 2020. Among rural males and females, standardised death rates were higher for circulatory, respiratory, and digestive systems diseases and external causes of death for all periods ($p<0.05$), except for external causes of death in 2003-2005. In contrast, neoplasm mortality was consistently higher in urban than rural areas ($p<0.05$). Mortality from infectious diseases was not significantly different between urban and rural areas, except in 2003-2005 among men and the last two observation periods among women. Mortality from the residual group of causes of death was higher in rural settings only in 1991-1993.

The maximum values of absolute (RD, rate difference) and relative (RR, rate ratio) differences in overall mortality were registered in 2014-2016 both among men (RD=370 deaths per 100000; RR=1.15 times, p<0.05) and women (325 deaths per 100000; RR=1.2, p<0.05). After excluding 2020, the differences in urban-rural mortality for all causes of death were minimal in 2003-2005 for men (RD=131 deaths per 100000; RR=1.05, p<0.05) and women (RD=229 deaths per 100000; RR=1.12, p<0.05) (Figure5.2, Figure5.3, Annexe 7).

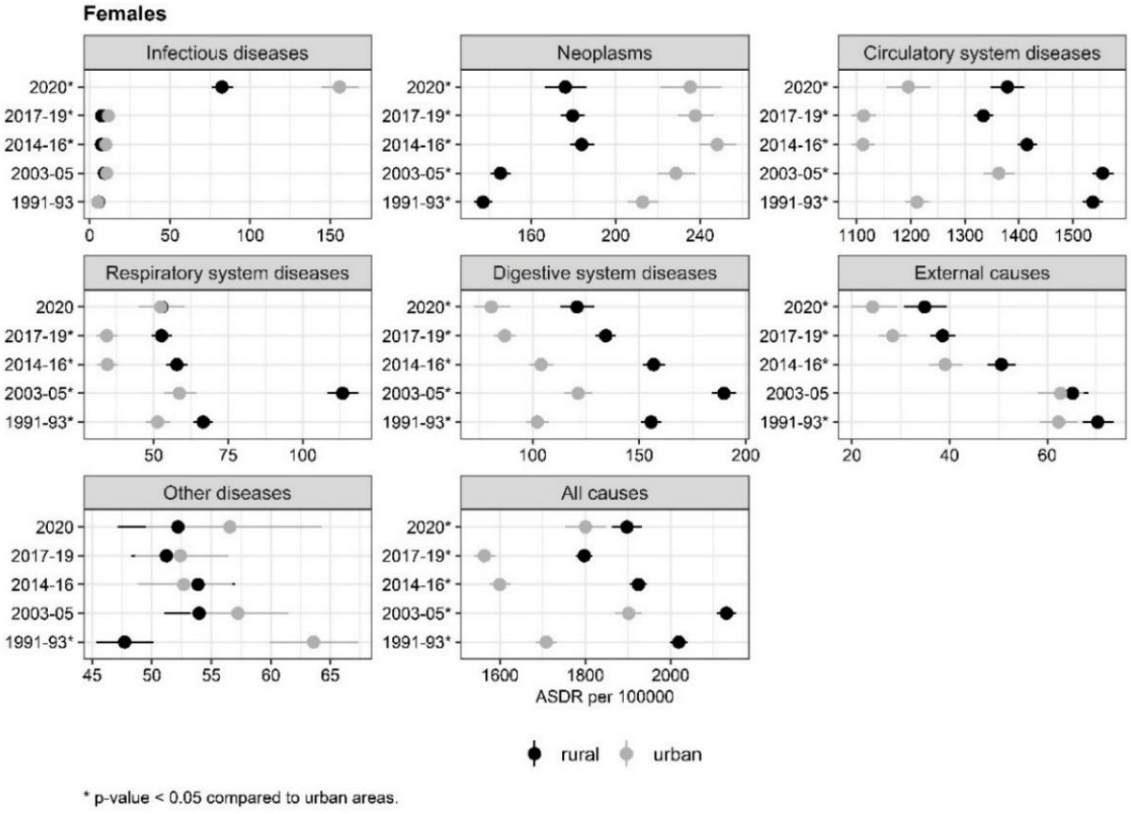


Fig. 5.3 Standardised death rates by main cause of death and place of residence among Moldovan females in 1991-1993, 2003-2005, 2014-2016, 2017-2019 and 2020 (per 100000)
Source: author's calculations based on NBS and NAPH data.

Changes in absolute and relative differences in mortality by place of residence were studied for the following four periods:

a) The period of stagnation or deterioration (from 1991-1993 to 2003-2005);
b) The period of improvement (from 2003-2005 to 2014-2016);
c) The period of recent changes (from 2014-2016 to 2017-2019);
d) The effect of COVID-19 infection (from 2017-2019 to 2020).

A) Period of deterioration (between 1991-1993 and 2003-2005)

From 1991-1993 to 2003-2005, standardised death rates in rural areas increased statistically significantly for all causes, infectious diseases, respiratory system diseases, digestive system diseases and other diseases (p<0.05). On the other hand, changes in standardised death rates from circulatory system diseases and neoplasms were not substantial in rural areas during the

period of deterioration ($p>0.05$). However, in urban areas, men and women demonstrated a considerable increase in mortality from circulatory system diseases ($p<0.05$). This growth in cardiovascular mortality in urban areas (15% in males and 12% in females between 1991-1993 and 2003-2005) contrasts sharply with a relatively stable situation in rural areas. Between 1991-1993 and 2003-2005, the situation in urban areas also deteriorated statistically significantly for infectious diseases, digestive system diseases for both sexes and respiratory system diseases among men ($p<0.05$). The increase in mortality from respiratory system diseases between 1991-1993 and 2003-2005 was much more pronounced for the rural population than for the urban one (60% in rural males vs 20% in urban males) (Figure5.2, Figure5.3, Annexe 6, A6.1).

In 2003-2005, compared to 1991-1993, the absolute and relative differences in all-cause mortality between rural and urban men have almost disappeared, and between rural and urban women have been considerably reduced due to a faster increase in mortality in urban areas than in rural areas. The absolute difference in mortality from cardiovascular diseases decreased by 66% among men ($p<0.05$) and 41% among women ($p<0.05$). The relative differences for this cause of death also declined in men ($RR_{1991-1993}=1.27$, $RR_{2003-2005}=1.08$, $p<0.05$) and women ($RR_{1991-1993}=1.27$, $RR_{2003-2005}=1.14$, $p<0.05$). Due to a notable increase in rural mortality from respiratory system diseases, the relative difference for this pathology increased by more than 30% among men ($RR_{1991-1993}=1.19$, $RR_{2003-2005}=1.57$, $p<0.05$) and 45% among women ($RR_{1991-1993}=1.30$, $RR_{2003-2005}=1.93$, $p<0.05$). In 2003-2005, rural-urban disparities in mortality from external causes of death were negligible in terms of absolute and relative measures (Figure 5.4, Figure 5.5, Annexe 7, A7.1).

B) Period of improvement (between 2003-2005 and 2014-2016)

During the period from 2003-2005 to 2014-2016, standardised mortality rates for both men and women fell in rural and urban settings for all causes of death and main causes of death ($p<0.05$), except for neoplasms and the residual group of causes of death in both sexes and respiratory diseases in women. Mortality from neoplasms increased in both sexes ($p < 0.05$). Improvements in all-cause mortality and mortality from circulatory system disease were more pronounced in urban than rural areas, especially in urban men, who had experienced significant health deterioration over the previous period. The change in the cardiovascular mortality difference between rural and urban areas was 157.93 deaths for men and 111.44 deaths for women per 100000 population (Annex 6, A6.2). The positive values of this change suggest that the mortality reduction was more pronounced in urban areas than in rural areas. In rural areas, there was a sharp decrease in mortality from respiratory diseases, which had increased considerably in the period of deterioration. The change in the differences in respiratory disease mortality between

rural and urban areas was -40.44 deaths per 100000. Negative values of the change mean that the mortality reduction was more marked in rural than urban areas. The increase in mortality from neoplasms was more robust in rural than in urban areas, particularly in males (Figure 5.2, Figure 5.3, Annexe 6, A6.2).

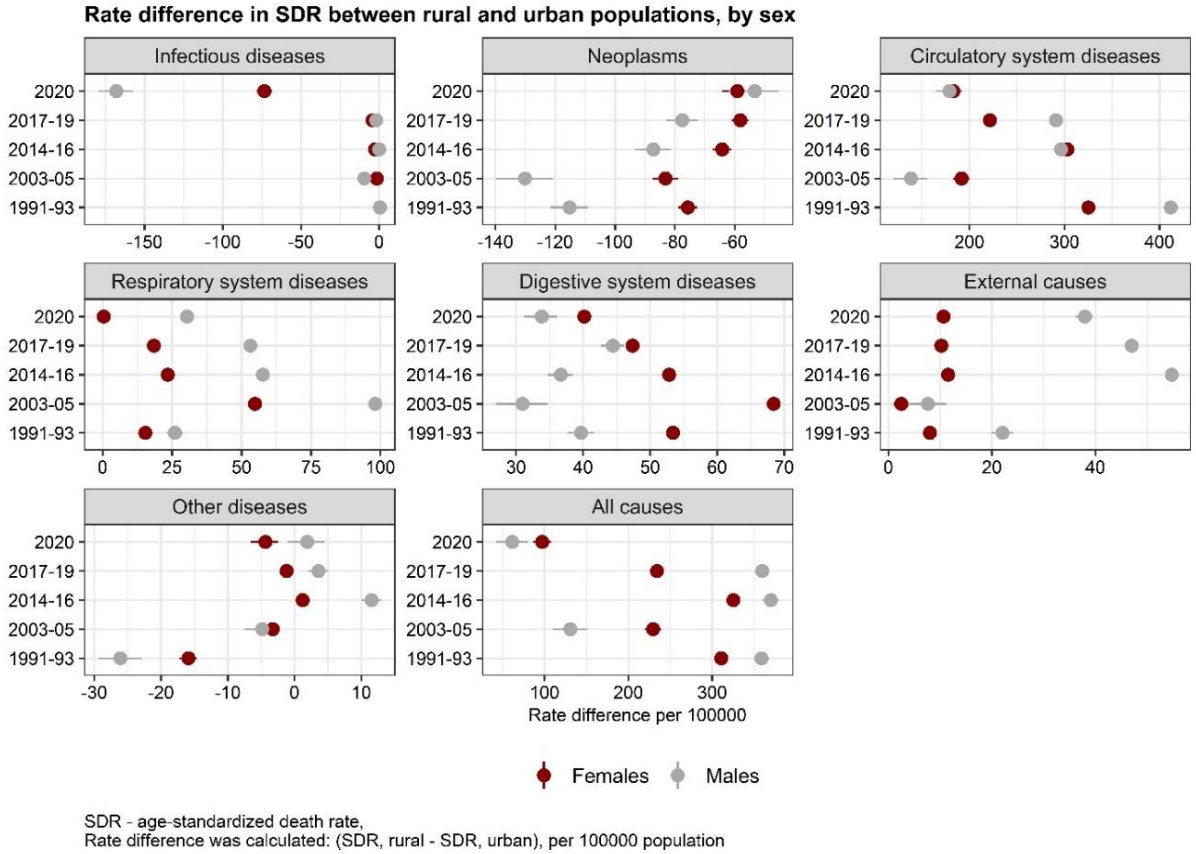


Fig. 5.4 Mortality rate difference between rural and urban populations by main cause of death and sex in Moldova in 1991-1993, 2003-2005, 2014-2016, 2017-2019 and 2020 (per 100000)

Note: reference group (ref.) – urban population.
Source: author's calculations based on NBS and NAPH data.

As a consequence of a more rapid decline in urban versus rural mortality between 2003-2005 and 2014-2016, differences in mortality by place of residence in 2014-2016 reached the highest values ever recorded after independence. During this period, the absolute difference in mortality from circulatory system diseases between rural and urban areas more than doubled among men ($RD_{2003-2005}$=139, $RD_{2014-2016}$=296 deaths per 100000, $p<0.05$) and increased by 58% among women ($RD_{2003-2005}$=192, $RD_{2014-2016}$=303 deaths per 100000, $p<0.05$). Relative differences in cardiovascular mortality increased by 11% in men ($RR_{2003-2005}$=1.08, $RD_{2014-2016}$=1.2, $p<0.05$) and women ($RR_{2003-2005}$=1.14, $RD_{2014-2016}$=1.27, $p<0.05$). The improvements in mortality from digestive system diseases and external causes of death were also more pronounced in urban than rural areas. In 2014-2016, urban-rural differences in male mortality from external causes of death increased more than six times in terms of absolute difference ($RD_{2003-2005}$=8, $RD_{2014-2016}$=55 deaths

per 100000, $p<0.05$) and by 30% in terms of relative difference ($RR_{2003-2005}=1.03$, $RR_{2014-2016}=1.36$, $p<0.05$). In contrast, death rates from neoplasms increased significantly between 2003-2005 and 2014-2016, more in rural than urban areas and more among men than women. The absolute inequalities in neoplasm mortality in males were reduced by 33% ($RD_{2003-2005}=-131$, $RD_{2014-2016}=-87$ deaths per 100000, $p<0.05$) (Figure 5.4, Figure 5.5, Annexe 7, A7.2).

C) Recent changes (between 2014-2016 and 2017-2019)

The progress observed over the second period continued from 2014-2016 to 2017-2019 for selected causes of death only, but this time the improvements were more evident in rural than urban areas, especially among rural females (Figure 5.2, Figure 5.3, Annexe 6, A6.3).

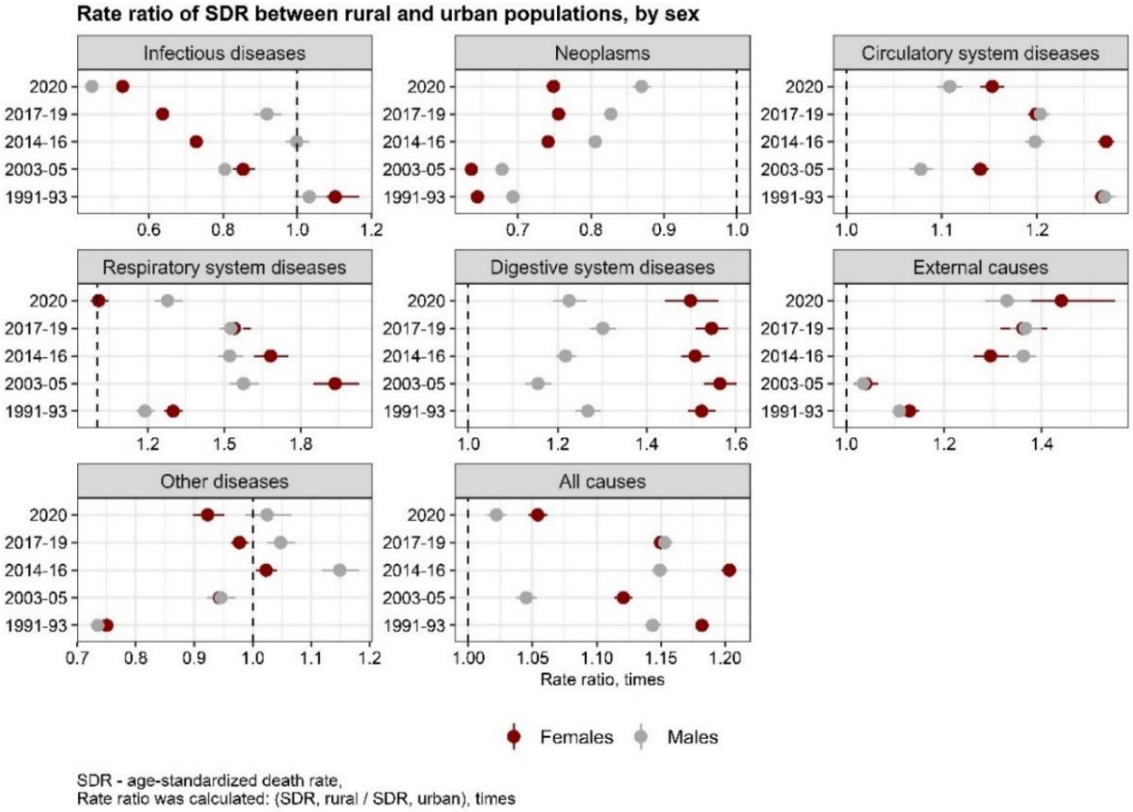


Fig. 5.5 Mortality rate ratio by main cause of death, place of residence and sex in Moldva in 1991-1993, 2003-2005, 2014-2016, 2017-2019 and 2020 (times)

Note: reference group (ref.) – urban population.
Source: author's calculations based on NBS and NAPH data.

The decrease in standardised death rates among the rural population was statistically significant for all causes of death combined, cardiovascular diseases and external causes of death ($p<0.05$). There was also a marked decrease in mortality from digestive system diseases in rural females and other diseases in rural males ($p<0.05$). In contrast, the decrease in overall mortality was statistically significant only for men but not women in urban areas. Changes in mortality from circulatory system diseases were also insignificant in urban areas ($p>0.05$). Positive changes in urban mortality were seen only for digestive system diseases and external causes of death ($p<0.05$).

Among males, all-cause and cause-specific mortality disparities by place of residence did not vary considerably in absolute and relative terms during the third period ($p>0.05$). Among females, the drop in cardiovascular mortality from 2014-2016 to 2017-2019 was more pronounced in rural than urban areas, closing the gap between the two settings. The mortality rate difference for this group of causes of death in females declined by 27% ($RD_{2014\text{-}2016}=303$, $RD_{2017\text{-}2019}=221$ deaths per 100000, $p<0.05$), and the mortality rate ratio decreased by 6% ($RR_{2014\text{-}2016}=1.27$, $RR_{2017\text{-}2019}=1.20$, $p<0.05$). This moderate progress in cardiovascular mortality, more rapid in rural than urban areas, accounted for the decline in absolute and relative disparities in all-cause mortality among women (Figure 5.4, Figure 5.5, Annexe 7, A7.3).

D) Impact of COVID-19 on urban-rural mortality differences

In the year of the COVID-19 pandemic, overall mortality increased in both areas, but the population from urban areas was more severely affected than that from rural areas. The change in the all-cause mortality difference between rural and urban areas was -298.23 deaths in males and -136.92 deaths in females per 100000 population. Among males, there was a statistically significant increase in mortality in 2020 compared to the preceding period for infectious diseases and diseases of the circulatory system ($p<0.05$). In both cases, the increase was more robust in urban than rural areas. The difference in mortality between rural and urban males was -166 deaths per 100000 population for infectious diseases and -112 for cardiovascular diseases.

Among females, mortality rates increased statistically significantly in 2020 for infectious diseases, more so in urban than rural areas (a negative change in rural-urban difference was -69 deaths per 100000 population). Female mortality from circulatory and respiratory system diseases increased statistically significantly only in urban areas ($p<0.05$).

The most drastic increase in mortality in 2020 occurred in the case of infectious diseases. Standardised death rates from this cause of death rose 13 times among urban men and six times among rural men, while the growth among women was 11-fold and 14-fold (Figure 5.2, Figure 5.3, Annexe 6, A6.4).

In 2020, the absolute difference in all-cause mortality was reduced by 80% for men and 60% for women compared with the previous period ($p<0.05$) due to more severe population health deterioration in urban than rural areas. For both sexes, the relative difference in all-cause mortality became virtually nil in 2020 (RR was close to one). The absolute difference in mortality from infectious diseases between rural and urban populations multiplied several-fold because of the higher prevalence of COVID-19 in cities. For example, in men, RD for infectious diseases changed from -1.92 deaths in 2017-2019 to -168 deaths per 100000 population in 2020 ($p<0.05$) (Figure 5.4, Figure 5.5, Annexe 7, A7.4).

5.2. Mortality disparities by marital status

In this section, mortality inequalities are discussed by marital status for two periods around the last two censuses conducted after independence in 2004 and 2014. First, differences in life expectancies and age-specific probabilities are discussed, then absolute and relative differences are shown.

5.2.1. Differences in all-cause mortality by marital status

Life expectancy at age 30 was highest among married males and females and lowest among never-married females and divorced males in 2003-2005 and 2013-2014 (Table 5.5). The difference between the two categories was greater among Moldovan males (12 years) than among Moldovan women (8.2 years) in the first period, while it reached almost 13 years for both sexes in the second period ($p<0.05$). The life expectancy of married men was 40.9 years in 2013-2014, more than ten years higher than that of never-married, divorced or widowed men ($p<0.05$). The life expectancy of married women (47.7 years) in 2013-2014 was 12.8 years higher than that for never-married women, 7.4 years higher for divorced women and 3.7 years for widowed women. The maximum values of life expectancy at age 60 in 2013-2014 were found for married men (16.2 years) and women (20.4), while the minimum values were found for divorced men (9.6 years) and never-married women (12.4 years). Differences in life expectancy at age 60 were much more minor than at age 30 for both males and females but were statistically significant ($p<0.05$), with the exception of divorced females in 2003-2005.

Table 5.5 Life expectancy at ages 30 and 60 with 95% confidence intervals by marital status in 2003-2005 and 2013-2014, Moldova, by sex (years)

	2003-2005		2013-2014	
	Males	**Females**	**Males**	**Females**
At age 30				
Never-married	28.41 (27.88-28.96)*	35.81 (35.35-36.23)*	30.54 (30.05-31.07)*	34.87 (34.39-35.38)*
Married	38.29 (38.17-38.41)	44.0 (43.88-44.13)	40.91 (40.76-41.07)	47.71 (47.51-47.9)
Divorced	26.26 (25.83-26.67)*	42.69 (42.23-43.16)*	27.72 (27.29-28.16)*	40.33 (39.95-40.73)*
Widowed	27.21 (26.19-28.22)*	41.23 (40.81-41.63)*	30.91 (29.47-32.2)*	43.97 (43.53-44.44)*
Difference (max.-min.)	*12.04*	*8.19*	*13.19*	*12.84*
At age 60				
Never-married	12.51 (11.76-13.26)*	13.41 (13.1-13.75)*	13.63 (13-14.29)*	12.4 (12.05-12.74)*
Married	14.94 (14.85-15.03)	17.48 (17.35-17.6)	16.15 (16.02-16.3)	20.38 (20.18-20.55)
Divorced	10.74 (10.29-11.21)*	17.52 (17.09-17.99)	9.61 (9.31-9.92)*	14.7 (14.39-15.03)*
Widowed	10.96 (10.79-11.16)*	16.94 (16.83-17.04)*	12.1 (11.85-12.34)*	18.64 (18.49-18.78)*
Difference (max.-min.)	*4.19*	*4.07*	*6.54*	*7.97*

Note: without Transnistria. * p-value < 0.05 compared to married males and females.

Source: author's calculations based on NBS and NAPH data.

The improvements in population health observed at the national level between the two censuses were not evenly reflected across marital status categories (Table 5.6). The gains in life expectancy at age 30 were the highest among married women and widowed men (3.7 years). Over the study period, life expectancy at age 30 increased by more than two years for married and never-married men and 2.7 years for widowed women ($p<0.05$). Changes in mortality were most unfavourable for divorced men and, in particular, divorced women whose life expectancy at the age of 30 or 60 decreased considerably (more than two years). No progress or growth in mortality between 2003-2005 and 2013-2014 was observed for never-married women.

Table 5.6 Changes in life expectancy at ages 30 and 60 by marital status between 2003-2005 and 2013-2014, Moldova, by sex (years)

Status	At age 30		At age 60	
	Males	Females	Males	Females
Never-married	2.13*	-0.93	1.12	-1.0*
Married	2.62*	3.71*	1.22*	2.9*
Divorced	1.47*	-2.36*	-1.13*	-2.82*
Widowed	3.7*	2.75*	1.13*	1.7*

Note: without Transnistria. * The difference is statistically significant (p-value < 0.05).
Source: author's calculations based on NBS and NAPH data.

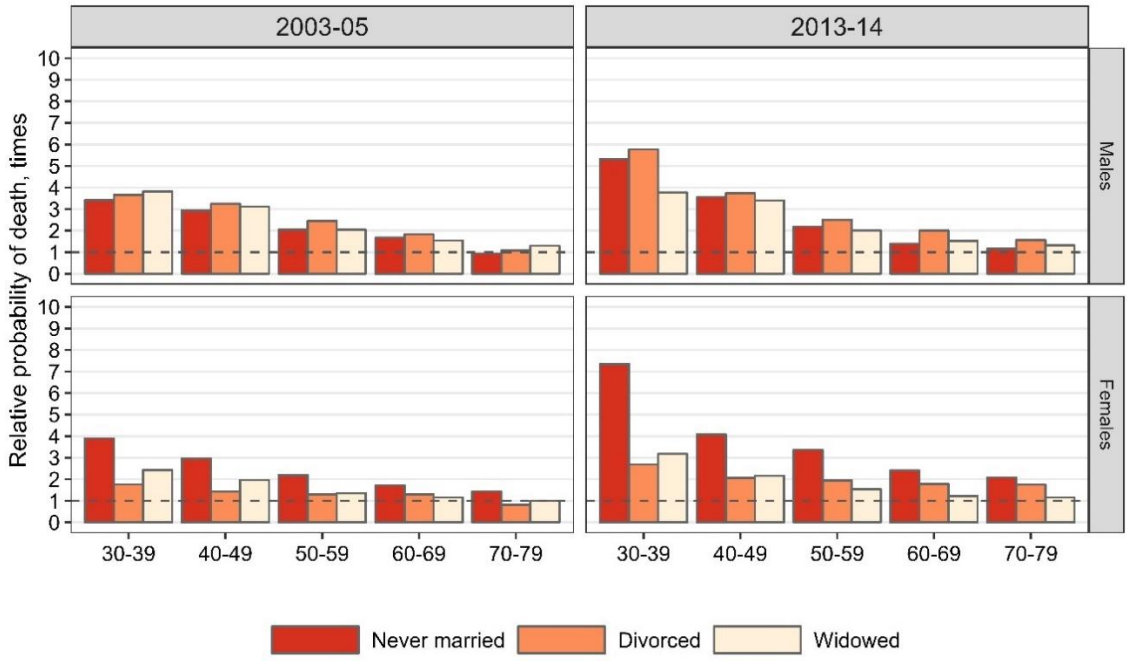


Fig. 5.6 Age-specific ratios between the probabilities of dying by marital status in 2003-2005 and 2013-2014, Moldova, by sex (times)

Note: reference group – married population.
Source: author's calculations based on NBS and NAPH data.

Figure 5.6 illustrates the age-specific ratios of death probabilities by marital status and sex. The reference group is the married population, while the study group is the non-married population, which includes three categories: never-married, divorced and widowed. Among

women, the highest ratios were attributed to never-married women aged 30 to 39 (4 times in 2003-2005 and 7 times in 2013-2014). The ratio of dying between divorced and married women or widowed and married women was also highest at age 30-39 (2.7 and 3.2, respectively, in 2013-2014). The probability of dying at age 30 to 39 was more than three times higher for never-married, divorced and widowed men than for married men. For both sexes, disparities in mortality between the married population and other categories gradually diminish with age. Among older adults, especially among males, these differences are pretty negligible.

5.2.2. Differences in cause-specific mortality by marital status

This section discusses absolute and relative differences in mortality by marital status, cause of death and sex. First, absolute differences are discussed, and then more attention is given to relative differences. In both cases, the situation is analysed for all-cause mortality and mortality by broad groups of causes of death. Relative differences are also analysed for specific detailed causes of death.

5.2.2.1. Absolute differences by marital status and main causes of death

Age-standardised death rates by marital status, cause of death and sex with 95% confidence intervals in 2003-2005 and 2013-2014 for males and females aged 30 years and over are presented in figures 5.7 (for males) 5.8 (for females) and Annexe 8. Absolute differences or rate differences computed between the reference group and a study group for the two periods and their changes are presented in Annexe 9.

Among *males*, standardised death rates from all causes of death combined were higher among the three non-married categories compared to married males for the two study periods ($p<0.05$) (Figure 5.7). The cause-specific mortality pattern by marital status corresponded to that observed for the male population. Diseases of the circulatory system represented the leading cause of death for males independent of their marital status, with a share between 54% in never-married males and 62% in married and widowed males. Neoplasms occupied the second place contributing to the overall mortality from 10% in never-married and widowed males to 17% in married males. External causes of death and diseases of the digestive and respiratory systems were placed in third place. The exception was never-married males for whom external causes of death had the same impact as neoplasms on mortality structure.

The maximum absolute difference in all-cause mortality was recorded between widowed and married males in the first period (RD=2569 per 100000 population, $p<0.05$) and between divorced and married males in the second period (RD=4587 per 100000 population, $p<0.05$). In the first period, widowed males recorded the highest absolute inequalities in mortality from infectious diseases, circulatory system diseases, respiratory system diseases and digestive system

diseases (p<0.05). At the same time, the mortality disadvantage for neoplasms, external causes of death and other diseases was most marked for divorced males (p<0.05). In the second period, the situation changed. Rate differences in mortality were highest between married and divorced males for all main groups of causes of death (p<0.05), except for respiratory diseases, where RD had a maximum between married and never-married males (Annexe 8, A8.1). Between the two study periods, the increase in absolute differences in all-cause mortality was statistically significant only for divorced males (change in RD=123%, p<0.05), while for the other two non-married categories, the situation remained virtually unchanged (Annexe 9, A9.1). For divorced males, the increase in absolute differences in mortality between 2003-2005 and 2013-2014 was statistically significant for diseases of the circulatory system (309%, p<0.05), neoplasms (132%, p<0.05) and diseases of the digestive system (129%, p<0.05) (Annexe 9, A9.1).

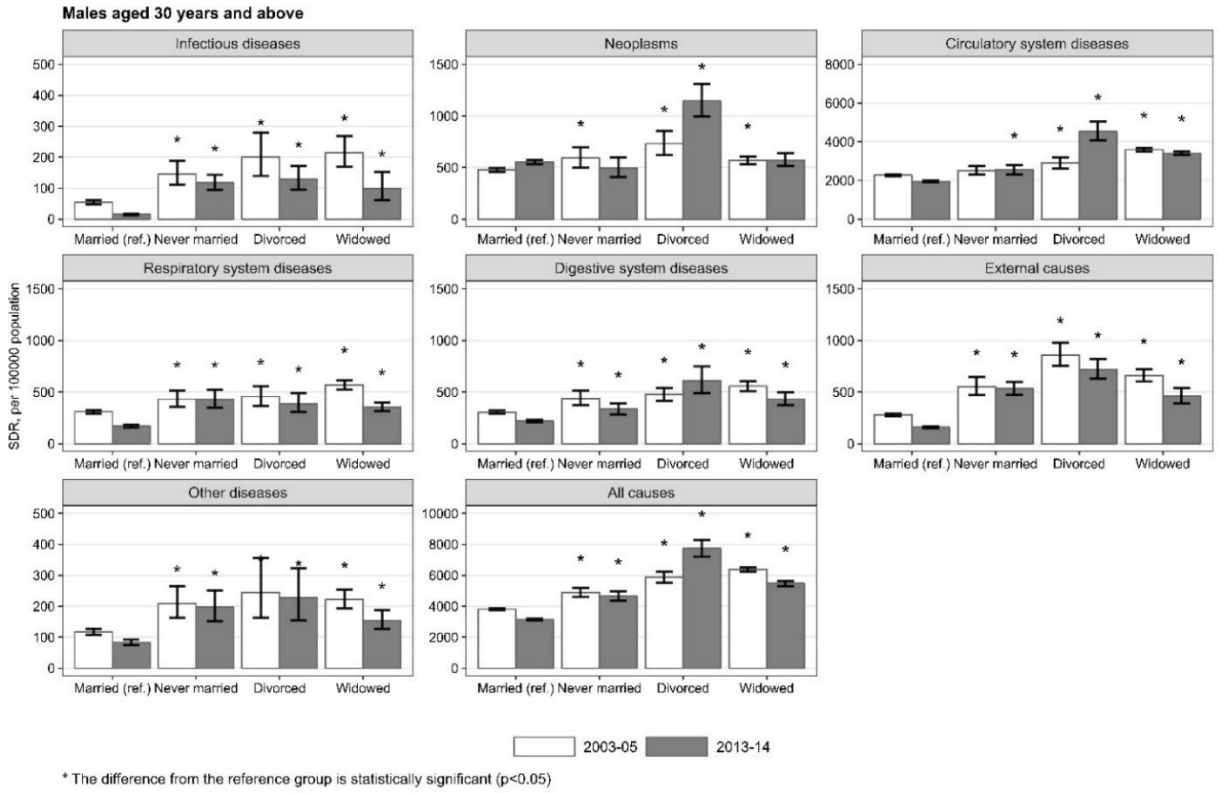


Fig. 5.7 Standardised death rates by main cause of death and marital status in 2003-2005 and 2013-2014, Moldova, males aged 30 years and over (per 100000 population)

Note: reference group (ref.) – married males.
Source: author's calculations based on NBS and NAPH data.

Overall mortality for non-married females was statistically significantly higher than for married females except for divorced females in the first period (Figure 5.8). The impact of circulatory system diseases on all-cause mortality varied between 68% in divorced females to 76% in never-married females. On the other hand, the contribution of mortality from neoplasms was maximum among divorced females (16%) and minimum among never-married females (10%).

Diseases of the digestive system, which occupied the third place in the mortality pattern, ranged from 6% in never-married females to 9% in widowed females.

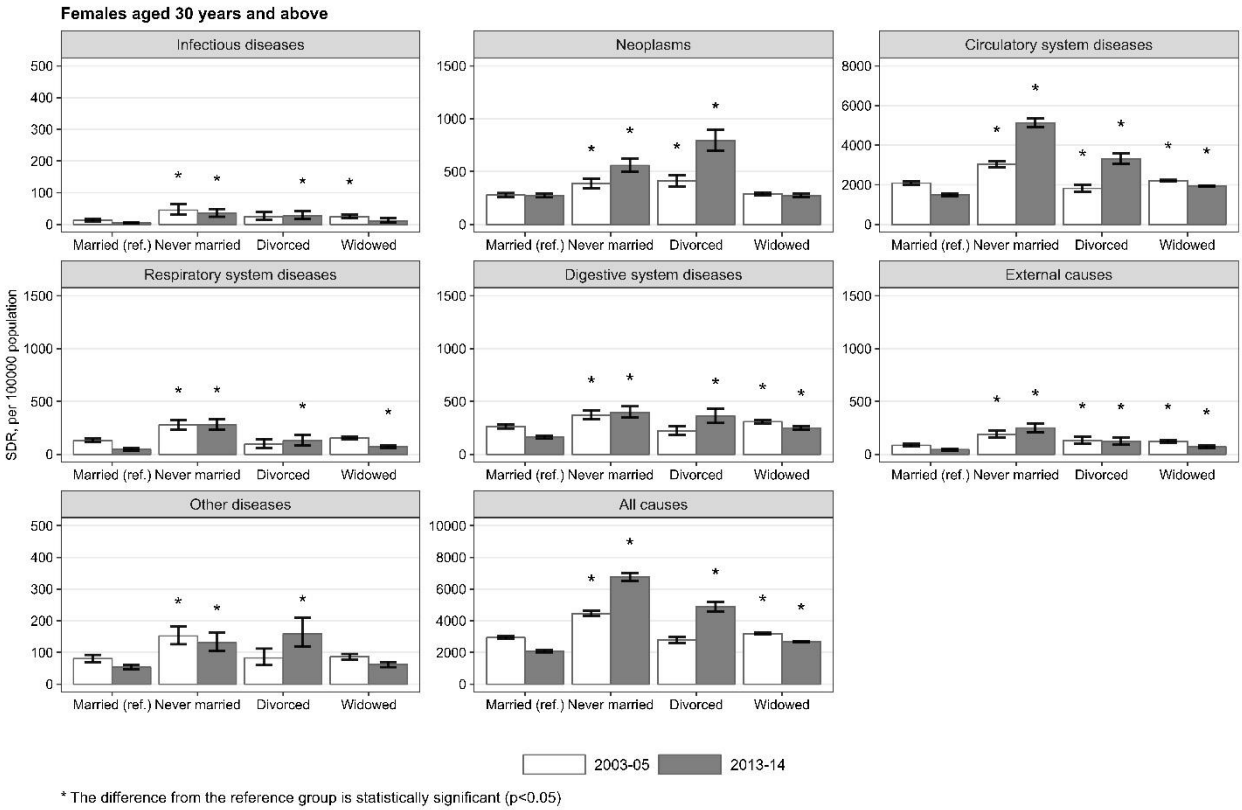


Fig. 5.8 Standardised death rates by main cause of death and marital status in 2003-2005 and 2013-2014, Moldova, females aged 30 years and over (per 100000 population)

Note: reference group (ref.) – married females.
Source: author's calculations based on NBS and NAPH data.

Among females, the most pronounced absolute disparities in all-cause mortality were found between married and never-married females both in the first (RD=1522 per 100000 population, $p<0.05$) and the second (RD=4693 per 100000 population, $p<0.05$) periods. For never-married females, absolute differences in mortality recorded the highest values for the leading causes of death, except for neoplasms in the two periods and other diseases in the second period. Mortality excess for the latter two causes of death was registered for divorced women. All-cause mortality inequalities between the two periods increased statistically significantly for all three non-married groups, especially among never-married and divorced females. Among never-married women, the growth in absolute differences between the two periods was statistically significant for diseases of the circulatory system (281%, $p<0.05$), neoplasms (162%, $p<0.05$), digestive system diseases (120%, $p<0.05$) and external causes of death (97%, $p<0.05$) (Annexe 9, A9.2).

Table 5.7 Impact of absolute differences by marital status and cause of death on absolute differences in all-cause mortality in 2003-2005 and 2013-2014. Moldova, by sex (%)

	Impact of RD, 2003-2005 (%)			Impact of RD 2013-2014 (%)		
	Never-married	Divorced	Widowed	Never-married	Divorced	Widowed
Males						
Infectious diseases	8.61	7.15	6.26	6.82	2.49	3.64
Neoplasms	10.78	12.39	3.55	-3.95	12.88	0.76
Circulatory system diseases	22.69	30.64	51.40	39.69	56.08	62.75
Respiratory system diseases	11.51	7.21	10.20	17.50	4.78	8.04
Digestive system diseases	12.39	8.29	9.76	7.80	8.51	9.21
External causes	25.50	28.32	14.84	24.96	12.18	12.98
Other diseases	8.59	6.19	4.06	7.62	3.16	3.07
All causes of death combined	100.00	100.00	100.00	100.00	100.00	100.00
Females						
Infectious diseases	2.13	-8.09	4.55	0.65	0.82	1.15
Neoplasms	7.14	-88.99	4.55	6.08	18.51	0.19
Circulatory system diseases	62.55	175.99	49.12	77.26	64.26	74.00
Respiratory system diseases	9.55	23.74	8.58	4.96	2.86	4.11
Digestive system diseases	7.05	27.77	16.90	5.03	7.06	14.97
External causes	6.88	-29.43	14.13	4.39	2.75	4.55
Other diseases	4.70	-1.61	2.22	1.65	3.77	1.41
All causes of death combined	100.00	100.00	100.00	100.00	100.00	100.00

RD - rate difference per 100000 population.
The impact of RD in mortality from a cause i on RD in all-cause mortality was calculated: RD a cause i / RD all causes x 100
Source: author's calculations based on NBS and NAPH data.

Table 5.7 illustrates the impact of rate differences by seven main groups of causes of death on the rate differences in all-cause mortality over the two study periods. For the non-married population, circulatory system diseases were the leading cause of death responsible for absolute inequalities in overall mortality relative to their married counterparts. In 2013-2014, the contribution of this pathology varied between 40% for never-married males and 63% for widowed males. Among females, the corresponding figures were higher and ranged from 64% for divorced females to 77% for never-married females. Diseases of the circulatory system contributed most to the growing rate difference in overall mortality between married and non-married populations, particularly for divorced males and females and never-married females.

The impact of neoplasms was the most marked for divorced males (13% in 2013-2014) and females (18% in 2013-2014), especially in the second period. The contribution of external causes

of death to overall mortality inequalities varied between 12% for divorced and widowed males to 25% for never-married males in the second period. The influence of external causes of death on absolute mortality inequalities among non-married females was less evident than for males. On the other hand, the impact of digestive system diseases was quite considerable for widowed females (15-17%) in both periods. Digestive system diseases accounted for about 10% of the rate difference in all-cause mortality between married and non-married males in both study periods. Diseases of the respiratory system played an important role in absolute inequalities between married and never-married males (17% in 2013-2014).

5.2.2.2. Relative differences by marital status and main causes of death

Relative differences indicate how many times the standardised death rates in a study group (never-married, widowed or divorced) are above or below those in the reference group (married population). Annexe 10 provides detailed information on the relative differences in mortality computed by cause of death and the marital status during the two periods and their change. The mortality rate ratios for seven broad groups of causes of death among *males* aged 30 years and over in 2003-2005 and 2013-2014 are shown in Figure 5.9. In 2013-2014, the highest all-cause mortality differentials were found for divorced males (RR=2.5 times, $p<0.05$), while for the other categories, inequalities were less marked (RR=1.7 for never-married males and RR=1.9 times for widowed males, $p<0.05$). The most striking difference for divorced males was observed for infectious diseases (RR=7.8 times, $p<0.05$). For never-married and widowed men, the rate ratio for infectious diseases was 7.5 and 6.6 times, respectively. Divorced males had a 4-fold risk of dying from external causes of death compared to married males. The rate ratio for this group of causes of death for never-married and widowed males was 3.5 and 3 times, respectively. The mortality disadvantage for respiratory system diseases had the maximum values for divorced and never-married men (RR=3.0 times, $p<0.05$), while for widowed males, it was 2.5 times ($p<0.05$). The rate ratio for circulatory system diseases, digestive system diseases and other causes of death varied between 1.5 and 2.8 times ($p<0.05$). In the second period, neoplasms mortality showed statistically significant differences between married and divorced men (RR=2.0 times, $p<0.05$) but not between married and never-married or widowed men.

Between 2003-2005 and 2013-2014, the relative disparities in all-cause mortality among males did not change considerably, except for divorced males (from 1.9 times in 2003-2004 to 2.5 times in 2013-2014, $p<0.05$) (Annexe 10, A10.1). Among divorced males, the most considerable changes in rate ratio occurred for infectious diseases (130%, $p<0.05$) and diseases of the circulatory, digestive and respiratory systems (more than 50%, $p<0.05$). The risk of dying among never-married males compared to married males increased most substantially for infectious

diseases (190%, p<0.05), respiratory diseases and external causes of death (more than 50%, p<0.05). Over the study period, widowed males experienced a 60% rise in relative differences in mortality from infectious diseases, while for other groups of causes of death, the rise was slight or not statistically significant. The relative differentials in neoplasm mortality between 2003-2005 and 2013-2014 increased modestly for divorced males (35%, p<0.05), while for the other two non-married groups, the situation remained unchanged (Annexe 10, A10.1).

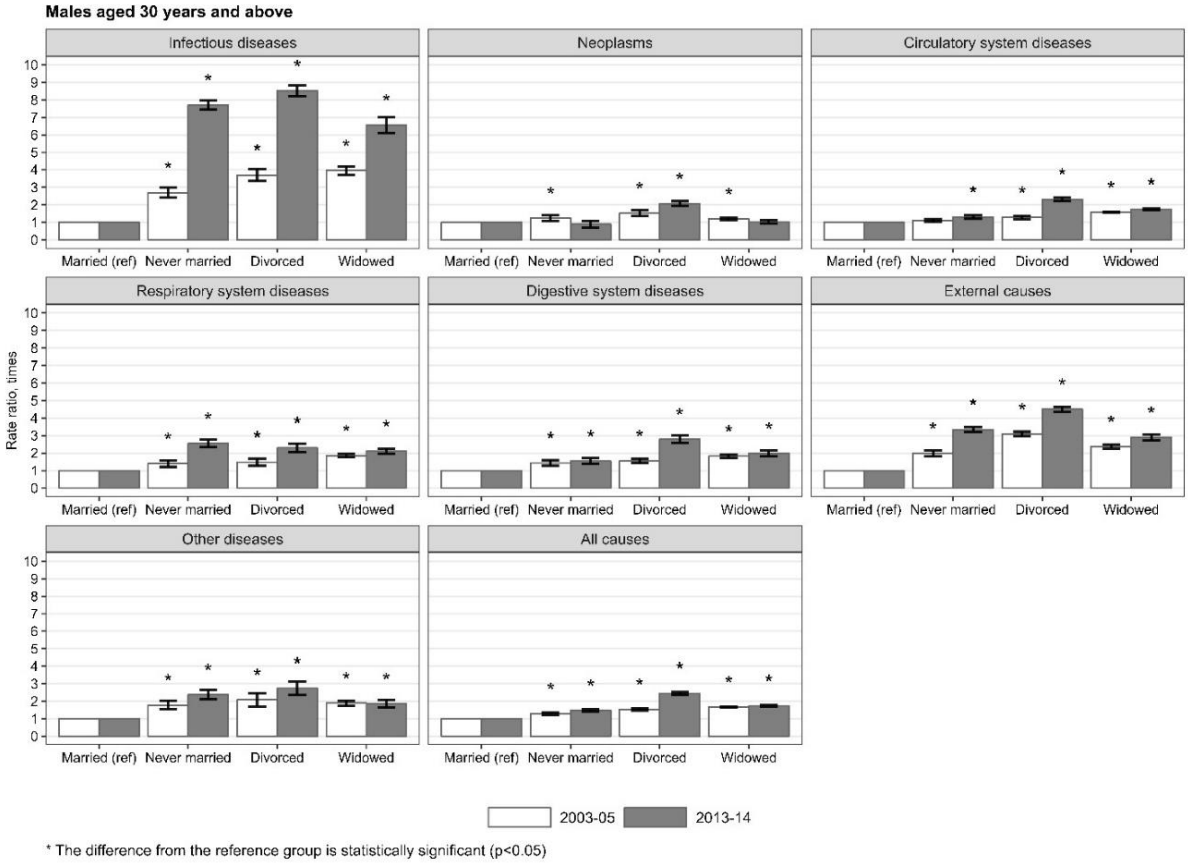


Fig. 5.9 Mortality rate ratio by main cause of death and marital status in 2003-2005 and 2013-2014, Moldova, males aged 30 years and over (times)

Note: reference group (ref.) – married males.
Source: author's calculations based on NBS and NAPH data.

The mortality rate ratios for seven broad groups of causes of death among *females* aged 30 years and over in 2003-2005 and 2013-2014 are shown in Figure 5.10. Relative disparities in mortality by marital status were more pronounced in females than males. In 2013-2014, the highest all-cause mortality differences were found for never-married females (RR=3.3 times, p<0.05). Differences in all-cause mortality were less pronounced but statistically significant for the two other categories (RR=2.4 for divorced females and RR=1.3 times for widowed females, p<0.05) (Annexe 10, A10.3).

Among never-married women, the rate ratio of mortality rates attributable to infectious diseases was nearly eight in 2013-2014 (p<0.05). At the same time, the risk of dying from external

causes of death and respiratory system diseases in never-married women was over five times higher than in their married counterparts. The mortality disadvantage among never-married females for chronic diseases such as neoplasms, circulatory system diseases and digestive system diseases was less marked and varied between 2.1 (neoplasms) and 3.4 (circulatory system diseases).

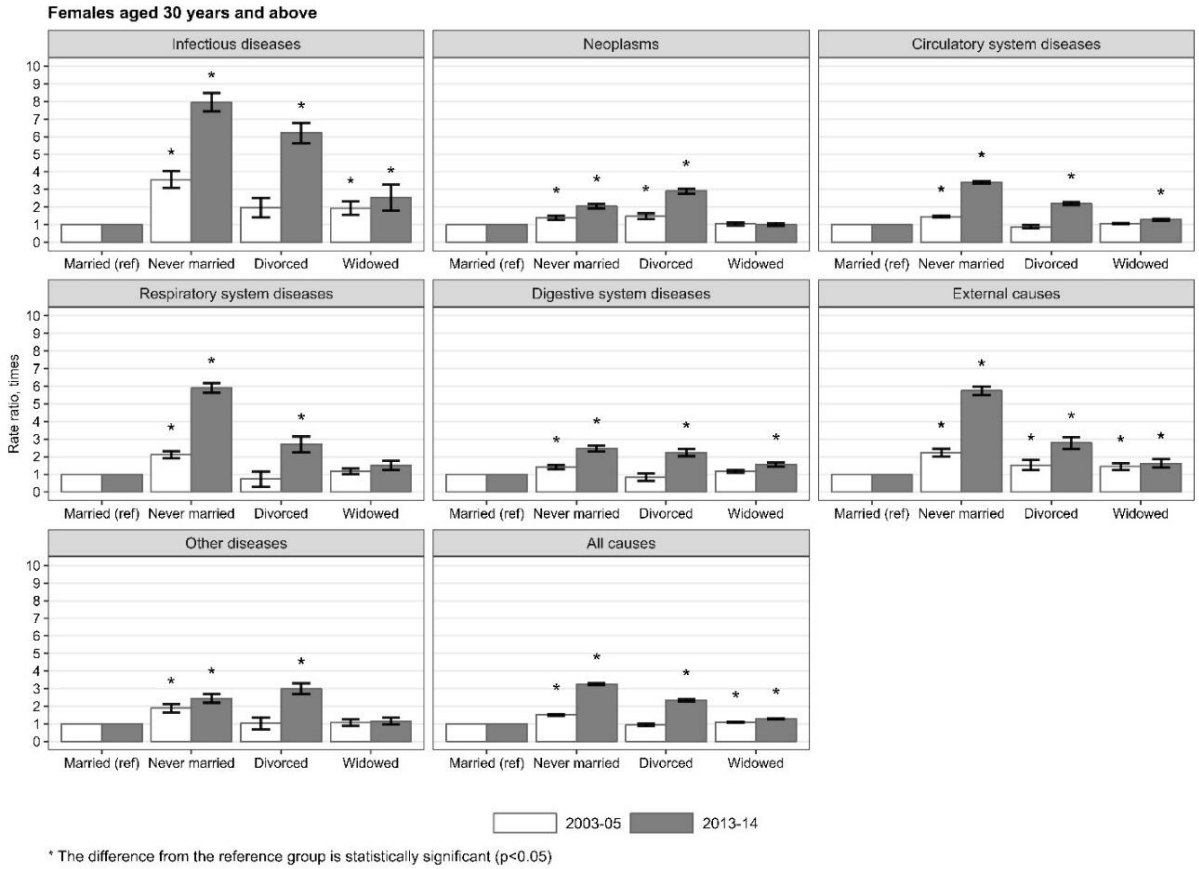


Fig. 5.10 Mortality rate ratio by main cause of death and marital status in 2003-2005 and 2013-2014, Moldova, females aged 30 years and over (times)

Note: reference group (ref.) – married females.
Source: author's calculations based on NBS and NAPH data.

Among divorced women, the mortality rate ratio was higher than six for infectious diseases and between two and three for other causes of death. The excess of deaths from neoplasms was the highest among divorced females (RR=2.9, $p<0.05$). Widowed women had the least pronounced cause-specific mortality differentiation compared to married women. The mortality rate ratio among widowed women was 2.5 for infectious diseases, while the indicator was higher than 1.5 times for respiratory diseases, digestive diseases and external causes of death (<0.05) and statistically insignificant for neoplasms and other diseases.

Between 2003-2005 and 2013-2014, mortality inequalities compared to the category of married females more than doubled for divorced and never-married females, while for widowed females, the changes were moderate (Annexe 10, A10.3). Among divorced females, the increase

in relative mortality inequalities over the study period more than tripled for respiratory and infectious diseases and doubled for circulatory diseases, digestive diseases and other causes of death. For neoplasms and external causes of death, the rate ratio for divorced women increased by over 80% between 2003-2005 and 2013-2014. Mortality differentials between married and never-married females rose most markedly for respiratory diseases and external causes of death (more than 150%, $p<0.05$), circulatory diseases and infectious diseases (more than 100%, $p<0.05$). The increase in relative disparities in mortality from neoplasms was less pronounced than for other groups of causes of death among divorced women (72%, $p<0.05$) and never-married women (43%, $p<0.05$). Widowed women had small (less than 50%) or no statistically significant changes in mortality rate ratios for most causes of death over the study period.

5.2.2.3. Relative differences by marital status and detailed causes of death

Relative disparities in mortality related to heart diseases were highest among widowed males in 2003-2005 (RR=1.6, $p<0.05$) and divorced males in 2013-2014 (RR=2.3, $p<0.05$) (Figure 5.11). The mortality rate ratio for heart diseases over the study period increased for all three non-married groups but most for divorced males (97%, $p<0.05$). The inequalities in mortality related to cerebrovascular diseases were most pronounced for divorced and widowed males in the early 2000s (RR=1.5 times, $p<0.05$). A decade later, the mortality rate ratio for the given cause of death increased by 50% between married and divorced males but remained unchanged between married and widowed males. For never-married males, disparities in mortality related to heart and cerebrovascular diseases were minor (RR was less than 1.5 times) or statistically insignificant.

Among females, relative differences in mortality associated with heart diseases in both periods were highest for never-married females and lowest for widowed females. The mortality rate ratio for heart disease in never-married females increased from 1.5 times in 2003-2005 ($p<0.05$) to 3.6 times in 2013-2014 ($p<0.05$) or by 141% ($p<0.05$). In the first period, differences in heart disease mortality were unimportant between married and divorced or widowed women. However, these inequalities widened considerably in the second period, especially for divorced women (RR=1.9 times, $p<0.05$). Concerning cerebrovascular diseases, the differences in mortality in the first period were statistically significant only between married and never-married females (RR=1.4, $p<0.05$). In the second period, the mortality rate ratio for this type of pathology increased considerably in never-married (RR=3.0, $p<0.05$) and, particularly, divorced women (RR=2.9 times, $p<0.05$).

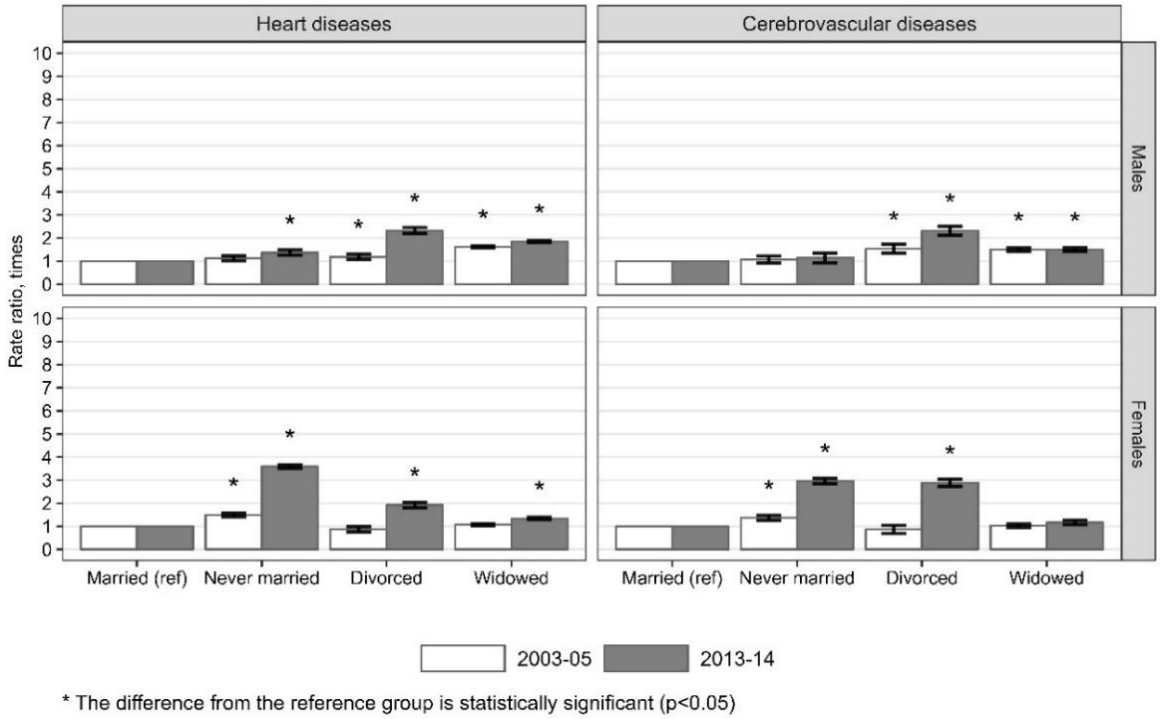


Fig. 5.11 Mortality rate ratio for heart diseases and cerebrovascular diseases by marital status in 2003-2005 and 2013-2014, Moldova, males and females aged 30 years and over (times)

Note: reference group (ref.) – married population.
Source: author's calculations based on NBS and NAPH data.

The relative differences in cancer mortality between the married and non-married populations were much less pronounced compared to other causes of death, with the divorced being the most vulnerable group. The more detailed analysis demonstrated that divorced males were particularly susceptible to cancer of the digestive system (RR=2.3 times, $p<0.05$), while the mortality rate ratio for neoplasms of other locations varied between 1.7 and 2 times ($p<0.05$). Moreover, the increase in cancer mortality inequalities for divorced males between the two periods was mainly associated with cancer of the digestive system (77%, $p<0.05$) (Annexe 10, A10.2).

Cancer mortality inequalities were more pronounced in females than males. In divorced women, mortality from digestive system cancer was three times higher than in married women. The mortality rate ratio for breast cancer and cancer of the respiratory system in divorced and never-married women was more than 2.5 times higher than in married women. The increase in cancer mortality inequalities between the two periods was essentially related to cancer of the digestive system and breast cancer in divorced females and cancer of the respiratory system in never-married females (more than 100%, $p<0.05$) (Figure 5.12, Annexe 10, A10.4).

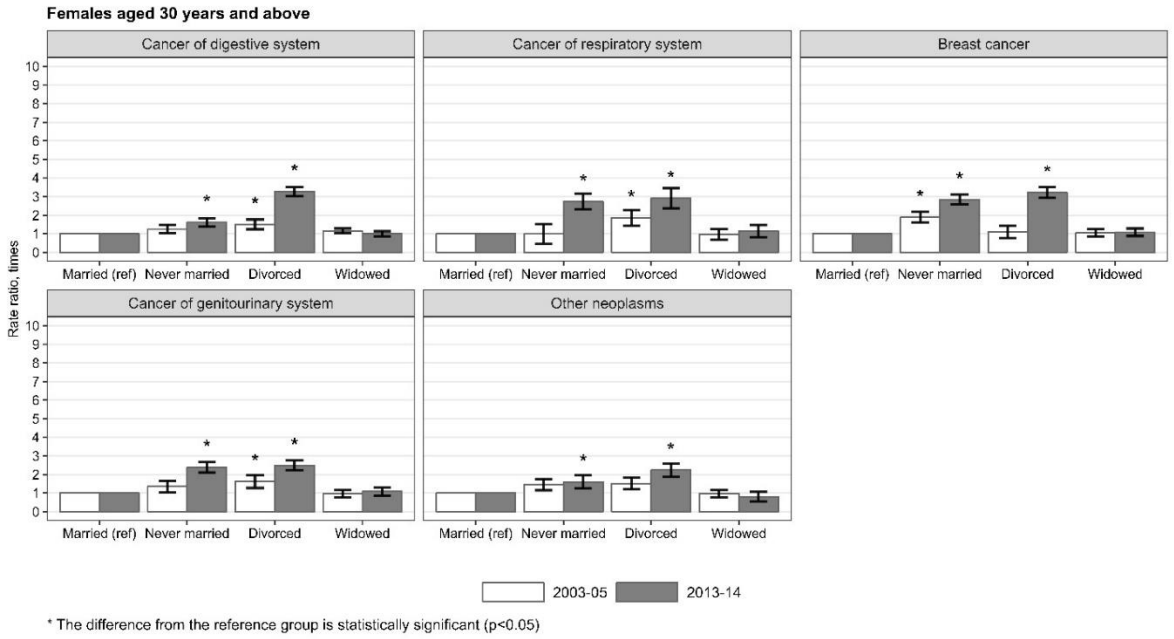


Fig. 5.12 Mortality rate ratio for neoplasms of different locations by marital status in 2003-2005 and 2013-2014, Moldova, females aged 30 years and over (times)

Note: reference group (ref.) – married females.
Source: author's calculations based on NBS and NAPH data.

Our findings showed that marital status had an important role in differentiating mortality from external causes for both sexes. Among males, the most marked inequalities in the two periods were observed in divorced males for the group of causes including suicide, homicide and accidents with undetermined intent and the residual group of external causes of death (Figure 5.13). In the second period, the risk of death from these two causes in divorced males was more than four times higher than in married males ($p<0.05$). For the other two categories of non-married males, the rate ratio varied from 1.8 to 3.8 times ($p<0.05$). At the same time, mortality disparities for transport accidents were less pronounced (RR=3.8 times, $p<0.05$) and statistically significant only for divorced males. Among females, the highest inequalities were registered for never-married females in the second period for the groups of causes "suicide, homicide and accidents with undetermined intent" (RR=7 times, $p<0.05$). For this group of external causes of death, the growth in the mortality rate ratio in never-married women between the two periods was particularly pronounced (238%, $p<0.05$). Differentiation in mortality from transport accidents in women, like in men, was less dependent on marital status and statistically significant only for never-married and divorced women (rate ratio in 2013-2014 was between 3 and 3.8 times, $p<0.05$).

Inequalities in male mortality from liver diseases and other diseases of the digestive system ranged from 1.4 times (never-married males in 2003-2005) to 2.8 times (divorced males in 2013-2014) (Figure 5.14). The growth in mortality rate ratio for these two causes of death over the study period was found only for divorced males (more than 60%, $p<0.05$). Inequalities in female

mortality from liver diseases were the most pronounced between married and never-married categories in 2003-2005 (RR=1.4, p<0.05) and 2013-2014 (RR=2.4, p<0.05). On the other hand, for other diseases of the digestive system, the rate ratio was most noticeable in the second period for divorced (RR=5 times, p<-0.05) and never-married women (RR=2.9, p<0.05).

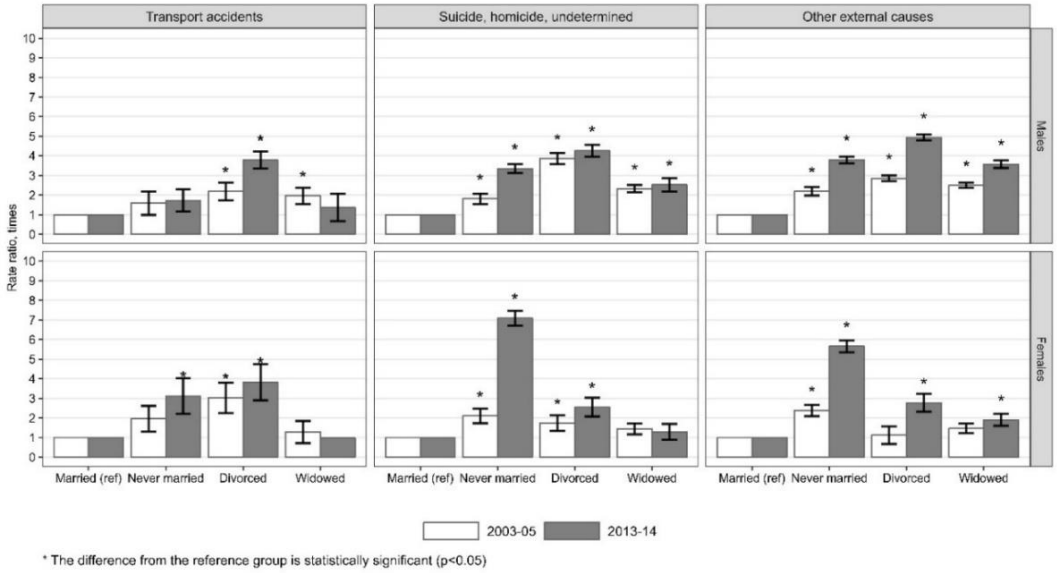


Fig. 5.13 Mortality rate ratio for external causes of death by marital status in 2003-2005 and 2013-2014, Moldova, males and females aged 30 years and over (times)

Note: reference group (ref.) – married population.
Source: author's calculations based on NBS and NAPH data.

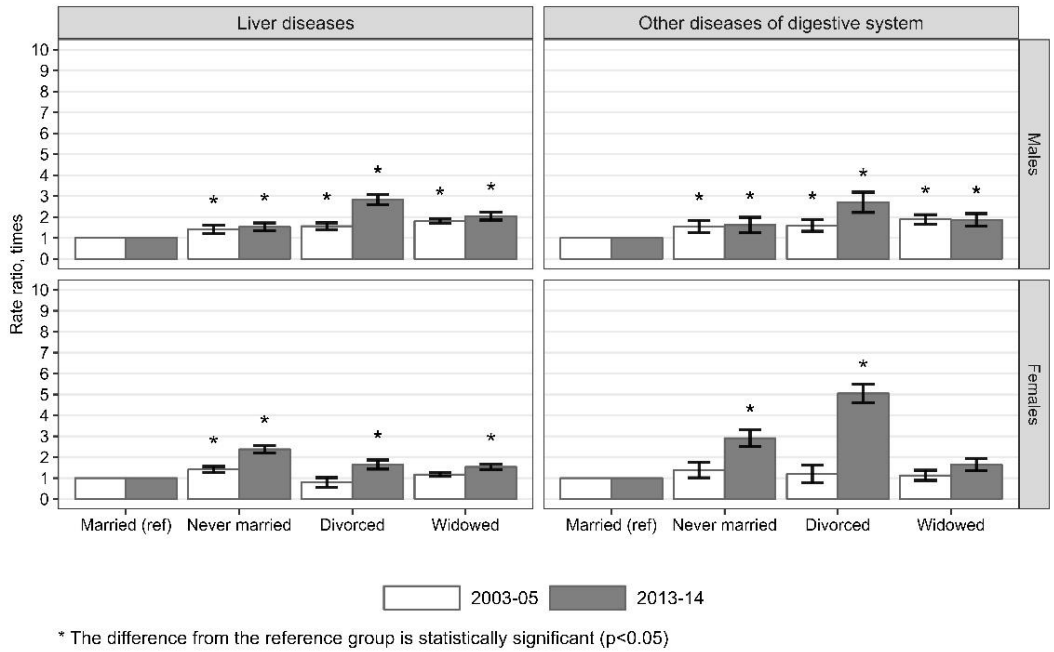


Fig. 5.14 Mortality rate ratio for liver disease by marital status in 2003-2005 and 2013-2014, Moldova, males and females aged 30 years and over (times)

Note: reference group (ref.) – married population.
Source: author's calculations based on NBS and NAPH data.

5.3. Mortality disparities by the level of education

Mortality disparities by the level of education, as those by marital status, were analysed for two periods around the 2004 and 2014 population censuses. First, differences in mortality from all causes of death combined are presented, and then absolute and relative differences by cause of death are shown.

5.3.1. Differences in all-cause mortality by the level of education

Table 5.8 presents life expectancy at 30 and 60 years by educational level for Moldovan men and women in 2003-2005 and 2013-2014. There was a maximum difference in life expectancy at age 30 between higher education and primary or lower education for men and women in both study periods. In 2013-2014, the life expectancy at age 30 of Moldovan men with higher education was 44.3 years, while it was 37.5 years and 33.6 years for those with secondary and primary or lower education, respectively. In the second period, the difference in life expectancy between men with higher education and men with secondary education was 6.8 years, whereas the difference between men with higher education and men with primary or lower education was 10.7 years. From 2003-2005 to 2013-2014, the gap in life expectancy at age 30 increased between men with higher education and men with secondary education by more than one year, while it was constant between men with higher education and men with primary or lower education.

Table 5.8 Life expectancy at age 30 and 60 and 95% confidence intervals by the level of education and sex in 2003-2005 and 2013-2014, Moldova (years)

	2003-2005		2013-2014	
	Males	**Females**	**Males**	**Females**
At age 30				
Primary or lower	31.82 (31.26-32.35)*	39.49 (38.94-40.02)*	33.59 (32.9-34.25)*	40.92 (40.14-41.62)*
Secondary	36.68 (36.53-36.84)*	45.29 (45.11-45.49)*	37.48 (37.31-37.66)*	45.89 (45.72-46.06)*
Higher	41.88 (41.55-42.22)	50.77 (50.31-51.2)	44.31 (43.93-44.73)	50.75 (50.38-51.16)
Difference (max.-min.)	*10.06*	*11.28*	*10.72*	*9.83*
At age 60				
Primary or lower	12.63 (12.5-12.77)*	16.11 (16.02-16.22)*	11.92 (11.6-12.25)*	16.41 (16.18-16.67)*
Secondary	15.35 (15.19-15.51)*	19.95 (19.75-20.13)*	15.51 (15.35-15.66)*	19.78 (19.64-19.93)*
Higher	16.9 (16.6-17.21)	23.48 (23.03-23.94)	18.54 (18.21-18.86)	23.07 (22.71-23.4)
Difference (max.-min.)	*4.27*	*7.36*	*6.62*	*6.65*

Note: without Transnistria. * p-value < 0.05 compared to the population with higher education.

Source: author's calculations based on NBS and NAPH data.

Women aged 30 years with higher education lived an average of 50.7 years in 2013-2014, while their counterparts with secondary education and primary education or less lived 45.9 and 40.9 years. The difference in female life expectancy at age 30 between women with higher educational attainment and women with secondary and primary or lower educational attainment was 4.8 and 9.8 years, respectively ($p<0.05$). Between the two censuses, the longevity gap between women with higher education and women with primary or lower education declined by 1.5 years (11.3 in 2003-2005, $p<0.05$). At the same time, the difference between women with higher education and women with secondary education was almost the same over the study period (5.3 years in 2003-2005, $p<0.05$).

Inequalities in life expectancy at age 60 by educational level were similar to those at age 30 but less pronounced. In 2013-2014, the highest life expectancy at age 60 was found among the population with higher education (18.5 years for males and 23.1 years for females) and the lowest life expectancy among those with primary education or less (11.9 years and 16.4 years, respectively). The difference between these two categories among older men increased from 4.3 years in 2003-2005 to 6.6 years in 2013-2014. The inequalities in mortality between older women with higher education and older women with primary education or less have been somewhat reduced (7.4 years in 2003-2005 and 6.6 years in 2013-2014).

In men, the growth in life expectancy at 30 years between 2003-2005 and 2013-2014 was most marked among men with higher education, reaching 2.4 years ($p<0.05$) (Table 5.9). During the same period, the indicator rose by 1.8 years for men with primary or lower education and about one year for men with secondary education ($p<0.05$). Among older men, improvements were statistically significant only for the higher education category (1.6 years, $p<0.05$), while the health status of older men with primary or lower education deteriorated. In contrast to males, female life expectancy at age 30 has not increased for the higher education category. Among older women, changes in life expectancy were not statistically significant over the study period.

Table 5.9 Changes in life expectancy at age 30 and 60 by the level of education between 2003-2005 and 2013-2014, Moldova, by sex (years)

	At age 30		At age 60	
	Males	**Females**	**Males**	**Females**
Primary or lower	1.78*	1.43*	-0.71*	0.3
Secondary	0.8*	0.6*	0.15	-0.17
Higher	2.43*	-0.02	1.63*	-0.41

Note: without Transnistria. * The difference is statistically significant (p-value < 0.05).

Source: author's calculations based on NBS and NAPH data.

Figure 5.15 shows relative differences in age-specific probabilities of dying by the level of education and sex over the two periods. The reference group was the population with higher

education, while the study groups were those with secondary and primary or lower education. The largest relative differences were observed among those aged 30 to 39. In 2013-2014, men and women in this age group with primary or lower education were 4.6 and 6 times more likely to die, respectively, than men and women with higher education. Men and women aged 30 to 39 with secondary education were, respectively, at three times and twice the risk of dying compared to the reference group. Between 2003-2005 and 2013-2014, the ratios of death probabilities between the population with primary or lower education and the population with higher education were relatively stable across ages. However, they increased in the 30-39 age group from 3.5 to 4.7 times in males and from 5.3 to 6 times in females. As in the case of marital status, inequalities in mortality by the level of education declined with age. However, if in the 70-79 age group, excess mortality risk for men and women with secondary education was negligible, it remained notable (1.6-1.7 times) for the population with primary or lower education in 2013-2014.

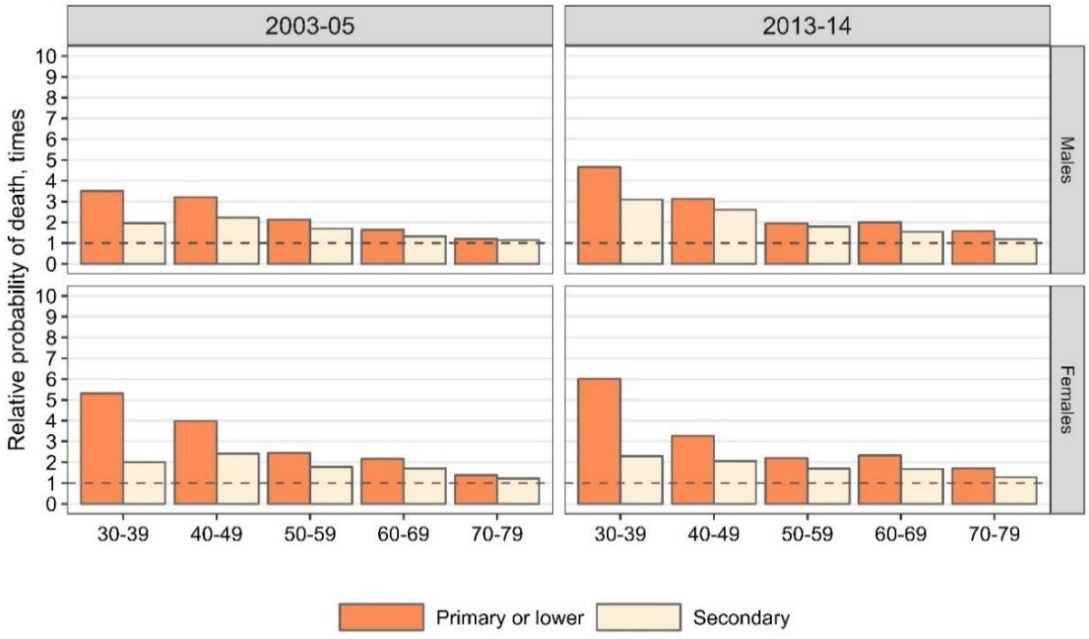


Fig. 5.15 Age-specific ratios between the probabilities of dying by the level of education in 2003-2005 and 2013-2014, Moldova, by sex (times)

Note: reference group – a population with higher education.
Source: author's calculations based on NBS and NAPH data.

5.3.2. Differences in cause-specific mortality by the level of education

5.3.2.1. Absolute differences by level of education and main causes of death

Figures 5.16 and 5.17 show standardised death rates by marital status and cause of death with 95% CIs for males and females, respectively. Annexes 11 and 12 provide more detailed data, including absolute differences over the two study periods.

In 2013-2014, the share of diseases of the circulatory system ranged from 59% for *males* with secondary education to 65% for males with primary or lower education. The proportion of

neoplasms in the mortality profile was lowest among males with primary or lower education (10%) and highest among males with higher education (19%). Digestive system diseases and external causes of death together accounted for less than 15% of all deaths in the three educational categories. The impact of respiratory system diseases was greater among primary-educated men and comparable to neoplasms.

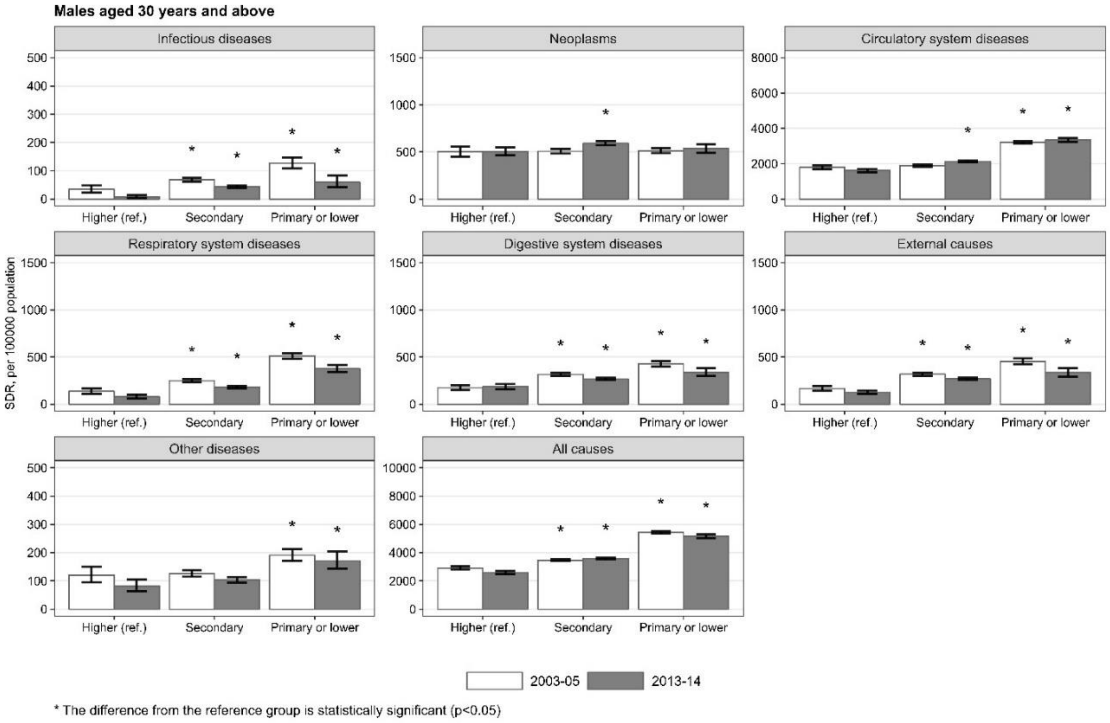


Fig. 5.16 Standardised death rates by main cause of death and the level of education in 2003-2005 and 2013-2014, Moldova, males aged 30 years and over (per 100000 population)

Note: reference group (ref.) – males with higher education.
Source: author's calculations based on NBS and NAPH data.

In both periods, the highest absolute differences in all-cause mortality occurred for men with primary or lower education (RD in 2013-2014=2565 per 100000 population, $p<0.05$). In the two periods, primary-educated men had the most pronounced and statistically significant rate differences for infectious diseases, circulatory system diseases, respiratory system diseases, digestive system diseases and external causes of death. At the same time, the differentiation of mortality from neoplasms between married and non-married populations was not evident (Annexes 11, A11.1). Between 2003-2005 and 2013-2014, absolute disparities in all-cause mortality between men with primary or lower education and men with higher education have not changed but increased for men with secondary education by 80% ($p<0.05$). Statistically significant growth in rate differences between the two periods was found for circulatory system diseases in men with primary or lower education (23%, $p<0.05$) and men with secondary education (408%, $p<0.05$). On the other hand, absolute disparities were reduced for diseases of the digestive system

by about 40% ($p<0.05$) for males with secondary and primary or lower education (Annexe 12, A12.1).

Diseases of the circulatory system and neoplasms were the two leading causes of death among women, regardless of educational attainment. In the second period, the impact of cardiovascular mortality was lower for females with higher education (66%) and higher for females with primary or lower education (75%). In contrast, the share of neoplasm-related deaths was more considerable among women with university degrees (21%) than women with primary or lower education (8%). The contribution of digestive system diseases was the most marked in women with secondary education (9%). A similar mortality pattern was in the first period of the study (Figure 5.17). In both periods, absolute differences in mortality were highest for primary-educated women for all causes of death (RD in 2013-2014=1577 per 100000, $p<0.05$) and leading causes of death ($p<0.05$), excluding neoplasms. Similar to males, mortality associated with neoplasms in females was not significantly differentiated by educational level (Annexes 11, A11.2).

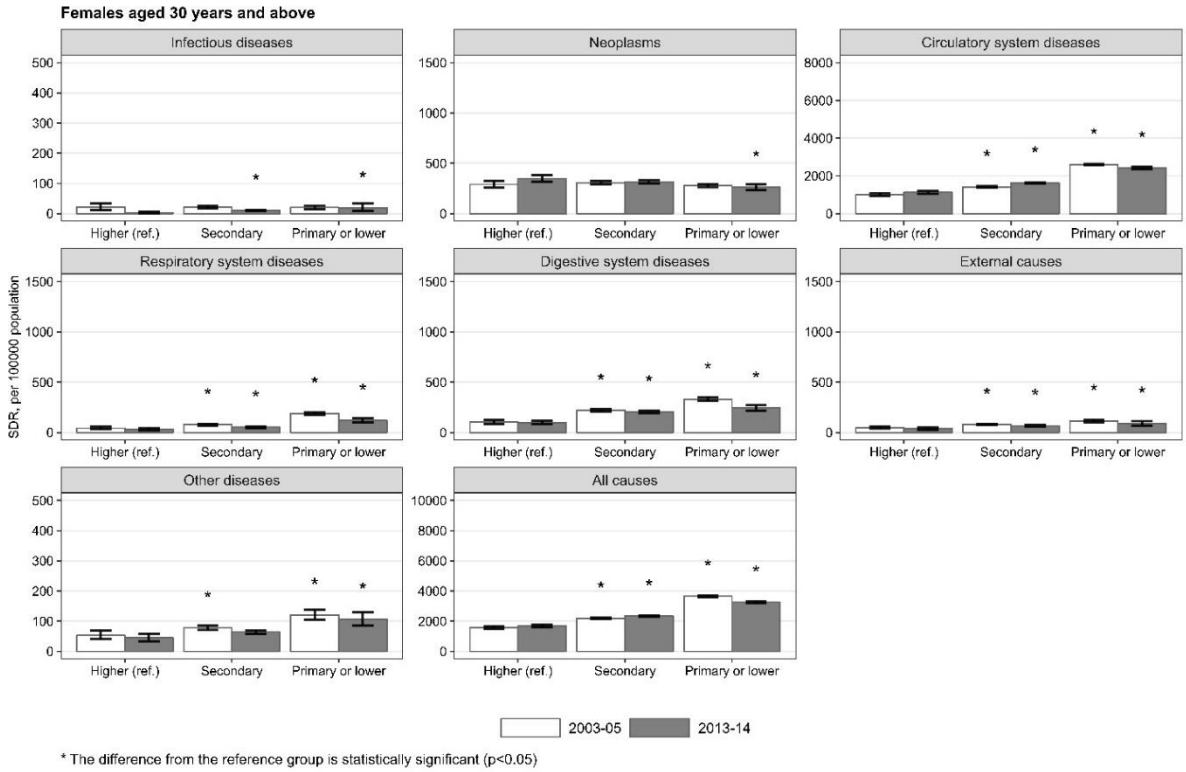


Fig. 5.17 Standardised death rates by main cause of death and the level of education in 2003-2005 and 2013-2014, Moldova, females aged 30 years and over (per 100000 population)

Note: reference group (ref.) – females with higher education.
Source: author's calculations based on NBS and NAPH data.

Compared to the 2003-2005 period, the rate difference in overall mortality for women with primary or lower education was reduced by more than 20% in 2013-2014 ($p<0.05$) due to

improvements in circulatory system diseases (17%, p<0.05), respiratory system diseases (40%, p<0.05) and diseases of the digestive system (36%, p<0.05). Changes in mortality disparities between women with higher and secondary education were not apparent between the two periods (Annexe 12, A12.2).

Table 5.10 gives information about the contribution of absolute difference for a specific cause of death expressed as a per cent to the absolute difference in mortality from all causes of death combined. In the second period, the impact of circulatory system diseases was the highest for males and females with primary or lower education and secondary education. The influence was the strongest among females with primary or lower education (83%) and weakest among males with secondary education (52%). In 2013-2014, the impact of this pathology on overall mortality inequalities increased, especially for males with secondary education.

Table 5.10. Impact of absolute differences by the level of education and cause of death on absolute differences in all-cause mortality in 2003-2005 and 2013-2014. Moldova, by sex (%)

	Impact of RD, 2003-2005 (%)		Impact of RD 2013-2014 (%)	
	Primary or lower	Secondary	Primary or lower	Secondary
Males				
Infectious diseases	3.71	6.01	2.01	3.65
Neoplasms	0.46	0.99	1.29	8.79
Circulatory system diseases	56.51	18.59	67.65	52.42
Respiratory system diseases	14.95	20.57	11.53	10.17
Digestive system diseases	10.06	25.58	5.91	8.27
External causes	11.51	27.35	8.12	14.44
Other diseases	2.80	0.89	3.48	2.19
All causes of death combined	100.00	100.00	100.00	100.00
Females				
Infectious diseases	-0.04	0.01	1.03	1.26
Neoplasms	-0.66	2.59	-5.47	-5.12
Circulatory system diseases	76.22	63.85	82.55	76.92
Respiratory system diseases	7.04	5.70	5.53	3.10
Digestive system diseases	10.98	18.90	9.20	16.50
External causes	3.17	4.88	3.27	4.44
Other diseases	3.29	4.04	3.87	2.83
All causes of death combined	100.00	100.00	100.00	100.00

RD - rate difference per 100000 population.
The impact of RD in mortality from a cause *i* on RD in all-cause mortality was calculated: RD a cause i / RD all causes x 100.
Source: author's calculations based on NBS and NAPH data.

Although neoplasms occupy second place in cause-specific mortality patterns for different educational categories, this group of causes of death does not explain mortality differentiation by education level. By contrast, in 2013-2014, diseases of the respiratory system, diseases of the

digestive system and external causes of death accounted for more than 30% of absolute differentiation in mortality for men with secondary education and more than 25% for men with primary or lower education. The combined impact of these causes of death was exceptionally high among men with secondary education in the first period and comprised more than 70%. Diseases of the digestive system are the second leading cause of death responsible for all-cause mortality differences between women with higher education and women with secondary or primary education. The impact of this pathology varied between 9% in primary-educated women in 2013-2014 and 19% among women with secondary education in 2003-2005.

5.3.2.2. Relative differences by level of education and main causes of death

Figures 5.18 and 5.19 show the rate ratios of standardised death rates according to the level of education and the leading cause of death over both periods for males and females. Annexe 13 gives detailed information on the changes in mortality rate ratios by sex and level of education in 2013-2014 compared to 2003-2005.

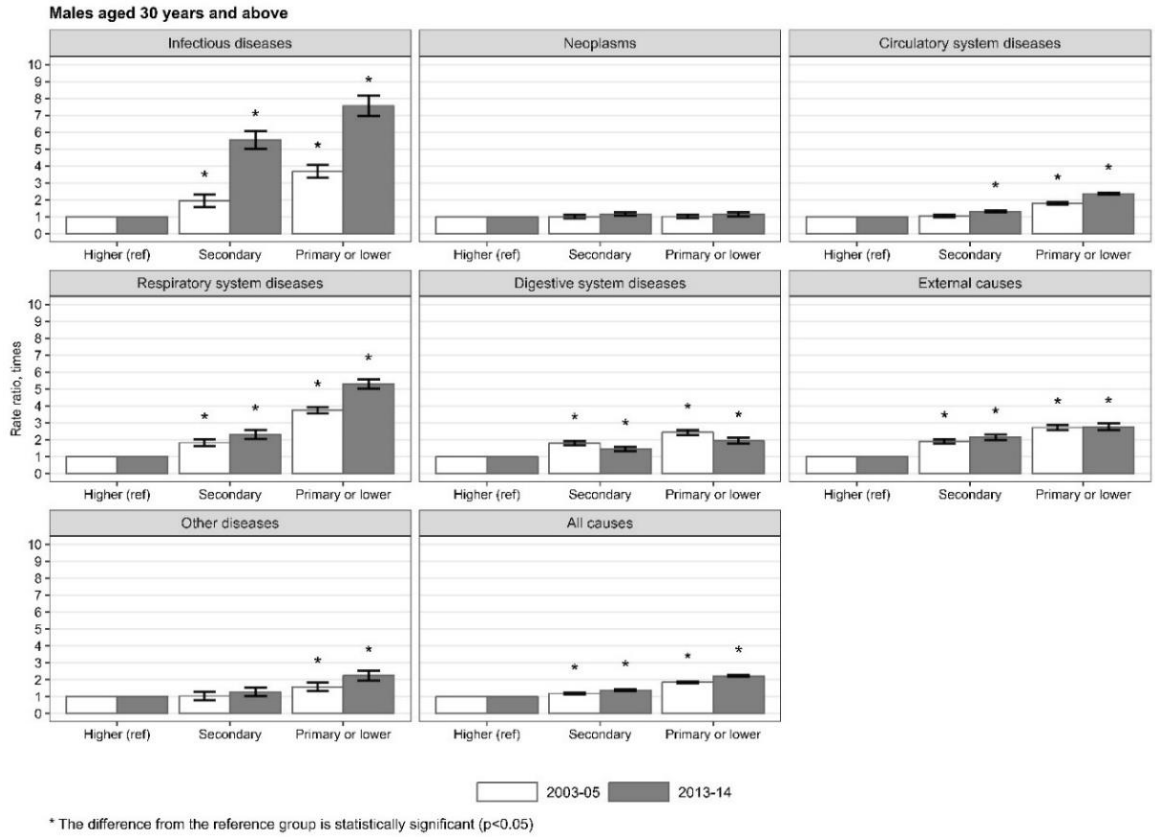


Fig. 5.18 Mortality rate ratio by main cause of death and the level of education in 2003-2005 and 2013-2014, Moldova, males aged 30 years and over (times)

Note: reference group – males with higher education.
Source: author's calculations based on NBS and NAPH data.

In 2013-2014, the relative disparities in all-cause mortality were most pronounced among men and women with primary or lower education who were at double risk of dying compared to the higher education group ($p<0.05$). The corresponding excess mortality increased by about 20%

for males between 2003-2005 and 2013-2014, while it declined slightly for females (Annexe 13, A13.1 and A13.3). The risk of dying for men and women with secondary education was about 40% higher than in the reference group ($p<0.05$). The corresponding changes in the rate ratios between the two time periods were statistically significant only for males (16.5%, $p<0.05$).

The mortality rate ratio for men with a primary or lower education was highest for infectious diseases (RR=7.6 times, $p<0.05$), diseases of the respiratory system (RR=5.3 times, $p<0.05$) and external causes of death (RR=2.8 times, $p<0.05$). Between the two marginal education categories in males, the relative difference varied between 1.9 and 2.2 ($p<0.05$) for diseases of the circulatory system, digestive system diseases and other causes of death. At the same time, no statistically significant differences were found for neoplasm mortality. Men with secondary education had very notable differences compared to the higher education group in mortality for infectious diseases (RR=5.5 times, $p<0.05$), diseases of the respiratory system (RR=2.3 times, $p<0.05$) and external causes of death (RR=2.1 times, $p<0.05$). As for the primary or lower education category, no differences in neoplasm mortality in males between secondary and higher education groups were identified.

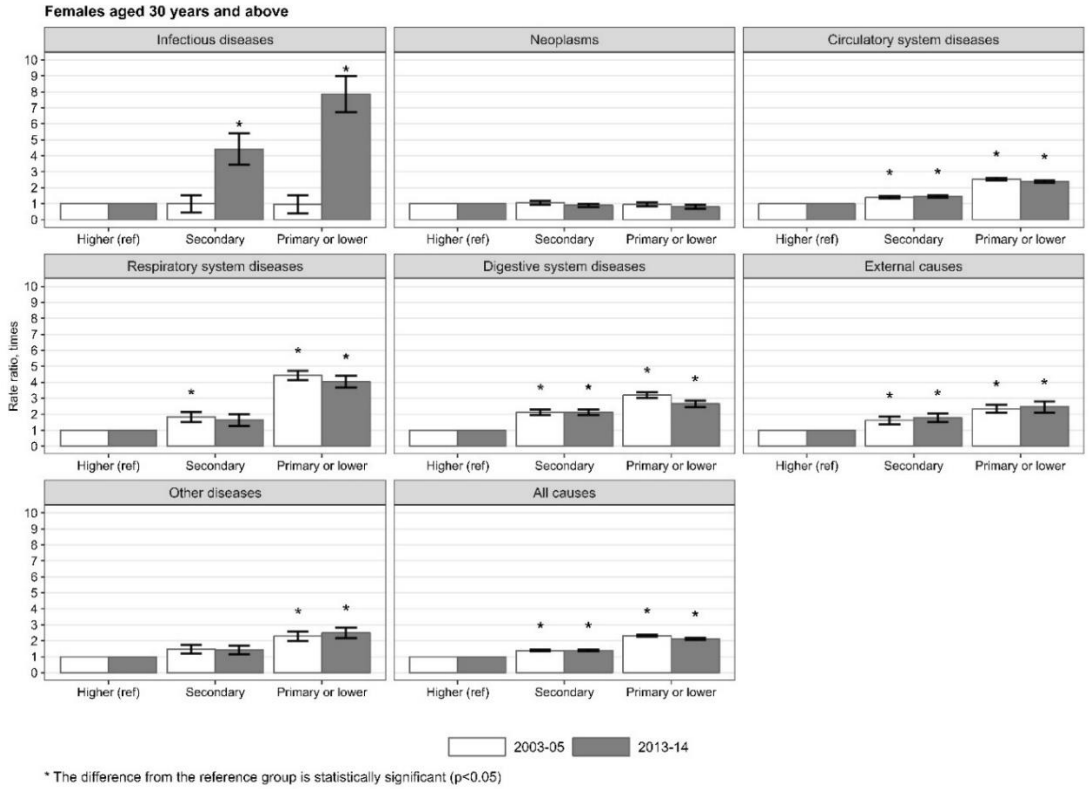


Fig. 5.19 Mortality rate ratio by main cause of death and the level of education in 2003-2005 and 2013-2014, Moldova, females aged 30 years and over (times)

Note: reference group – females with higher education.
Source: author's calculations based on NBS and NAPH data.

In 2013-2014, the mortality rate ratios among females with primary or lower education were highest for infectious diseases (RR=7.7 times, $p<0.05$) and diseases of the respiratory system (RR=4.1 times, $p<0.05$). For other causes of death except for neoplasms, the rate ratio varied between 2.4 and 2.7 times. As for men, differences in cancer mortality between females with primary or lower education and females with higher education were not statistically significant. Mortality disparities between women with secondary and higher education were the most marked for infectious diseases (RR=4.4 times, $p<0.05$) and diseases of the digestive system (RR=2.1 times, $p<0.05$).

The increase in the rate ratios between the two study periods was the most striking for infectious diseases, especially among females for whom this type of mortality was not differentiated significantly according to educational level in the early 2000s. For example, the relative mortality differential attributable to infectious diseases increased sevenfold for women with primary or lower education and threefold for women with secondary education. Among men, relative differences in mortality increased statistically significantly for diseases of the respiratory system, circulatory system and other diseases, ranging from 25% to 42%. On the other hand, mortality inequalities by educational level were moderately reduced for diseases of the digestive system among males with secondary or lower education (around 20%, $p<0.05$) and females with primary or lower education (17%, $p<0.05$). Mortality inequalities between women with primary or lower and higher education were also reduced for circulatory system diseases (Annexe 13, A13.1 and A13.3).

5.3.2.3. Relative differences by level of education and detailed causes of death

Relative differentials were more pronounced for heart diseases than cerebrovascular diseases, especially for the primary or lower education group. Men and women in this category had a 2.5 times greater risk of dying from heart disease than their higher-educated counterparts. For the population with secondary education, mortality differences were less marked for heart diseases (1.3-1.5 times, $p<0.05$) or even absent for cerebrovascular diseases during the first period for males (Figure 5.20).

Although the relative inequalities in neoplasm mortality were not found statistically significant over the two study periods, a more detailed analysis revealed differences in mortality from lung cancer for men with primary or lower and secondary education (RR=1.9, $p<0.05$) in 2013-2014 (Annexe 13, A13.2). For this type of malignant neoplasms, the differences in mortality between men with higher education and the other two educational categories increased by more than 40% between the two censuses.

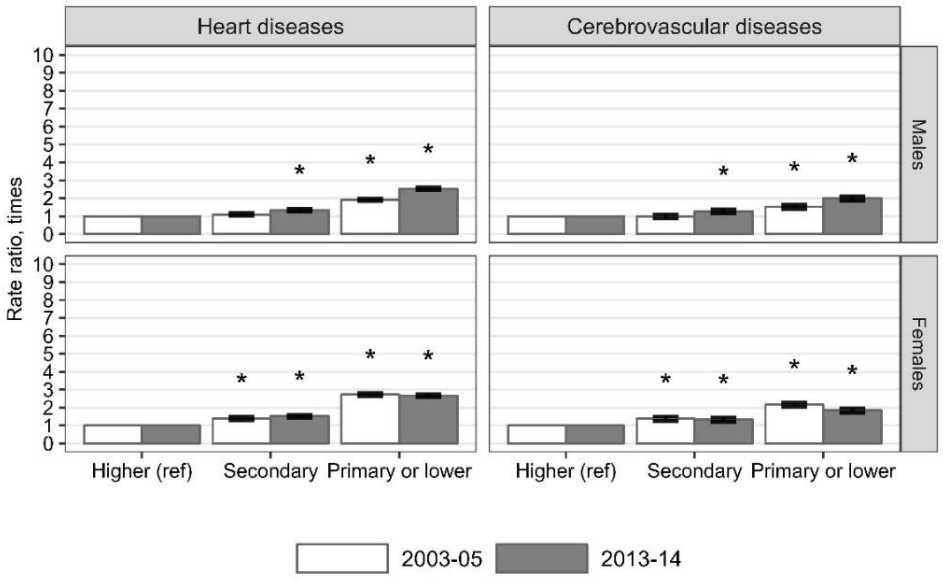


Fig. 5.20 Mortality rate ratio for heart diseases and cerebrovascular diseases by the level of education in 2003-2005 and 2013-2014, Moldova, males and females aged 30 years and over (times)

Note: reference group – males and females with higher education.
Source: author's calculations based on NBS and NAPH data.

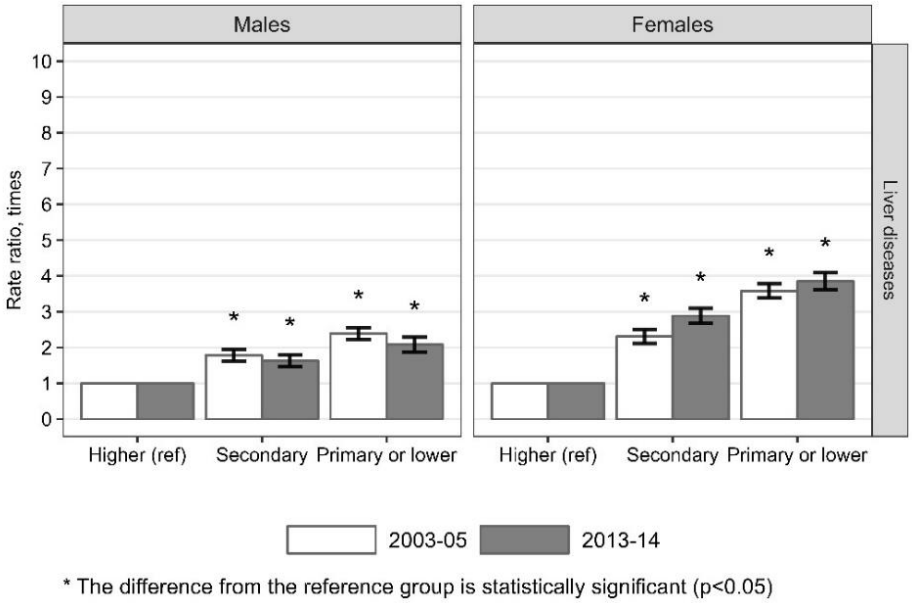


Fig. 5.21 Mortality rate ratio for liver disease by the level of education in 2003-2005 and 2013-2014, Moldova, males and females aged 30 years and over (times)

Note: reference group – males and females with higher education.
Source: author's calculations based on NBS and NAPH data.

The relative differences in mortality from liver disease were more pronounced in females than in males over the two periods (Figure 5.21). Women with primary or lower education had a 3.5-fold higher risk of dying from liver disease than women with higher education ($p<0.05$). No

statistically significant changes in rate ratios occurred between the two censuses for this pathology, except for women with secondary education, who experienced a 25% increase ($p<0.05$).

Among males, mortality rate ratios were statistically significant for a group of causes combining suicide, homicide and events undetermined whether accidentally or purposely inflected and for a residual group of external causes. On the other hand, relative differences in mortality attributable to transport accidents were not associated with the level of education (Figure 5.22, Annexe 13, A13.2 and A13.4).

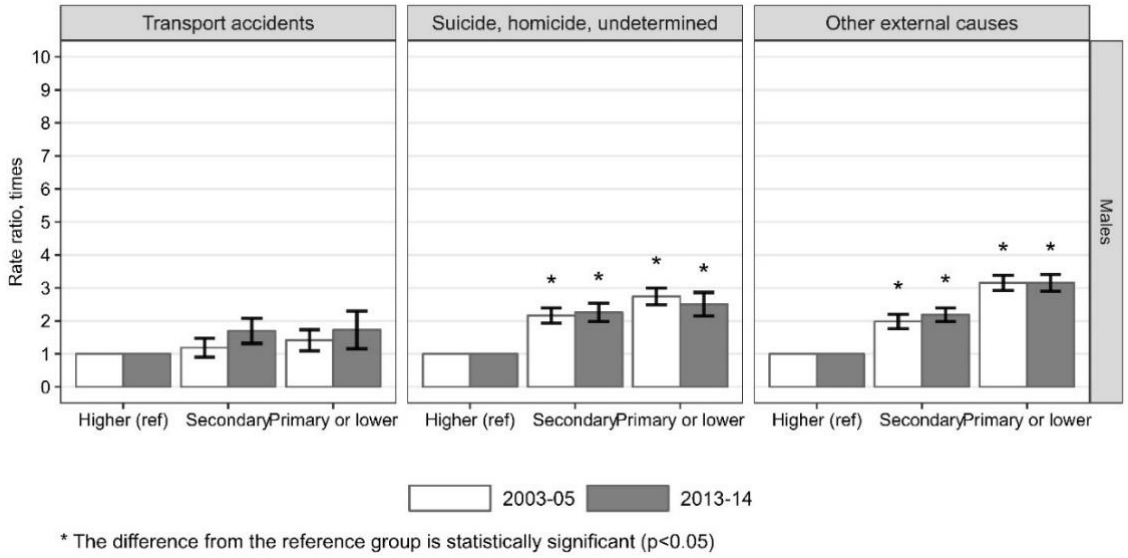


Fig. 5.22 Mortality rate ratio for external causes of death by the level of education in 2003-2005 and 2013-2014, Moldova, males aged 30 years and over (times)

Note: reference group – males with higher education.
Source: author's calculations based on NBS and NAPH data.

5.4. Discussion for Chapter 5

The study presented in Chapter 5 *aimed to* investigate the disparities in all-cause and cause-specific mortality by place of residence (rural/urban), marital status and level of education. The principal *hypothesis* of the study was that the high mortality at the national level coexists with high social disparities in mortality. Moreover, different population subgroups react differently to socioeconomic perturbations, such as the crisis of the 1990s, and contribute differently to life expectancy improvements that occurred recently in Moldova. Differences in rural-urban mortality were analysed since the early 1990s, distinguishing five different periods, including the impact of the CVID-19 infection. The data availability *limited* our study on mortality disparities by marital status and educational level to two periods close to the two population censuses conducted in 2004 and 2014, a unique source of population data by the analysed characteristics. Information on a detailed cause of death and the deceased's marital status and educational level was obtained by

linking two depersonalised death records databases as described in Chapter 2. Both death and population counts were preliminarily treated, as described in Chapter 3. This study is not census-linked, but the death registration system (see Chapter 1) connected to the Population Register ensured the high and accurate completeness of death records by marital status and the level of education. According to the international recommendations, absolute and relative disparities in all-cause and cause-specific mortality were analysed as described in Chapter 2.

Main findings and discussion

A) Rural-urban differentiation

Rural-urban mortality differentiation was examined for five different periods since independence: 1991-1993, 2003-2005, 2014-2016, 2017-2019 and 2020. First, we focused on the rural-urban mortality disparities and their global changes between 1991-1993 and 2017-2019. Then, the evolution of mortality inequalities was analysed according to four different periods: 1) the stagnation period (from 1991-1993 to 2003-2005); 2) the period of improvement (from 2003-2005 to 2013-2014); 3) recent changes (from 2013-15 to 2017-2019) and 4) the impact of the COVID-19 infection (from 2017-2019 to 2020). Using absolute (RD, rate difference) and relative (RR, rate ratio) measures of mortality inequalities with 95% confidence intervals, we examined all-cause and cause-specific mortality. The urban population was used as a reference group. Non-overlapping confidence intervals constructed for standardised death rates, RD and RR were considered statistically significant ($p<0.05$).

The study's results pointed to a rural-urban or a negative urban-rural mortality gradient in Moldova, which is typical of the FSU countries [202]. Disparities in life expectancy between the urban and rural populations were not expressed similarly during the five periods. The maximum difference in life expectancy at birth, about three years in both sexes, was observed during the socio-economic crisis of the early 1990s (1991-1993). The gap in life expectancy between urban and rural populations was minimal in 2003-2005 and 2020 due to the increase in mortality among the urban population, particularly males. Rural-urban disparities in age-specific probabilities of dying decreased with age and were almost negligible in old ages, especially in males. The discrepancy had maximum values among young adults (15-29 and 30-44 years). Excess death among children (0-14 years) in rural areas was also marked. Our results are similar to a census-linked study on socio-demographic mortality inequalities in Lithuania, which showed a relatively low involvement of older adults in rural-urban differentiation of life expectancy [12].

High mortality associated with *circulatory system diseases* is the principal determinant of rural mortality disadvantage, accounting for more than 80% of the absolute difference in all-cause mortality between rural and urban areas. On the other hand, during the independence, the

cardiovascular mortality gap between the two settings was reduced due to a faster decline in rural areas than urban areas. A relatively high pace of cardiovascular mortality amelioration in rurality is likely attributable to much worse initial positions in rural areas than in urban ones. The rapid mortality decline after its rapid growth has already been described when examining the post-crisis recovery in the late 1990s at the national level (see Chapter 4).

The study results also showed that men and women in urban areas had a higher risk of death from *neoplasms* than those in rural areas, known as a negative rural-urban gradient. This fact was partly related to the results obtained for Lithuania, where only women experienced higher cancer mortality in urban areas than in rural areas, especially from smoking-related cancers [12, 203]. In Moldova, cancer mortality over the independence period increased more rapidly in rural areas than in urban areas, thus narrowing the gap between the two areas. Both for cardiovascular and neoplasms mortality, the rural-urban gradient was reduced over the independence in absolute and relative terms. However, there are different mechanisms behind this reduction. If for cardiovascular diseases, the risk of dying declined in both areas but faster in rural areas, then for neoplasms, it increased in both areas but faster in rural areas [204].

The effect of the *digestive system diseases* on the absolute difference in all-cause mortality by place of residence was more substantial in women than men. In the early 1990s, mortality from digestive system diseases was the second highest among rural women, ahead of neoplasms. Throughout independence, the absolute and relative disparities in mortality from digestive system diseases between rural and urban areas were statistically significant and stagnant. Among males, the rate difference or rate ratio for digestive system diseases was constant due to the mortality stagnation in both areas. Conversely, absolute and relative disparities among females were constant over time due to similar improvements in urban and rural settings.

External causes of death had a more noticeable impact on absolute mortality differences by place of residence in males than in females. Over the study period, improvements for this type of mortality occurred in both areas, but due to faster progress in urban areas than in rural ones, both absolute and relative differences increased. A more favourable trend in mortality from respiratory system diseases in urban than rural areas has also contributed to the growing gap between the two settings. As a result of these contrasting trends in cause-specific mortality in urban and rural areas, the inequalities in overall mortality remained stagnant in males and declined in females [202].

Rural and urban populations responded differently to *the socioeconomic crisis of the 1990s*. Between 1990-1993 and 2003-2005, the urban population experienced a much deeper deterioration in health than the rural population due to a significant cardiovascular mortality increase. In

contrast, the rural population was more susceptible to respiratory and digestive system diseases. These different reactions of rural and urban populations to the social and economic changes in the 1990s probably reflect their underlying causes. A dramatic rise in cardiovascular mortality in the cities reflects the tremendous stress the adult population faced after a sudden transition to a market economy and associated social and economic upheavals. On the other hand, the rural population remained nearly untouched by cardiovascular mortality deterioration but experienced a profound rise in mortality associated with poverty and excessive alcohol consumption, such as diseases of the respiratory and digestive systems. National studies have shown a significant increase in adult mortality caused by pneumonia and liver cirrhosis during the crisis in the 1990s [17, 205].

Progress in life expectancy observed at the national level after 2005 was not homogeneous by place of residence. Between 2003-2005 and 2014-2016, the urban population, whose health status was affected in the 1990s far more than the rural population, showed a faster decline in mortality from circulatory system diseases, external causes of death and digestive system diseases. Consequently, disparities in all-cause mortality rose again in 2014-2016 and approached values observed in the early 1990s. Our results demonstrated that the urban population was more vulnerable to the health crisis caused by the COVID-19 pandemic [206]. Higher population aggregation and poor public transport systems led to a more rapid spread of infection in the cities than in villages.

B) Differentiation by marital status and the level of education

Absolute and relative differences in all-cause and cause-specific mortality were examined for the two time periods around the 2004 and 2014 censuses (2003-2005 and 2013-2014). The reference groups were the married population and the population with higher education. In the second period, marital status differences in life expectancy at age 30 were equally expressed in males and females. Married men and women had the highest life expectancy at age 30, while never-married women and divorced men had the lowest values. The maximum difference between these two population subgroups was about 13 years in men and women. The difference in life expectancy at age 30 between the population with higher education and those with primary education or lower was about ten years in the second period for men and women. The maximum disparities in death probabilities by analysed social characteristics were found in the age groups 30-39 and 40-49, while they were less pronounced in the older adults. Between the two censuses, the increase in mortality differences according to marital status was more marked in women than men. At the same time, life expectancy differentiation by the level of education was relatively constant over time in males and somewhat declined in females.

Our results are close to a census-linked study on socio-demographic disparities in Lithuania, where the lowest life expectancy at age 30 in 2001-04 was recorded among divorced males, never-married females and a population with lower than secondary education. The maximum difference in male life expectancy at age 30 by marital status and the level of education in Lithuania (11 years) was close to that observed in our study. However, the female life expectancy differentiation was less marked in Lithuania than in Moldova. The maximum difference between the two marginal population subgroups among Lithuanian women did not exceed seven years by the level of education and five years by marital status [12]. It seems that the health situation of Moldovan women is not only worse than in other FSU countries but also that sociodemographic inequalities are more pronounced among them.

In most cases, the identified advanced and disadvantaged population groups remained the same when mortality disparities were analysed by cause of death. The risk of dying from leading causes of death was consistently higher in the groups under consideration than in reference groups. Circulatory system diseases contribute the most to the absolute difference in all-cause mortality between the reference groups and the groups under consideration. However, the most striking relative differences according to marital status and the level of education were found for infectious and respiratory system diseases. The relative disparities were also very high for two alcohol-related causes of death, external causes and digestive system diseases. Never-married, divorced and primary or lower education statuses were associated with an increased risk of dying. At the same time, the level of education does not influence the risk of dying from neoplasms, except for lung cancer.

5.5. Main conclusions for Chapter 5

1. Our findings showed that living in urban areas, being married and having a higher education were closely correlated to a lower risk of death. These population groups were used as a reference to assess absolute and relative inequalities in all-cause and cause-specific mortality by place of residence, marital status and level of education. The study focused on the period of independence for rural-urban mortality analysis and the periods around the last two censuses (2004 and 2014) for analysis of mortality by marital status and the level of education.
2. Place of residence had a statistically significant impact on life expectancy differentiation in Moldova, although much less pronounced compared to marital status or the level of education. In terms of life expectancy at birth, the urban population lived, on average, 2.5 years longer than the rural population. The mortality excess was the highest among young adults, while health inequalities decreased with age. The socioeconomic crisis of the 1990s and the COVID-19

pandemic affected the urban population, especially males, more than the rural population, offsetting the rural-urban mortality disparities.

3. Immediately after independence and in the late 2000s, a positive rural-urban mortality gradient was found for all causes of death except for neoplasms. Over the 30 years of independence, the rural-urban gradient of all-cause mortality declined among women but not men. Circulatory and digestive system diseases among men and women, external causes of death and respiratory system diseases among men were the principal components accounting for the rural mortality disadvantage. For both sexes, a more rapid reduction in mortality from circulatory system diseases and a more rapid growth of neoplasm mortality in rural areas than urban ones narrowed the gap between the two settings. On the other hand, more rapid improvements in mortality from respiratory system diseases and external causes of death in urban males than in rural males raised the rural-urban mortality differentiation.

4. The socioeconomic crisis of the 1990s affected the urban population more than the rural population, first and foremost due to an increase in cardiovascular mortality. At the same time, the rural population experienced an immense rise in mortality from respiratory system diseases. In such a way, the socioeconomic crisis of the 1990s considerably reduced absolute and relative inequalities in all-cause mortality between the two areas. The subsequent improvement in life expectancy observed at the national level since 2005 was accompanied by growing health inequalities between rural and urban populations. The progress in cardiovascular mortality and external causes of death was more considerable in urban than rural areas. Although cancer mortality was systematically higher in urban areas than in rural ones, absolute and relative differences have been reducing recently due to a more rapid deterioration in rural areas. The COVID-19 pandemic removed absolute and relative differences in all-cause mortality between rural and urban areas. In urban areas, in 2020, mortality growth was more substantial than in rural areas for infectious diseases and cardiovascular and respiratory systems diseases.

5. Marital status was a significant determinant of longevity for Moldovan men and women. Never-married, divorced and widowed marital statuses were linked to an increased risk of dying. The inequalities in life expectancy at age 30 between divorced males or never-married females and their married counterparts exceeded 12 years. Between the two censuses, the disparities in life expectancy at ages 30 and 60 by marital status increased for both sexes. Mortality differentials by marital status were highly pronounced among young adults and diminished with age. Between the two population censuses, the progress in life expectancy was chiefly recorded among the married and widowed populations, while the situation worsened considerably among divorced men and women.

6. The maximum absolute differences in all-cause mortality among males were associated with widowed status in the first period and divorced status in the second. Never-married females experienced the most significant absolute differences in all-cause mortality over the two study periods. The absolute differences in all-cause mortality between non-married and married populations were primarily explained by a higher risk of dying from circulatory system diseases, particularly among females. The impact of external causes of death and respiratory system diseases was more pronounced for non-married males than females, especially never-married males. Excess mortality from neoplasms was more strongly associated with divorced status for both sexes than other non-married categories.

7. The most striking relative differences in mortality were attributable to infectious diseases, respiratory system diseases and external causes of death in divorced males and never-married females. The changes in relative differences in all-cause mortality between the two censuses were also the most significant for these two non-married categories.

8. The study results showed that the populations with secondary and primary or lower education were at a much higher risk of dying than those with higher education. The mortality disadvantage decreased along with increasing age. The maximum difference in life expectancy at age 30 between the population with higher education and those with primary or lower education was more than ten years for males and nine years for females. The changes in life expectancy at age 30 between the two study periods were mainly associated with the decline in mortality among men with higher and primary or lower education and women with primary or lower education.

9. Absolute differences in all-cause mortality by the level of education were essentially related to circulatory and digestive system diseases for both sexes and respiratory system diseases and external causes of death for males. Relative differences were the most pronounced among men and women with primary or lower education for infectious diseases, respiratory system diseases and external causes of death. Neoplasm mortality was not differentiated statistically significantly by the level of education, except for lung cancer in males.

6. REGIONAL MORTALITY DISPARITIES

This chapter examines the regional differentiation in all-cause and cause-specific mortality. First, geographical patterns in life expectancy and mortality by sex, age and cause of death around the 2014 census are presented. Next, particular attention is given to spatial mortality analysis. Finally, the evolution of regional mortality differentiation since independence for the three periods (1991-1995, 2002-2006 and 2012-2016) is presented.

6.1. Regional disparities in all-cause mortality

This section discusses regional differences in life expectancy at birth and ages 25 and 65. Geographical variations in all-cause mortality by broad age groups are analysed. The impact of age-specific mortality on disparities in life expectancy between Moldova and each administrative unit is shown. Data on life expectancy at birth and 95% confidence intervals by sex and district in 2012-2016 can be found in the annexes of the monograph on regional mortality disparities in the Republic of Moldova [207].

6.1.1. Life expectancy at birth by sex

At the national level, life expectancy at birth was 65.2 in males and 73.7 in females in 2012-2016, ranging from 61.6 years (Soldonesti) to 68.6 years (Chisinau) among males and from 69.1 (Cimislia) to 76.7 (Chisinau) among females. Life expectancy at birth was greater than at the national level in eight districts for men and thirteen districts for women (Figure 6.1). As far as confidence intervals are concerned, the situation was even worse. The lower limit of male life expectancy at birth was higher than the country's average value in the municipality of Chisinau, which was found to be a statistical outlier. At the same time, female life expectancy is constantly above the national average in the municipality of Chisinau and the districts of Briceni, Edinet and Drochia located in the north of the republic. The situation on the other side was different. The number of districts with a life expectancy below the national average was much more significant (27 for males and 22 for females). Based on the comparison between the upper confidence limit and life expectancy at birth at the national level, this figure was reduced to 11 for men and 12 for women.

The grouping of life expectancy values was based on Jenks' optimization method, which identifies categories of similar values and maximizes their differences. The following five categories of life expectancy at birth were defined:

1) "Very high": 66.8 to 68.6 years in males and 74.4 to 76.7 years in females;
2) "High": 65.6 to 66.8 years in males and 72.9 to 74.4 years in females;
3) "Moderate": 64.5 to 65.6 years in males and 71.3 to 72.9 years in females;

4) "Low": 63.1 to 64.5 in males and 70.2 to 71.3 in females;

5) "Very low": 61.6 to 63.1 in males and 69.1 to 70.2 in females.

Figure 6.2 presents the map of life expectancy by sex produced using Jenks' optimization method. For both sexes, the "*very high*" values were registered in the municipality of Chisinau. Among women, the highest values were also found in the northern districts. Districts with a "*high*" life expectancy were situated in the northern region for both sexes and in the southern region for women. Only two districts in the north (Briceni and Edinet) had a "high" life expectancy in men. In the Anenii Noi district, adjacent to the capital, life expectancy at birth was also considered "high". The location of districts with "high" and "very high" life expectancies in the northern region as a cluster was especially pronounced for females. For males, the situation in the north was better only in Briceni and Edinet than in other districts. In our study, districts with "very high" and "high" life expectancies were defined as the *leading* districts.

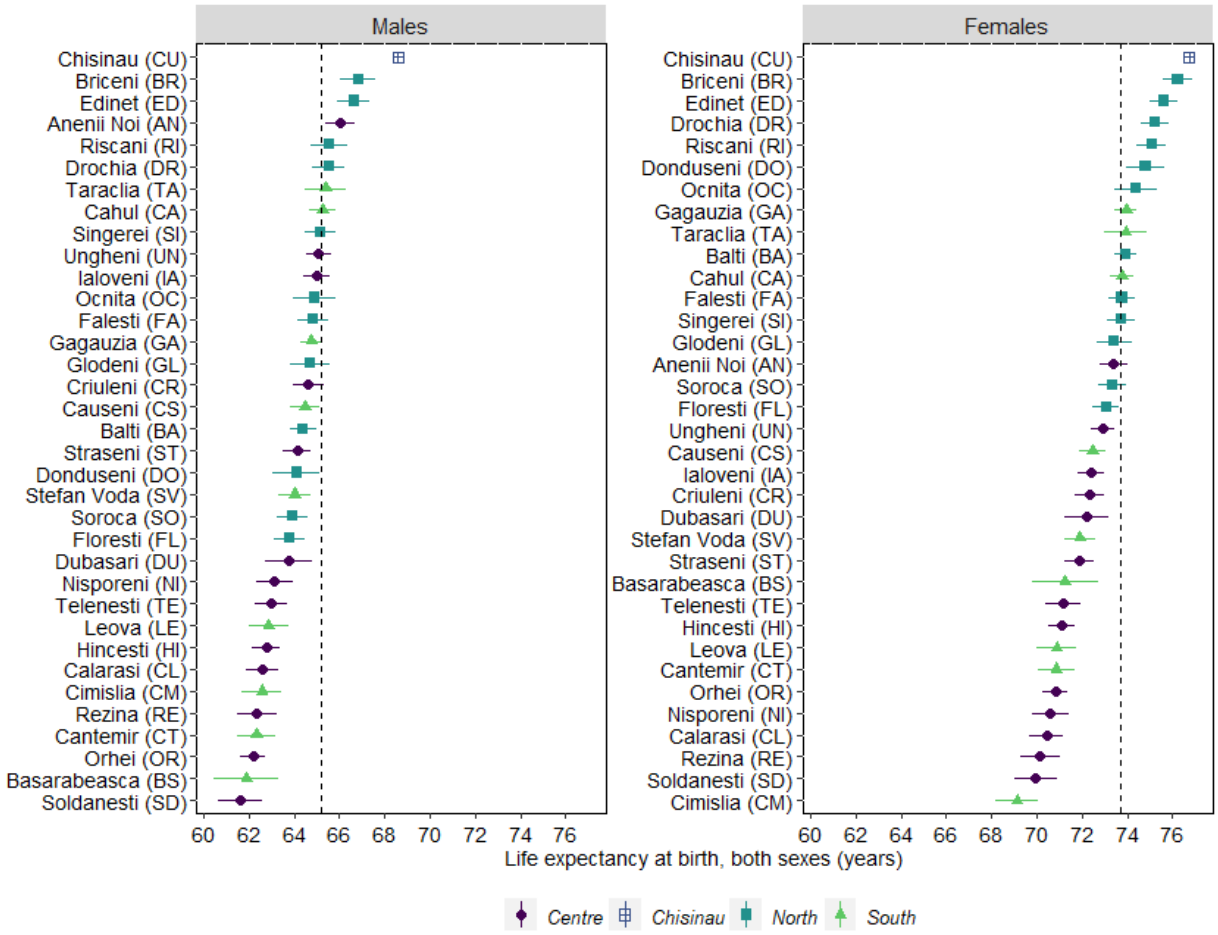


Fig. 6.1 Life expectancy at birth and 95% confidence intervals by district and sex in Moldova (years)

Note: vertical lines refer to the national level of life expectancy at birth
Source: author's calculations based on NAPH and NBS data.

Most districts with "*very low*" life expectancy were in the country's central region: Soldanesti, Rezina, Telenesti, Orhei, Calarasi, Nisporeni and Hincesti. The first two districts had the

lowest life expectancy values for both sexes, while the rest concerned only males. A few southern districts directly adjacent to the centre also had a "very low" life expectancy: Cantemir, Leova, Cimislia (both sexes) and Basarabeasca. Interestingly, among women, only three districts were found to have "very low" life expectancy at birth, while among men, this group was much larger (11 districts).

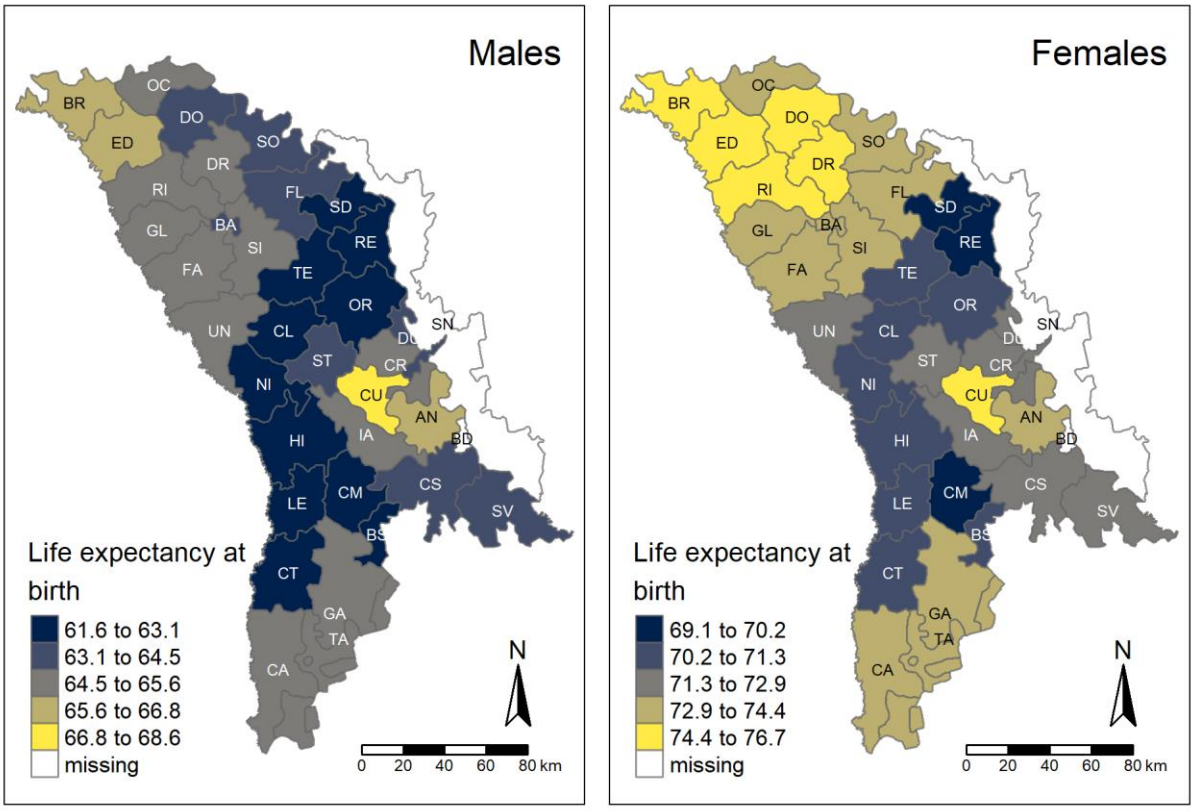


Fig. 6.2 Regional profile of life expectancy at birth by sex in Moldova (years)

Note: Jenks' optimization method of classification was used in these and the subsequent maps.
Source: author's calculations based on NBS and NAPH data.

The geographical situation of districts with "*low*" and *"very low"* life expectancy at birth also had particular characteristics. First, the location of districts with "low" life expectancy among women mainly corresponded to the location of districts with "very low" life expectancy among men. Second, while the female population in the northern region had a "high" or "very high" life expectancy, the male population in most northern districts, including the municipality of Balti, had "moderate" or "low" values. Third, certain districts that are first-order neighbours of the municipality of Chisinau (Straseni, Dubasari in males) also belonged to this category, although others referred to categories with "moderate" (Ialoveni, Criuleni) or "high" (Anenii Noi) life expectancy. This situation means that the geographical proximity to the capital does not guarantee better health for the population.

Districts with “very low” and “low” life expectancy values were identified as *lagging*. The most backward districts form *a red belt of high mortality* extending from Soldonesti to Cantemir. The situation is gradually improving while moving to the north or south of the country. In the southernmost districts (Cahul, Taraclia and Gagauzia) and the northern districts next to the centre, male life expectancy had “*moderate*” values. Among females, districts with “moderate” values were primarily in the central region. Lastly, life expectancy increases in the most remote northern districts to reach “very high” values in women and “high” in men.

6.1.2. Life expectancy by age and sex

The division of districts into leading (northern region, capital) and lagging (central region) areas regarding life expectancy at birth can be found for different age groups but with certain peculiarities. Figure 6.3 presents maps produced for life expectancy at age 25. For males, the location and number of districts with a “very low” life expectancy at 25 were identical to the life expectancy at birth. For females, in most districts where life expectancy at birth was “low”, life expectancy at 25 was “very low”. The red belt of high mortality was pronounced similarly for both sexes and covered 11 districts in males and nine districts in females, where life expectancy at 25 was “very low”.

The geographical location of districts with “low” life expectancy at 25 was, on the whole, similar for both genders. Districts directly adjacent to the country's capital, except for the Anenii Noi district for males, had the same unfavourable mortality pattern as most central districts. Consequently, without this exception, the municipality of Chisinau was surrounded by districts where the adult population, especially women, had severe health problems. Our earlier hypothesis that the proximity to the capital was not improving but rather worsening the health population was confirmed for life expectancy at 25. Among females, the number of districts in the north with “very high” and “high” life expectancy was significantly lower for life expectancy at 25 years compared to life expectancy at birth. Young adults living in Briceni or Edinet faced roughly the same risk of dying as their counterparts living in the capital. The geographical profile of life expectancy at 45 years (not shown) was very close to that of life expectancy at 25 years. While among young and mature adults, the red belt of high mortality was very pronounced, among older adults, it was less noticeable and consisted of a few districts (Figure 6.4). The number of districts with the lowest life expectancy at age 65 years was reduced to two for men and eight for women. At the same time, the area covering the top districts with “high” life expectancy at 65 in the north was enlarged, especially among men. In the municipality of Balti, life expectancy at age 65 was classified as “moderate” among older men and “high” among older women.

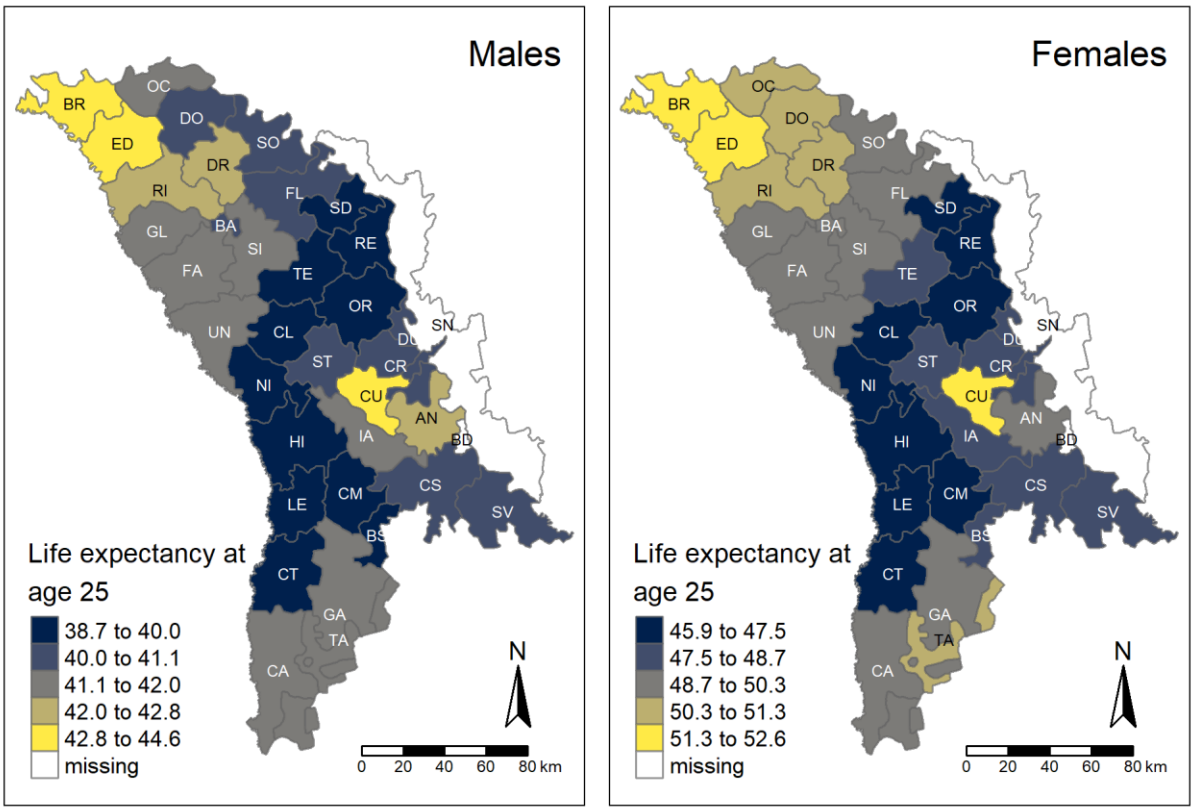


Fig. 6.3 Regional profile of life expectancy at age 25 by sex in Moldova (years)

Source: author's calculations based on NBS and NAPH data.

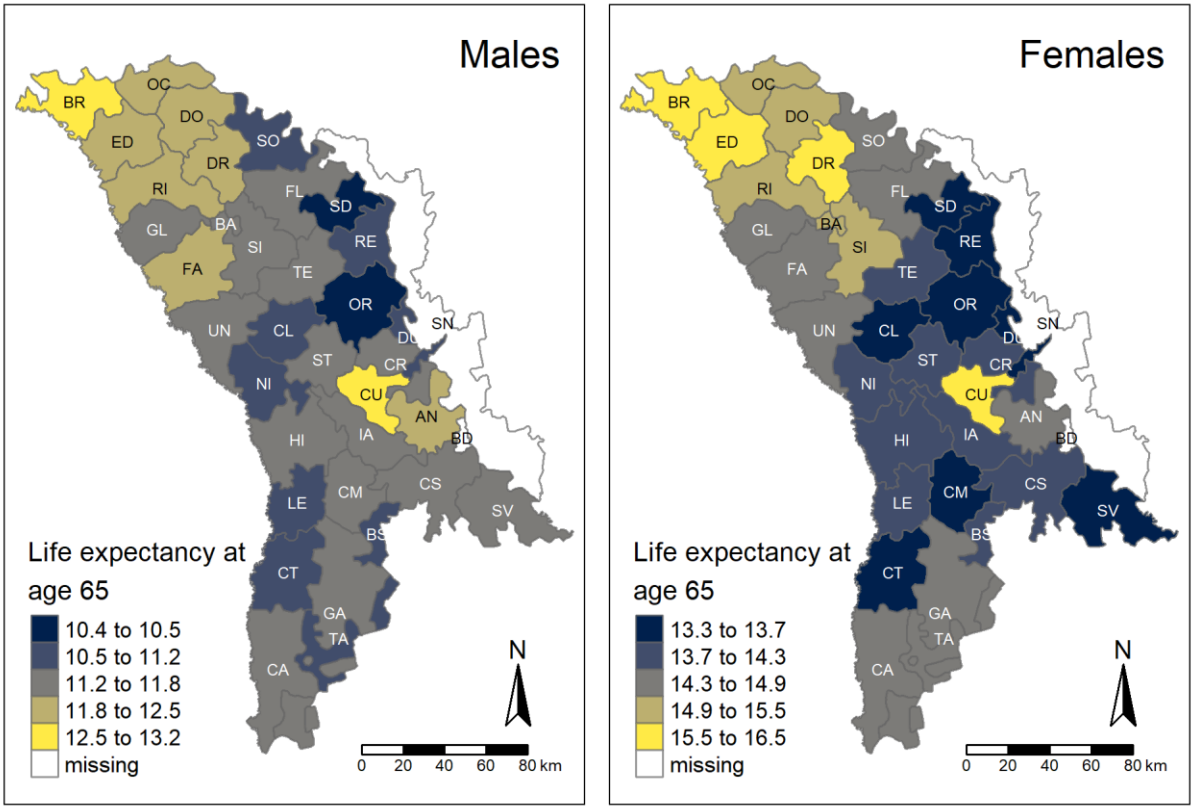


Fig. 6.4 Regional profile of life expectancy at age 65 by sex in Moldova (years)

Source: author's calculations based on NBS and NAPH data.

6.1.3. Age-specific death rates by sex

The geographical mortality patterns for infant mortality and child and adolescent mortality (1-19 years) were analysed for both sexes since sex differences nationally were negligible (Figure 6.5). Infant mortality was predominantly "low" and "very low" in the capital and its neighbouring first-order districts of Criuleni, Anenii Noi and Dubasari. The geographical proximity of the capital can explain the relatively favourable situation concerning under-one-year mortality in these districts. Infant mortality was higher in the more remote districts, possibly due to difficulties in providing qualified medical assistance to pregnant women and children. The mortality among children and adolescents has changed its pattern vis-à-vis infant mortality. While the municipality of Chisinau maintained the most advantageous position for this age category, the situation was more or less homogeneous in the rest of the country. In the neighbouring districts of the first order, the beneficial effect of the geographical proximity of the capital was not observed in the case of mortality in children and adolescents. At the same time, living conditions in the northern municipality of Balti seemed as beneficial for the health of children and adolescents as the capital.

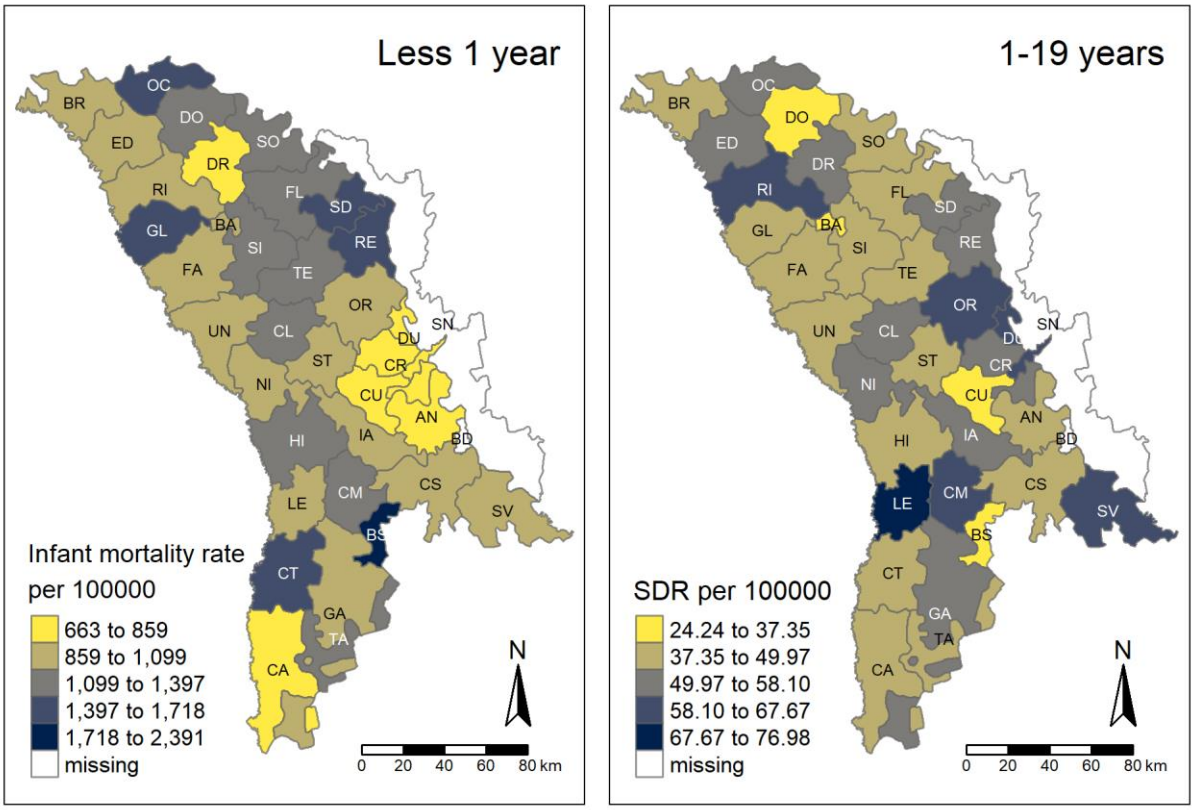


Fig. 6.5 Regional profile of infant mortality rate and standardised death rates at age 1-19 years in Moldova, both sexes (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

Among young adults aged 20 to 44 years, the male-female ratio of standardised death rates ranged from two to five, depending on the district. However, the geographical mortality profiles

for males and females were similar (Figure 6.6). Mortality rates for young adults, particularly for the female population, were consistently lower in the northern part of the country and higher in the central part of the country. For young women living in the north, mortality rates were mainly "very low" and "low", except for the municipality of Balti. Death rates for young men in the north of the country varied between "very low" in the districts of Briceni and Edinet and "very high" in the Donduseni district.

Young men in the Balti municipality tended to have more health problems than those in nearby districts. For most young people living in the central region, mortality rates varied from "high" to "very high" in men and from "moderate" to "high" in women. Some exceptions may be noted. Firstly, the capital of Chisinau had the lowest mortality rates among young adults, similar to the preceding two age groups. Secondly, the health status of young adults living in districts adjacent to the capital was much better than in other districts in the centre. Lastly, the death rate of young women is highest in the Cimislia district (an outlier).

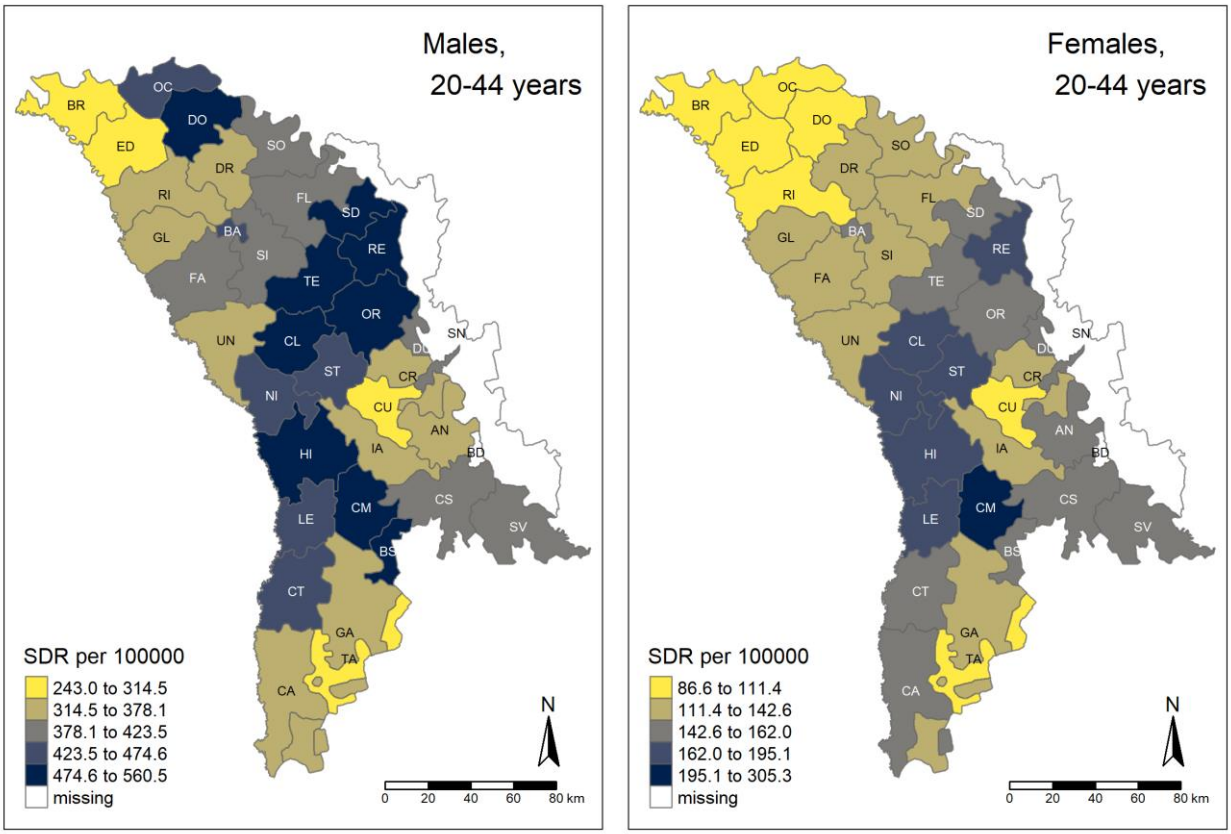


Fig. 6.6 Regional profile of standardised death rates at age 20-44 years in Moldova by sex (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

The regional mortality profile among mature adults between the ages of 45 and 64 largely followed the pattern already seen for the previous age group (Figure 6.7). However, the north-central gradient in mortality was much more pronounced in mature adults than in young adults,

especially among men. The geographical position of districts with "very low" and "low" mortality among mature adult males was much more prevalent than among young adult males. Furthermore, the number of districts with "very high" death rates has increased considerably for women, and their location on the map has become more similar to that for men. If in the centre, mortality among 20- to 44-year-old women ranged mainly between "moderate" and "high", then among women aged 45 to 64, between "high" and "very high" as in the case of men. In the southern region, the most affected districts (Cantemir, Leova) were directly adjacent to the central region, while in the most remote southern districts (Cahul, Gagauzia and Taraclia), the population health was much better, especially for the Gagauzia females.

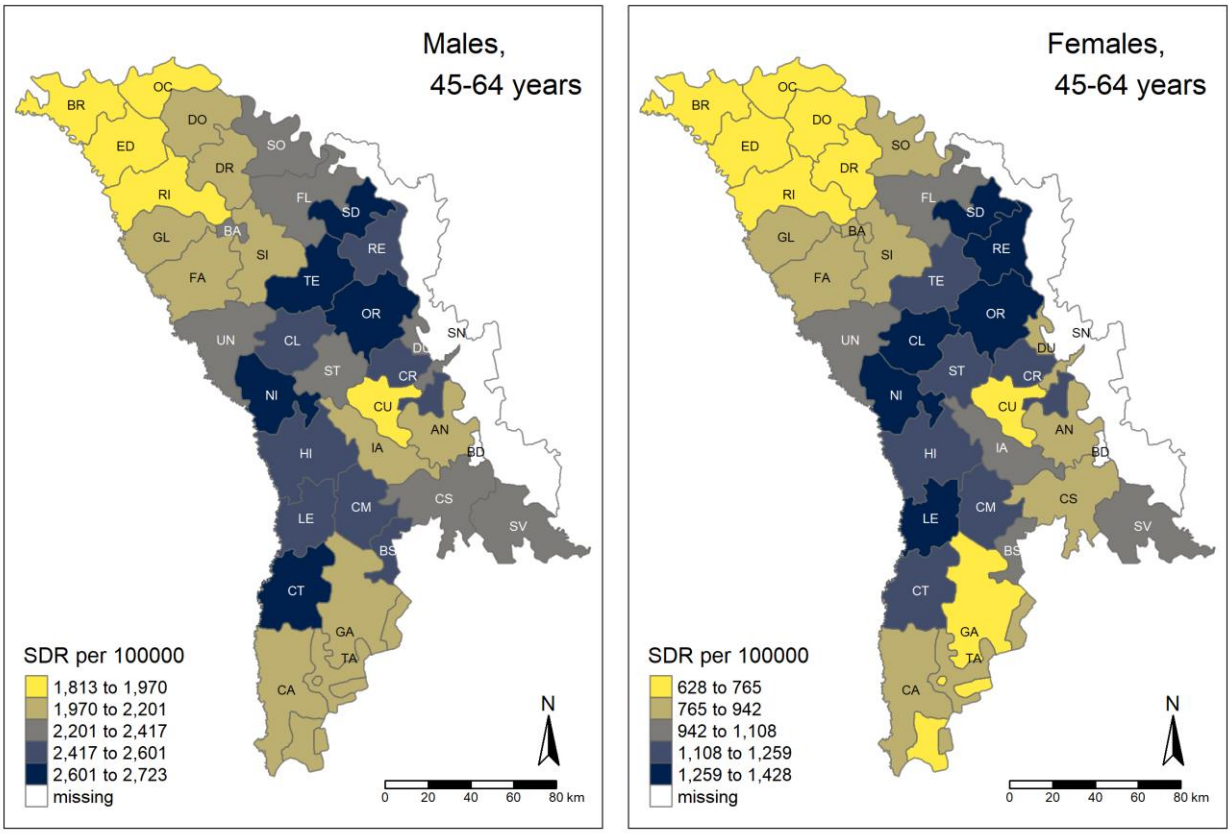


Fig. 6.7 Regional profile of standardised death rates at age 45-64 years in Moldova by sex (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

Differentiation in all-cause mortality between the north and centre was also observed in the older population, especially in women (Figure 6.8). The health of older men living in districts within the red belt of high mortality was somewhat better than that of the previous age group. At the same time, the situation of older women was the same, if not more problematic. In addition, the number of districts with "very low" mortality rates among older persons has been substantially reduced. Lastly, the sex ratio for older adults ranged from 1.2 to 1.5, lower than for young adults (between two and five) or mature adults (between two and three).

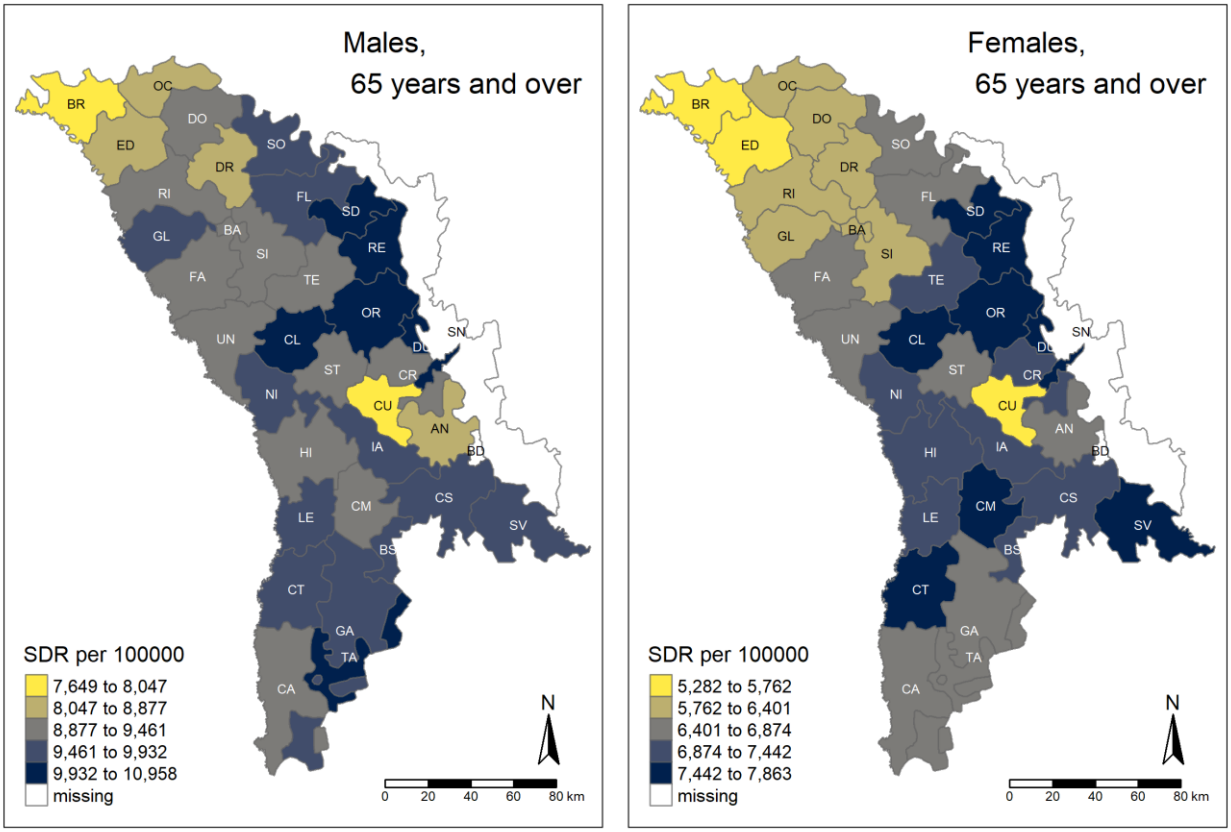


Fig. 6.8 Regional pattern of standardised death rates at age 65 years and over in Moldova by sex (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

6.1.4. Decomposition of interregional differences in life expectancy by age

Interregional differentiation in life expectancy depends on differences in age-specific mortality. Figure 6.9 presents the results of the decomposition of the difference in life expectancy at birth between each administrative unit and Moldova by the following broad age groups: less than one year, 1-19 years (children and adolescents), 20-44 years (young adults), 45-64 years (mature adults) and 65 years and over (older adults). First, the analysis is given for females and then for males.

The difference in life expectancy at birth among women between the municipality of Chisinau and Moldova was 3.1 years. Lower mortality among older women in the capital than at the national level accounted for 1.3 years or 44% of this gain. On the other hand, lower mortality among young and mature adult women added 0.4 years (14%) and 0.9 years (29%), respectively. Lastly, the impact of infant mortality and mortality among children and adolescents was 0.4 years (12%). In such a way, the higher life expectancy of females in Chisinau compared to the national level was chiefly explained by lower death rates among older and mature adults. Mortality disparities in these two age groups accounted for more than 70% of the life expectancy gap between the capital and the country. A similar situation was found in the two northern districts of

Briceni and Edinet. Lower mortality among mature and older adult women was responsible for more than 80% of the difference in life expectancy between these districts and the country average. In these two northern districts, the impact of lower mortality in old ages was less significant than in the capital, while it was more crucial in mature adults. The situation looked identical for other leading northern districts (Drochia, Riscani, Donduseni, Ocnita). The differences in mortality among young adults and children between the leading districts and the national average were unimportant.

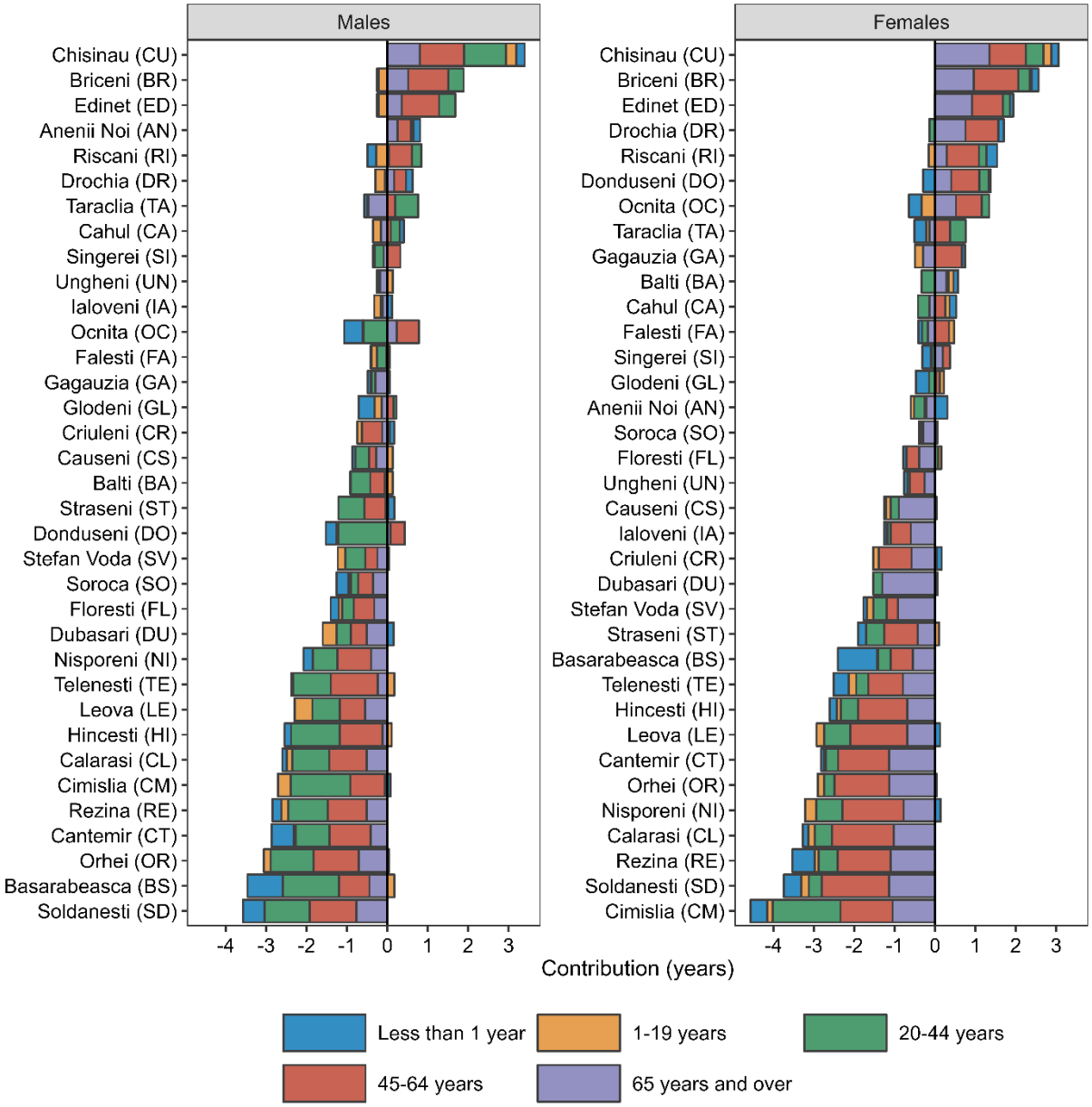


Fig. 6.9 Contributions of age-specific mortality to differences in life expectancy at birth between Moldova and 35 administrative units by sex (years)

Source: author's calculations based on NBS and NAPH data.

The opposite situation concerning the female life expectancy differentiation was found in the other pole where the most lagging districts were presented. The lion's share of life expectancy

losses was explained by higher mortality among adult women aged 45 to 64 and 65 and over. For instance, in the districts of Soldanesti or Rezina, where female life expectancy was 3.7 and 3.5 years below the national level, more than 70% of these losses were attributable to higher mortality in these two age groups. The Cimislia district was an exception due to a relatively bigger impact of mortality among young adult females compared to other lagging districts (1.7 years out of 4.6). Districts with "moderate" life expectancy values among women experienced gains or losses close to zero. In this case, mortality contributions across different age groups showed different signs and were offset. For instance, in the Anenii Noi district, the positive contribution was recorded only for infant mortality (0.3 years), whereas other age groups contributed negatively to the overall gap (-0.3 years).

For men, the impact of age-specific mortality on interregional differentiation in life expectancy at birth had particular characteristics relative to women. The number of districts with a higher life expectancy than the national average was lower for men than for women (8 vs 13). Next, the impact of old-age mortality on interregional disparities in life expectancy was much less pronounced in men than in women. Conversely, differences in mortality among young adults had a greater effect on life expectancy gains or losses in males than in females. Living in the municipality of Chisinau increased male life expectancy at birth by 3.4 years compared to the country-wide average. These gains were primarily attributable to a lower risk of dying among those aged 45 to 64 (1.1 years), 20 to 44 (1.0 years) and 65 years and over (0.8 years). In the districts of Briceni and Edinet, where life expectancy at birth among men was categorized as "high", the contribution of mortality in young adulthood was more modest than in the capital. In the most backward districts, death rates above the national average among young and mature adult men were essentially responsible for life expectancy losses. For example, men in the Hincesti district lost 2.2 years out of 2.4 due to higher mortality in these two age groups.

6.2. Regional disparities in cause-specific mortality

The present section looks at regional disparities in mortality by cause of death. Table 2.3 presents the list of causes of death and the corresponding ICD-10 codes used in the data analysis. Ill-defined causes (R00-R99 in ICD-10), which represented less than 1% of all deaths in 2012-2016, were redistributed proportionately across all other causes. Firstly, the contributions of seven leading causes of death to differences in life expectancy at birth between Moldova and each administrative unit are shown. Secondly, interregional differentiation of mortality by age and cause is examined between the municipality of Chisinau and the most lagging districts. Finally, geographical patterns of standardised death rates by cause of death are presented using thematic maps. For the leading causes of death, the analysis was produced by sex. More detailed causes of

death were examined for both sexes. The detailed results of the decomposition of the differences in life expectancy at birth between Moldova and 35 administrative units can be found in the annexes of the research monograph on regional mortality disparities in the Republic of Moldova [207].

6.2.4. Decomposition of interregional differences in life expectancy by causes of death

Figure 6.10 illustrates the impact of mortality by seven causes of death on the differences in life expectancy at birth between Moldova and 35 administrative units. Moldovan *women* from the municipality of Chisinau lived 3.1 years longer than the national average, primarily due to the lower risk of dying from circulatory system diseases, with a 55% contribution. Life expectancy among women in the northern district of Briceni, as in the capital, was defined as "very high". Here, cardiovascular diseases positively contributed 50% to the overall difference (1.3 years out of 2.6 years). Mortality from cardiovascular diseases in females was also significantly lower than national values in some northern districts and the municipality of Balti. In the municipality of Chisinau and the leading northern districts, low mortality from digestive system diseases was another critical factor explaining higher life expectancy among women. The positive effect of this disease ranged from 0.4 years (25%) in Drochia to 0.8 years (72%) in Donduseni out of the total difference (1.6 and 1.1 years, respectively). The health of the female population in the most backward districts was greatly affected by high mortality associated with circulatory and digestive system diseases. For example, in the districts of Calarasi or Orhei, high death rates from circulatory system diseases (-1.3 years) and digestive system diseases (-1.2 years) accounted for 80% of losses compared to the national average.

The regional differentiation in life expectancy at birth among *men* was mainly due to differences in mortality from the three leading causes: circulatory system diseases, external causes of death and digestive system diseases. The positive contribution of external causes of death was recorded only in the capital, while in other districts, even with a "high" life expectancy at birth, it was near zero or negative. Thus, around 60% of the life expectancy gains in males from the municipality of Chisinau relative to the national level were due to external causes of death and circulatory system diseases: respectively, 1.1 years and 0.8 years out of 3.4 years. In Briceni and Edinet, men lived 1.6 and 1.4 years longer than men in Moldova, primarily due to better cardiovascular mortality control. Lower mortality from circulatory system diseases explained 1.1 and 0.9 years, respectively, out of the difference in life expectancy at birth between males from these two northern districts and Moldovan males. External causes of death and digestive system diseases associated with acute and chronic excessive alcohol consumption were responsible for the lion's share of life expectancy losses among men in some lagging districts. The most

considerable negative contributions from external causes were recorded in Cantemir, Leova and Cimislia (more than 45%) districts and the Stefan Voda district (more than 90%). The negative effect of digestive system diseases was more marked in the central lagging districts such as Hincesti, Calarasi and Orhei. In Hincesti, for example, the combined effect of digestive system diseases and external causes of death declined male life expectancy by 1.7 years or 68% relative to the national level. The influence of other causes of death, including neoplasms, the second most common cause nationally, was of minor importance. The municipality of Balti was the only exception regarding neoplasms.

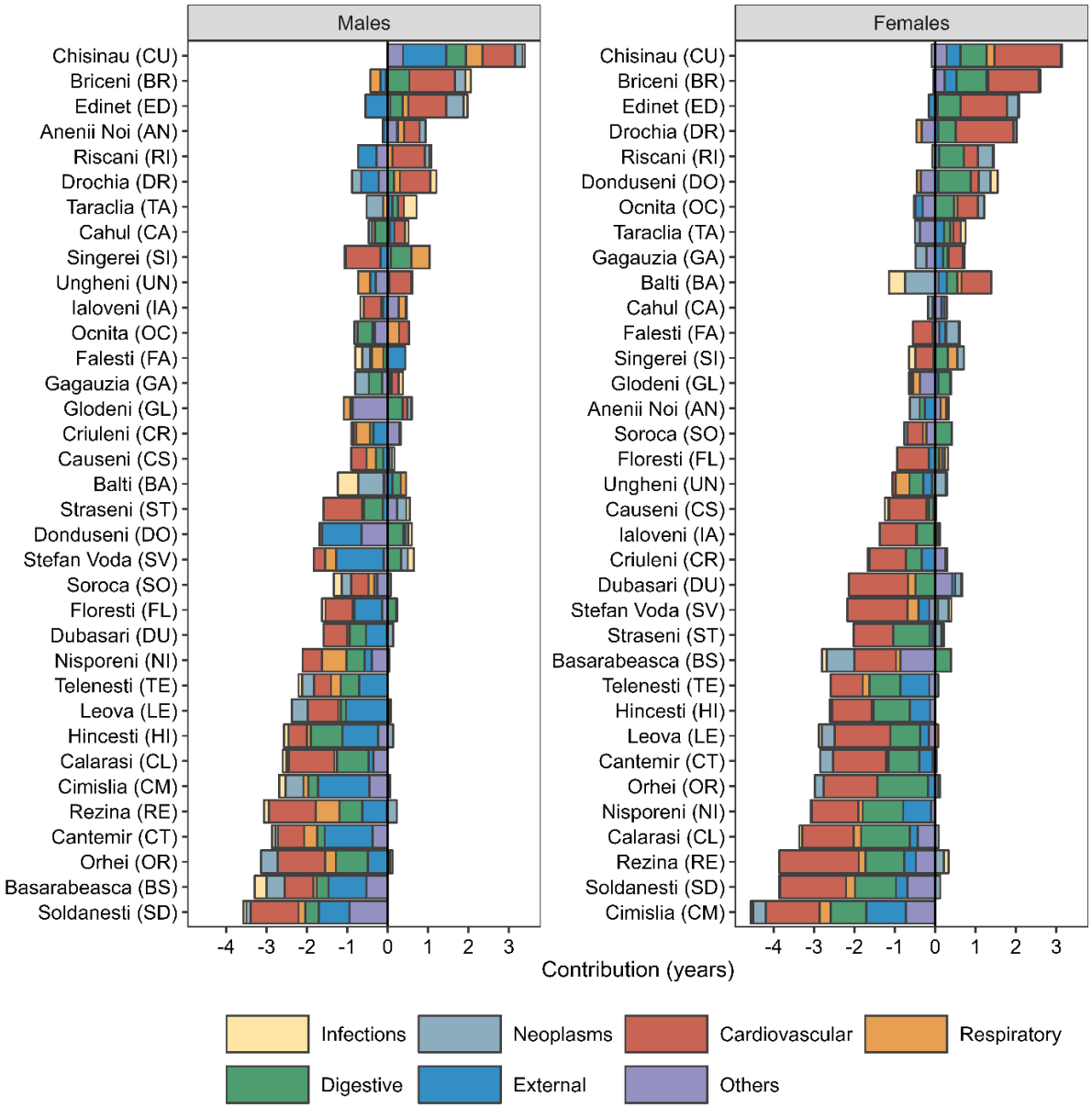


Fig. 6.10 Contributions of cause-specific mortality to differences in life expectancy at birth between Moldova and 35 administrative units by sex (years)

Source: author's calculations based on NBS and NAPH data.

6.2.5. Decomposition of differences in life expectancy between the most lagging and leading districts

To examine the combined effect of mortality by age and cause on life expectancy differentiation, we decomposed the difference in life expectancy at birth between two opposite population subgroups. The first subgroup represented the population in Chisinau, where 24% of females and 23% of males lived, according to the 2014 census. In this leading subgroup, life expectancy at birth was 68.6 years in men and 76.7 years in women. The population living in the most backward districts represented the second subgroup. The worst-lagging districts were selected according to life expectancy at 25 since the belt of high mortality was the most extensive based on this indicator. Eleven districts were selected where life expectancy at 25 was the lowest (less than 40.0 years in males and 47.5 years in females), and about 20% of the population lived. Life expectancy at birth registered in the lagging subgroup was 62.5 years for males and 70.4 years for females. Table 6.1 and Figure6.11 6.11 illustrate the contributions of mortality by age and cause of death to the difference in life expectancy at birth between the two population subgroups.

Table 6.1 Contributions of mortality by main age groups and causes of death to the difference in life expectancy at birth between the most lagging districts and the municipality of Chisinau by sex (years)

Age	Infections	Neoplasms	Circulatory system	Respira-tory system	Digestive system	External causes	Other	All causes
MALES								
0-19	-0.03	-0.02	0.00	-0.10	-0.02	-0.25	-0.25	-0.68
20-44	-0.09	-0.18	-0.21	-0.13	-0.30	-0.97	-0.19	-2.07
45-64	-0.02	-0.19	-0.38	-0.30	-0.58	-0.46	-0.19	-2.11
65+	0.01	0.08	-0.98	-0.10	-0.15	-0.05	0.00	-1.20
Total	-0.13	-0.31	-1.57	-0.63	-1.06	-1.73	-0.63	-6.07
FEMALES								
0-19	-0.01	-0.01	0.01	-0.09	-0.02	-0.21	-0.29	-0.64
20-44	-0.01	-0.08	-0.16	-0.02	-0.32	-0.26	-0.11	-0.97
45-64	-0.02	-0.15	-0.78	-0.08	-1.01	-0.19	-0.10	-2.33
65+	0.01	0.21	-2.08	-0.08	-0.32	-0.04	-0.02	-2.33
Total	-0.03	-0.04	-3.01	-0.28	-1.67	-0.71	-0.52	-6.26

Note 1: the sum by columns and rows may differ due to rounding.
Note 2: the most lagging districts had a life expectancy at age 25 lower than 40.0 years in males and 47.5 years in females.
Source: author's calculations based on NBS and NAPH data.

The difference in life expectancy between the two extreme population subgroups was 6.1 years for men and 6.3 years for women. Among men, the most significant losses occurred among young (-2.1 years) and mature adults (-2.1 years). Among women, the losses were mainly concentrated among mature adults (-2.3 years) and older adults (-2.3 years). High mortality from circulatory system diseases in the most backward districts decreased life expectancy at birth by 1.6 years for males and 3.0 years for females. Among males, external causes of death (-1.7 years)

and digestive system diseases (-1.1 years) were the other two causes of death that affected the population's health in the lagging subgroup. Among females, digestive system diseases were the second group of causes of death that considerably widened the gap between the lagging districts and the capital (-1.7 years).

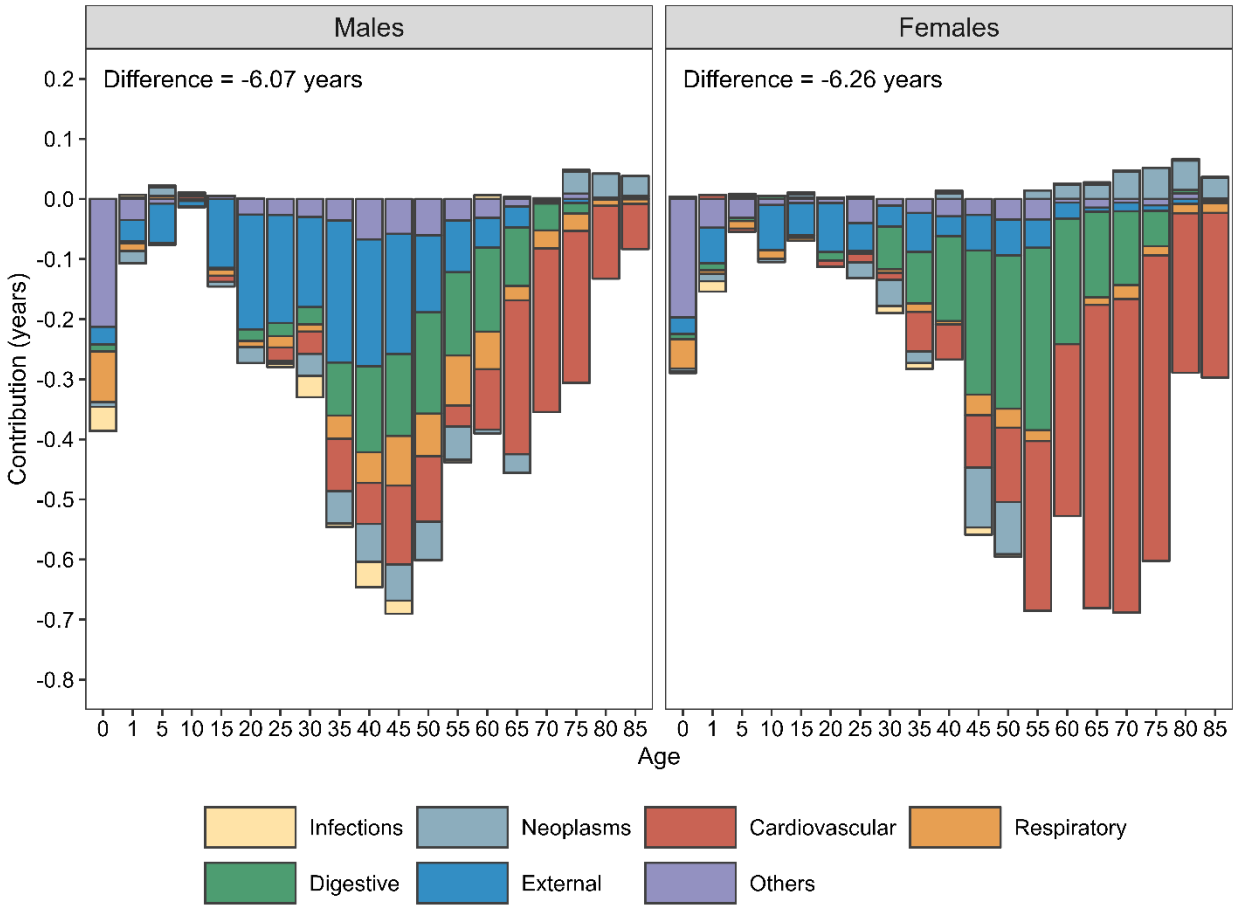


Fig. 6.11 Contributions of mortality by age and cause of death to differences in life expectancy at birth between the most lagging districts and the municipality of Chisinau by sex (years)

Note: see Note 2 for Table III.2
Source: author's calculations based on NBS and NAPH data.

The influence of mortality differences in children and adolescents was less than one year, with the largest contributions played by external causes and "other diseases". Losses in young adults from the lagging subgroup were mainly attributable to high mortality from external causes in males and digestive system diseases in females. Among mature adult males, negative contributions were registered for all causes of death, but external causes of death and digestive system diseases explained over half of all losses. The negative effect of high mortality from digestive system diseases in mature adult females (-1.0 years) was even greater than that of circulatory system diseases (-0.78 years). Among the older population, especially women, circulatory system diseases played a vital role for both sexes.

6.2.6. Geographical profile of standardised death rates by cause of death

Thematic maps were produced for indirectly standardised mortality rates for the causes of death listed in Table 2.3. Based on Jenks' optimization method of natural breaks, we identified five mortality rate categories, ranging from "very low" to "very high". Firstly, the thematic maps are examined for the three causes of death that are crucial in interregional mortality differentiation: circulatory and digestive system diseases and external causes of death. Secondly, attention is focused on causes that contribute to a lesser extent, such as neoplasms, infectious diseases, respiratory diseases and other causes. An additional set of maps is presented for detailed causes of death.

6.2.6.1. Circulatory system diseases

Circulatory system diseases were prevalent in the mortality profile nationally for males (54%) and females (64%). Figure 6.12 shows the standardised mortality rate maps for this type of pathology.

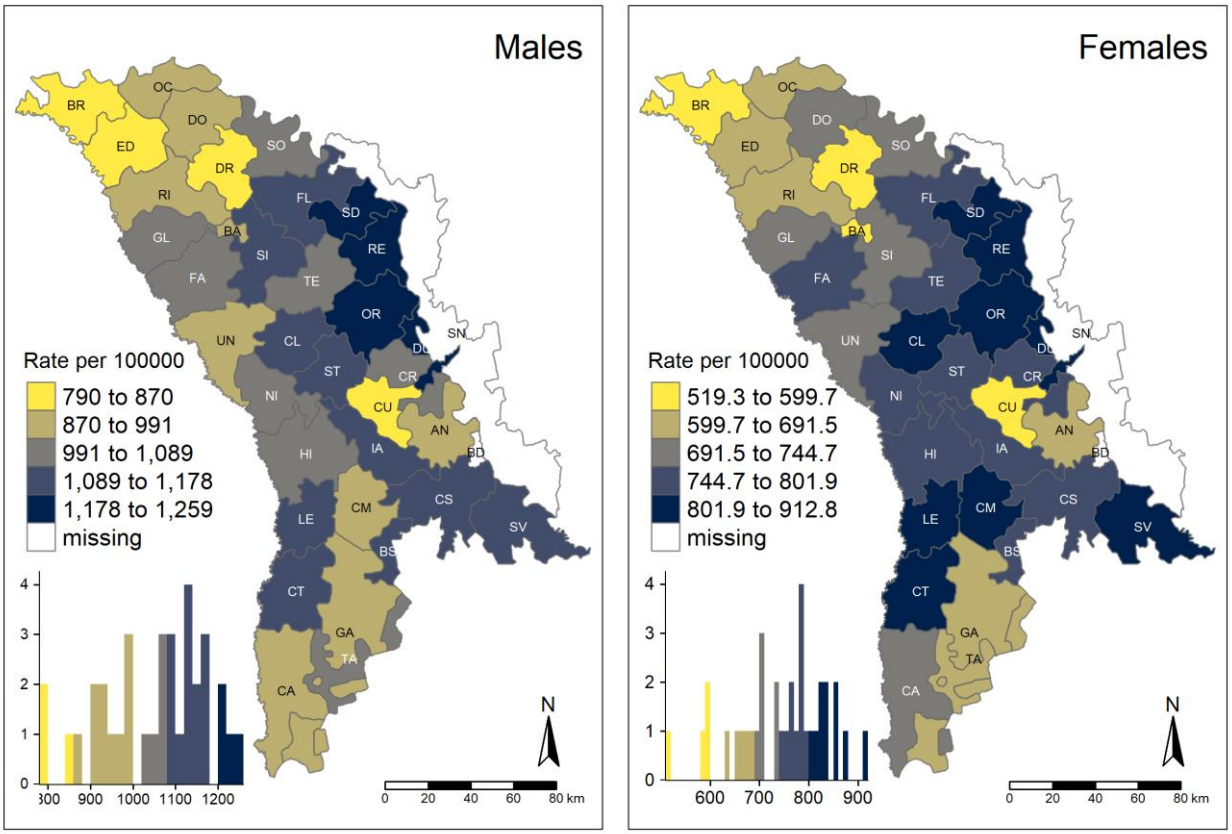


Fig. 6.12 Regional pattern of standardised mortality rates from diseases of the circulatory system by sex (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

The shape of the distribution tended to be skewed to the left, suggesting the prevalence of districts with an above-average mortality rate. In males, cardiovascular mortality was the lowest in the Briceni district (790 deaths per 100000 population) and highest in the Orhei district (1259

per 100000 population). Among females, the municipality of Chisinau (519 per 100000) and the Rezina district (913 per 100000) were positioned at the extreme poles. The central districts of Soldanesti, Rezina, Orhei and Dubasari had the highest cardiovascular mortality rates for both sexes. In other districts in the centre, cardiovascular mortality was high in females and high to moderate in males. In the central region, the "very low" or "low" mortality for both sexes was recorded only in the capital and the Anenii Noi district. In the south, the situation was better in districts further afield (Gagauzia, Cahul and Taraclia) than in those closer to the centre (Cantemir, Leova, Cimislia and Stefan Voda). The risk of dying from circulatory system diseases was much lower in the northern region compared to other regions. Cardiovascular mortality was "very low" and "low" in the more remote northern districts and the municipality of Balti and most often "moderate" in other northern districts. In the northern districts adjacent to the centre, the situation was similar to that observed in the central districts.

Figure 6.13 shows the geographic profile of mortality from heart and cerebrovascular diseases. Since "Other circulatory diseases" had a minor impact on cardiovascular mortality nationally (less than 5%), this group of diseases was combined with the group "cerebrovascular diseases".

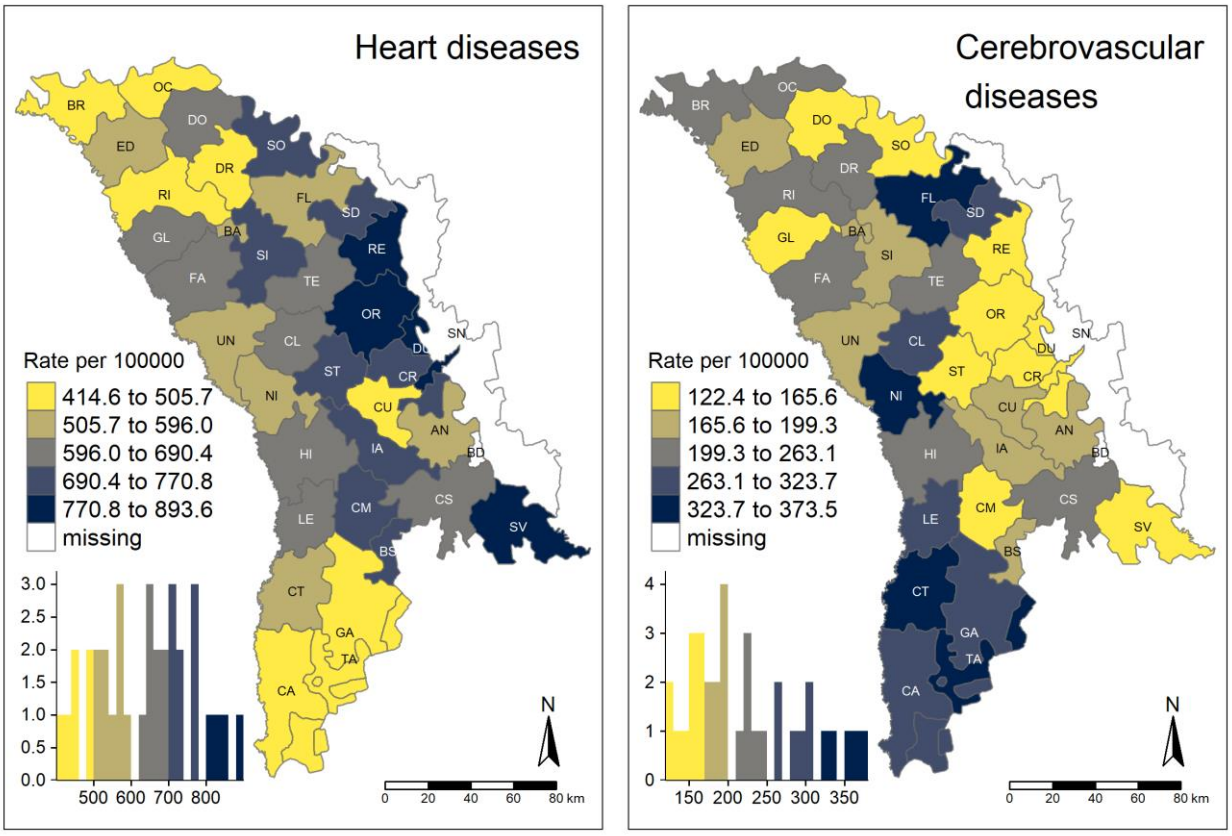


Fig. 6.13 Regional pattern of standardised mortality rates from heart diseases and cerebrovascular diseases, both sexes (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

The regional mortality profile observed for the two main components of circulatory system diseases was particularly interesting in the centre and south. The central lagging districts had "very high" cardiovascular mortality mainly due to heart diseases but not cerebrovascular diseases. In Rezina and Orhei, standardised mortality rates were "very high" for "heart diseases" and "very low" for "cerebrovascular diseases". At the same time, certain districts in the south (Cantemir, Cahul, Gagauzia, Taraclia) faced a lower risk of death from heart diseases and, on the contrary, a higher risk of death from cerebrovascular diseases.

6.2.6.2. Digestive system diseases

Digestive system diseases comprise about 10% of the total mortality, ranging from 4% in the northern district of Donduseni to 20% in the central district of Nisporeni. The partition between the north and centre for this pathology was particularly striking for females whose mortality rates in the north were represented only by "low" and "very low" values (Figure 6.14). The districts with "very high" and "high" mortality from digestive system diseases correspond to the red belt of high mortality described for the life expectancy map.

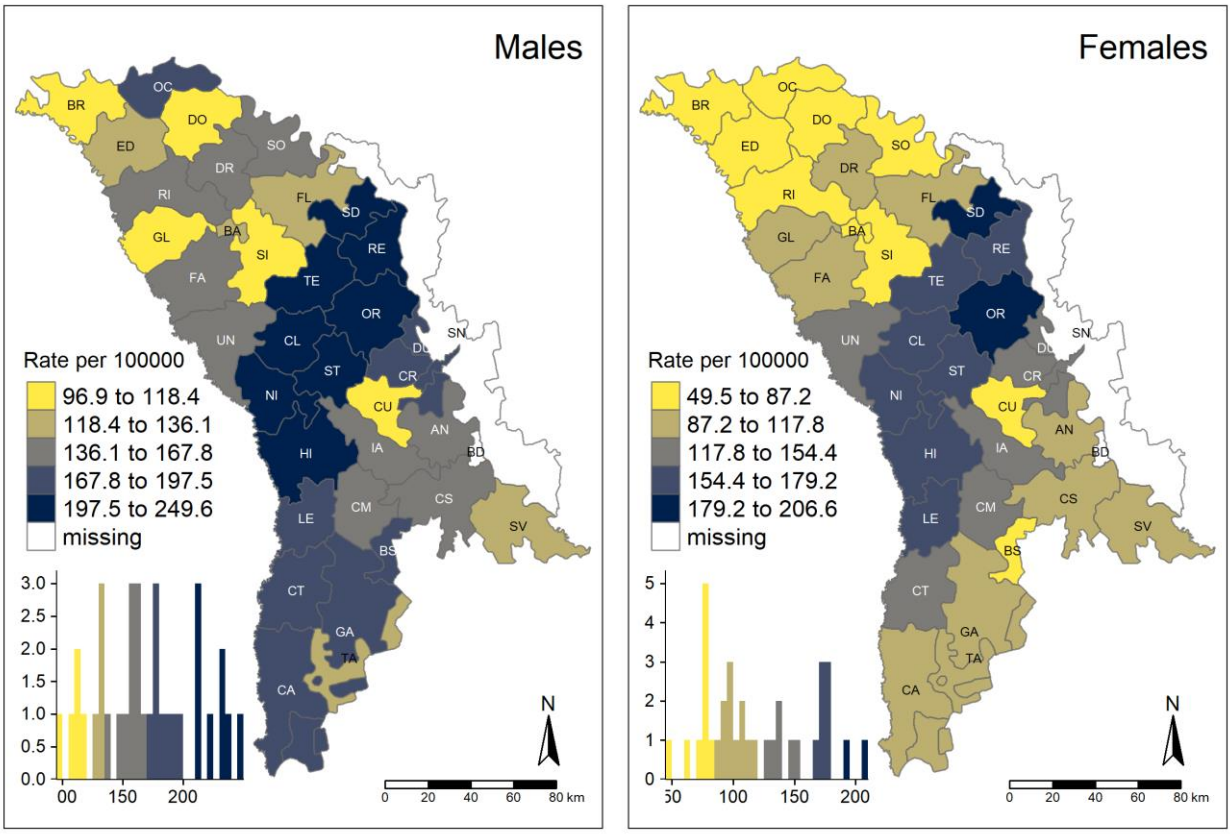


Fig. 6.14 Regional pattern of standardised mortality rates from diseases of the digestive system by sex (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

The highest mortality from digestive diseases was observed in the Orhei district, while the lowest was in the Donduseni district. The mortality indicator in Donduseni was lower by 2.5 times

in males and four times in females than in Orhei. The municipality of Chisinau was the only administrative unit of the centre unaffected by the burden of digestive illnesses. The thematic map for liver cirrhosis is not presented since it is responsible for 90% of deaths from digestive system diseases.

6.2.6.3. External causes of death

External causes of death are the third group of diseases that play a crucial role in interregional mortality differentiation, more so in men than in women. The impact of this group of causes of death on overall mortality is 10% in males and 4% in females. The geographical profile for external causes of death differs from that for circulatory and digestive diseases (Figure 6.15). The "very low" mortality was recorded only in the capital and the Falesti district for both sexes and in Balti, Gagauzia and Taraclia among females. The distinction between the leading north and the backward centre observed for all-cause mortality was not evident in the case of external causes of death. For men, the situation in the northern districts was similar to that in most central districts. Districts with "very high" and "high" mortality from external causes of death were mainly located within the red belt of high mortality. Particular attention should be given to a cluster of districts located on the border between the central and the southern regions (Hincesti, Cantemir, Leova, Cimislia). The sex ratio for external causes of death was the highest among all other major groups of causes of death and ranged between 2.6 in the central district of Nisporeni and 6.6 in the southern district of Taraclia. The southern district of Cimislia, directly adjacent to the central region, was the only district having a "very high" mortality rate from external causes of death in females (78.3 to 101.6). This district had the lowest life expectancy at birth in women, primarily due to higher mortality among young and mature adults. Mature adult women in the Cimislia district had more health problems related to cardiovascular and digestive diseases, while young adult women had higher mortality from external causes of death.

Detailed external causes of death also differed regionally (Figure 6.16). *Transport accidents*, which account for 12% of deaths from external causes at the national level, recorded the lowest mortality (8.5 per 100000) in the municipality of Chisinau. Although transport traffic is very heavy here, mortality from transport accidents was twice as low as in other geographical regions. The corresponding standardised rates were moderate to low in the districts directly adjacent to the capital. Another group of external causes is presented by *suicides, homicides and injuries undetermined whether accidentally or purposely inflicted* and accounts for one-third of deaths due to injury and poisoning. Districts with lower mortality were mainly placed in the northern region, while the most affected districts were located on the border between the centre

(Nisporeni, Hincesti) and the south (Leova, Cantemir, Cimislia). The same cluster of districts also experienced "very high" and "high" mortality rates from the *"other external causes"* group.

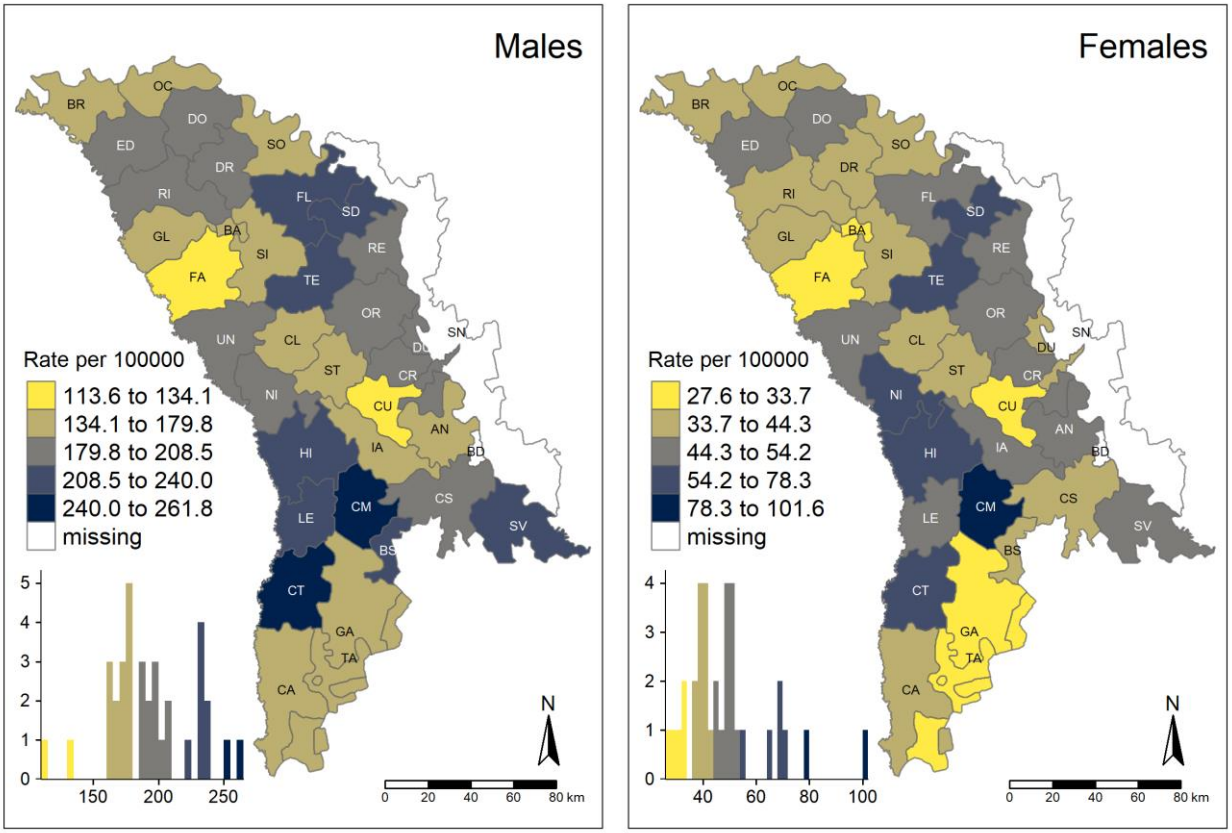


Fig. 6.15 Regional pattern of standardised mortality rates from external causes of death by sex (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

6.2.6.4. Neoplasms

Although neoplasm mortality ranks second in the overall mortality pattern (15% in men and 13% in women), its impact on interregional disparities is insignificant. For neoplasms, the shape of the distribution was skewed to the right moderately in males (skewness=0.8) and strongly in females (skewness=1.5). This asymmetric distribution results from outliers represented by the municipality of Balti (Figure 6.17). The relative difference between the maximum value (Balti for both sexes) and the minimum value (Edinet in males and Stefan Voda in females) was 1.6 and 1.9 times, respectively. Most districts (22 in men and 20 in women) had lower-than-average mortality related to neoplasms. Among women, districts in the south and lower centre, including the municipality of Chisinau, tended to be more affected by neoplasm mortality than districts in the north and upper centre. Among men, the cancer mortality pattern in the south was more problematic than elsewhere in the country. Unlike females, most central districts, including the capital, had "low" cancer mortality in males. In most districts with low life expectancy (except for the Orhei district), mortality from neoplasms was "low" or "very low".

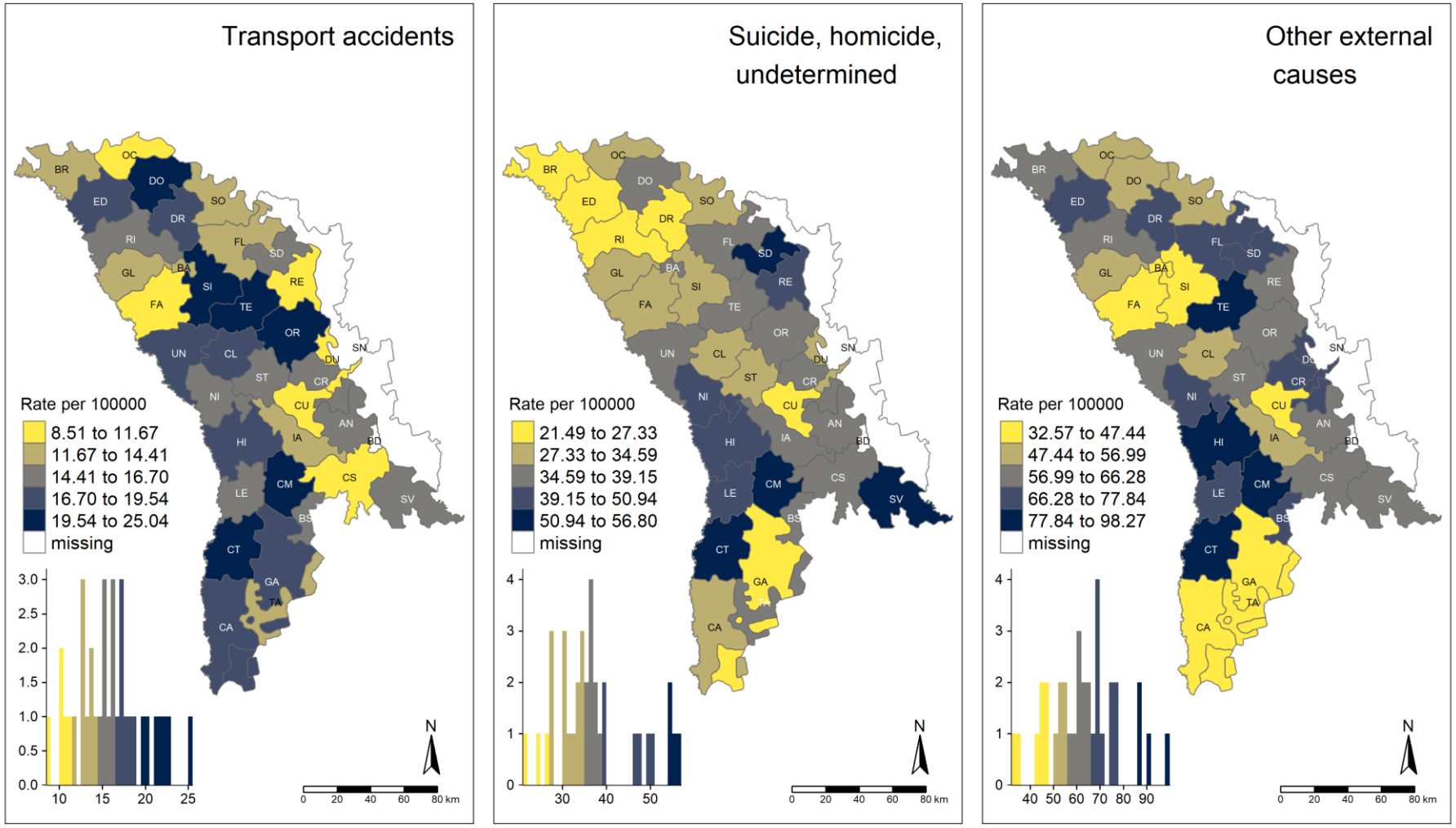


Fig. 6.16 Regional pattern of standardised mortality rates from transport accidents, suicide, homicide, injury undetermined whether accidentally or purposely inflicted and other external causes of death, both sexes (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

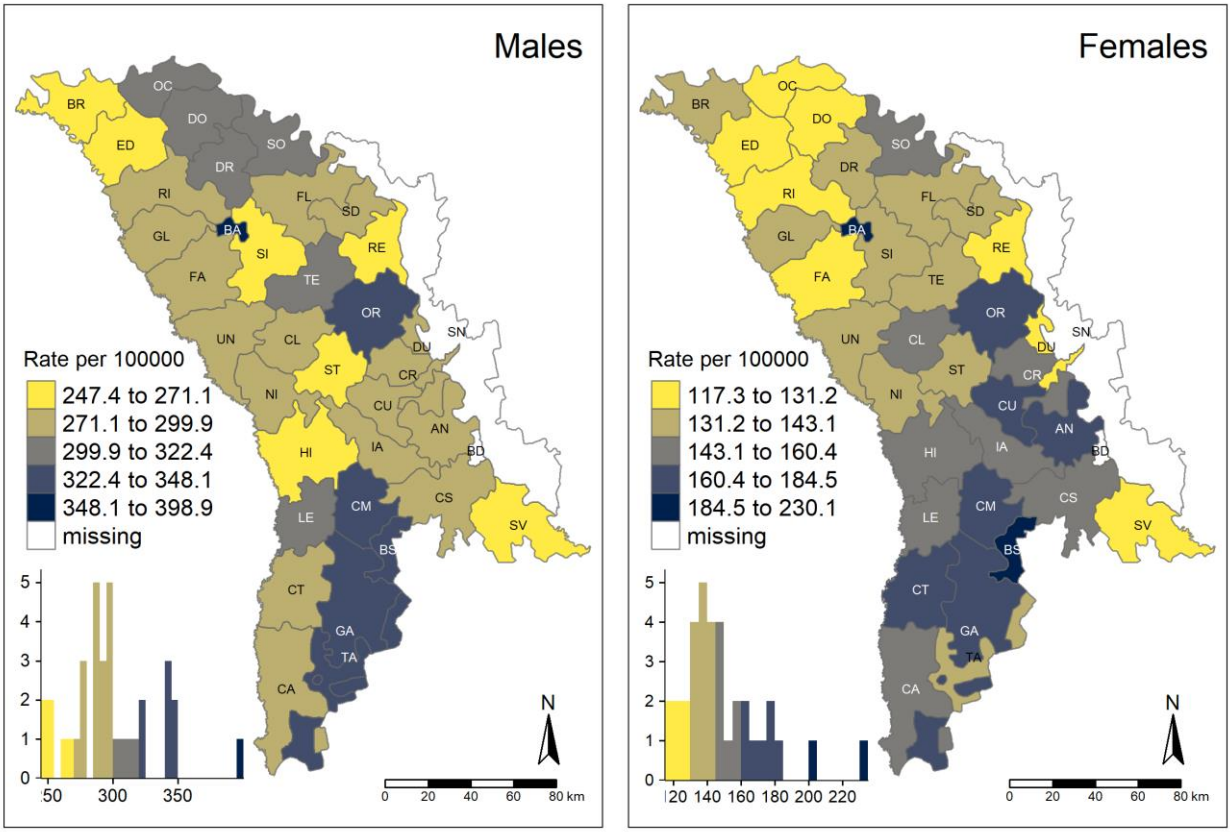


Fig. 6.17 Regional pattern of standardised mortality rates from neoplasms by sex (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

Neoplasms of different locations had particular geographic mortality profiles. At the national level, cancer of the digestive and respiratory systems made up 40% and 20% of all neoplasm deaths. The lowest mortality associated with *digestive system cancer* was in the northern region, with a minimum recorded in the Edinet district. High mortality rates from this cancer location were found in the south, with a maximum registered in the Cimislia district. The latter and the municipality of Balti were identified as outliers. The population in the capital and some adjacent districts had a lower risk of dying from *respiratory system cancer* than in the north or south. The highest value was recorded in the municipality of Balti (Figure 6.18). *Breast cancer* mortality tends to be lower in the north and higher in the south, with the maximum value in the municipality of Balti. The interregional differentiation was less evident for *cancer of the genitourinary system*, and the northern municipality recorded the highest values. The *"other neoplasms"* group, representing 14% of neoplasm mortality in the country, had the features typical of the entire class of neoplasms (Figure 6.19).

The population of the municipality of Chisinau experienced a lower risk of dying from cancer of the respiratory system and a higher risk of dying from cancer of the breast and other locations. On the contrary, the population in the north had a higher risk of dying from cancer of

the respiratory system and a lower risk of cancer in other locations, including breast cancer and cancer of the digestive system. Finally, the population in the south experienced a higher risk of dying from different types, particularly from cancer of the digestive and respiratory systems.

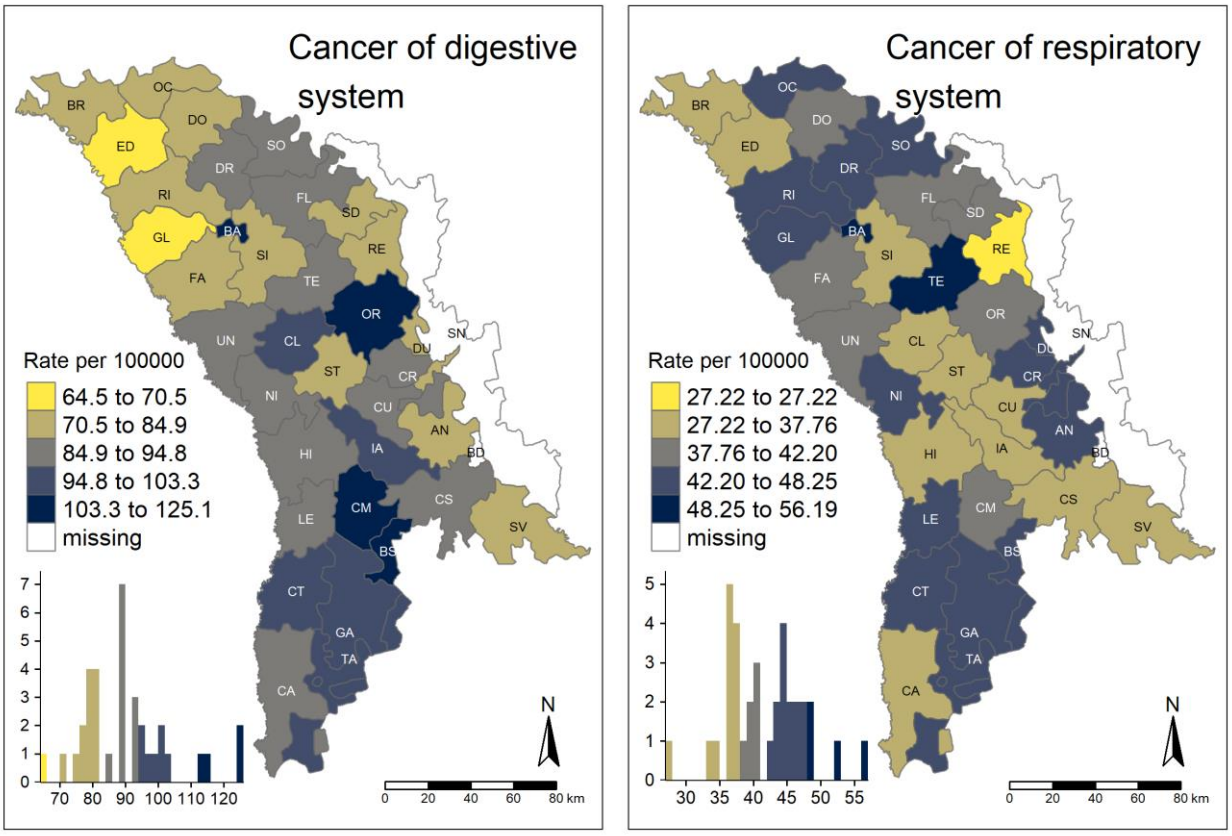


Fig. 6.18 Regional pattern of standardised mortality rates from cancer of the digestive system and cancer of the respiratory system, both sexes (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

6.1.4.1.Respiratory system diseases and infectious diseases

Mortality from respiratory system diseases was high in the north and low in the centre and south. This split was particularly pronounced for the female population. Infectious diseases, which accounted for less than 2% of total mortality among men and less than 1% among women during the study period, had different regional profiles depending on gender. Among males, most central districts had "moderate" to "high" standardised mortality rates, except for some districts. Men from the northern districts bordering the central region and Transnistria and from the municipality of Balti (an outlier) experienced more severe health problems related to infectious diseases. At the same time, this situation was more favourable for the male population in the more remote districts of the north and south. Among females, the distribution of standardised mortality rates from infectious diseases was highly skewed to the right (skewness=2.5) due to the presence of an outlier, the municipality of Balti, which was the only unit with "very high" mortality rates (Figure 6.20 and 6.21).

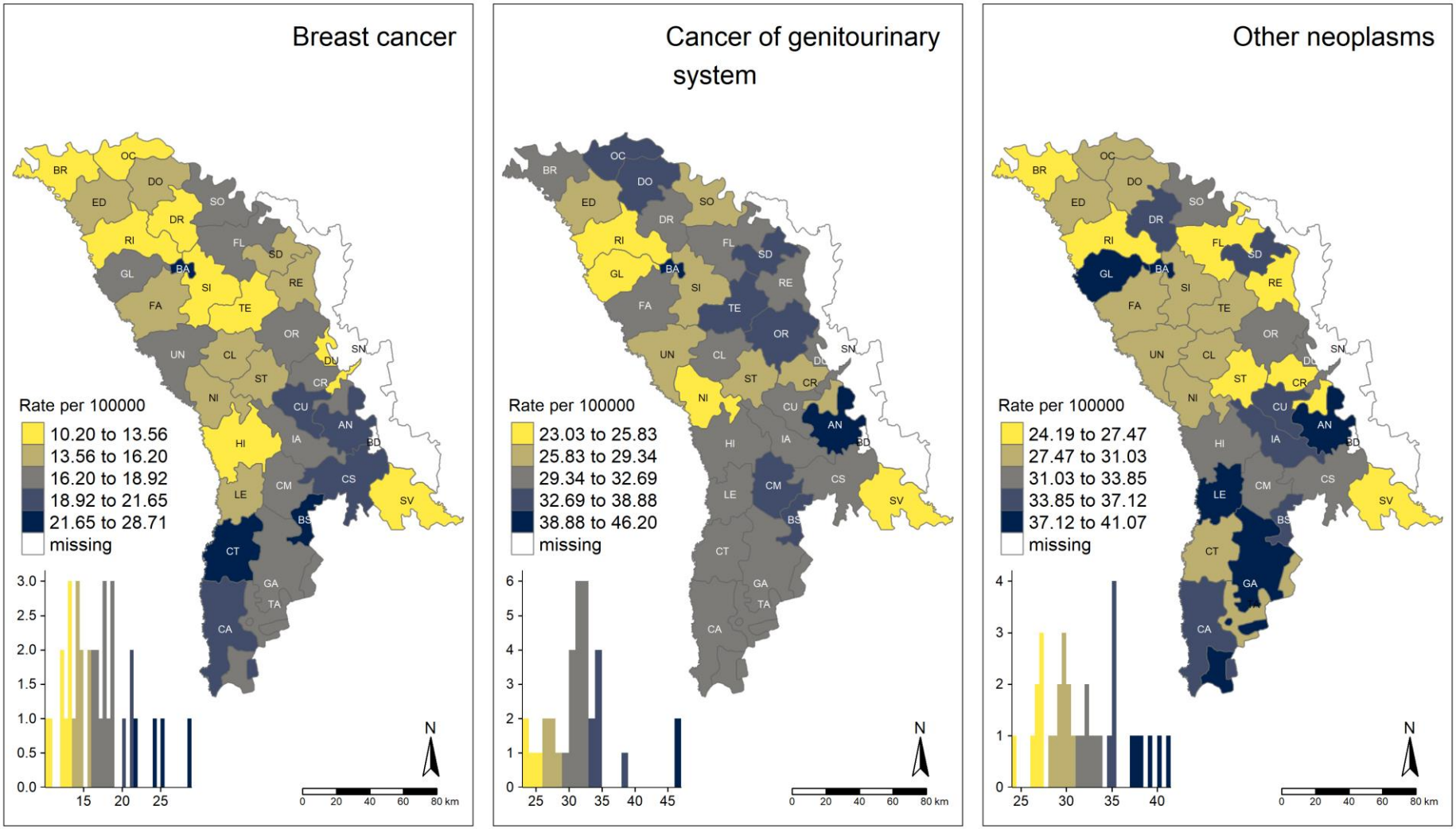


Fig. 6.19 Regional pattern of standardised mortality rates from breast cancer, cancer of the genitourinary system and other neoplasms, both sexes (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

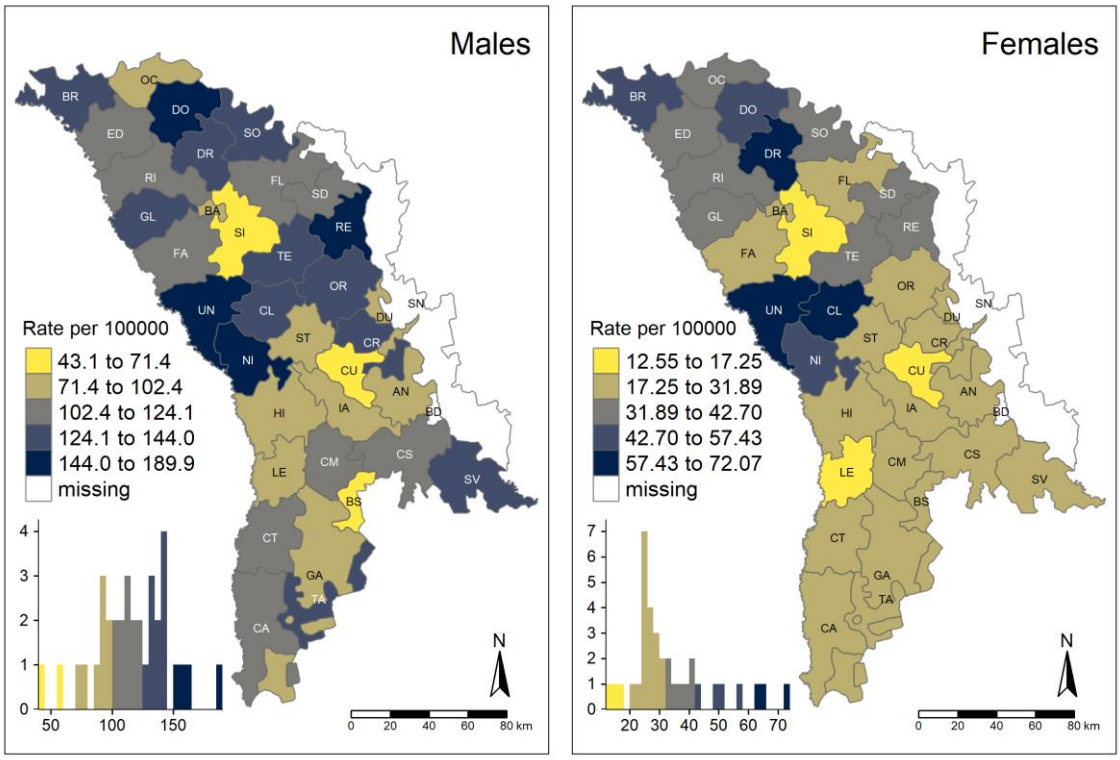


Fig. 6.20 Regional pattern of standardised mortality rates from diseases of the respiratory system by sex (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

6.1.4.2. Infectious diseases

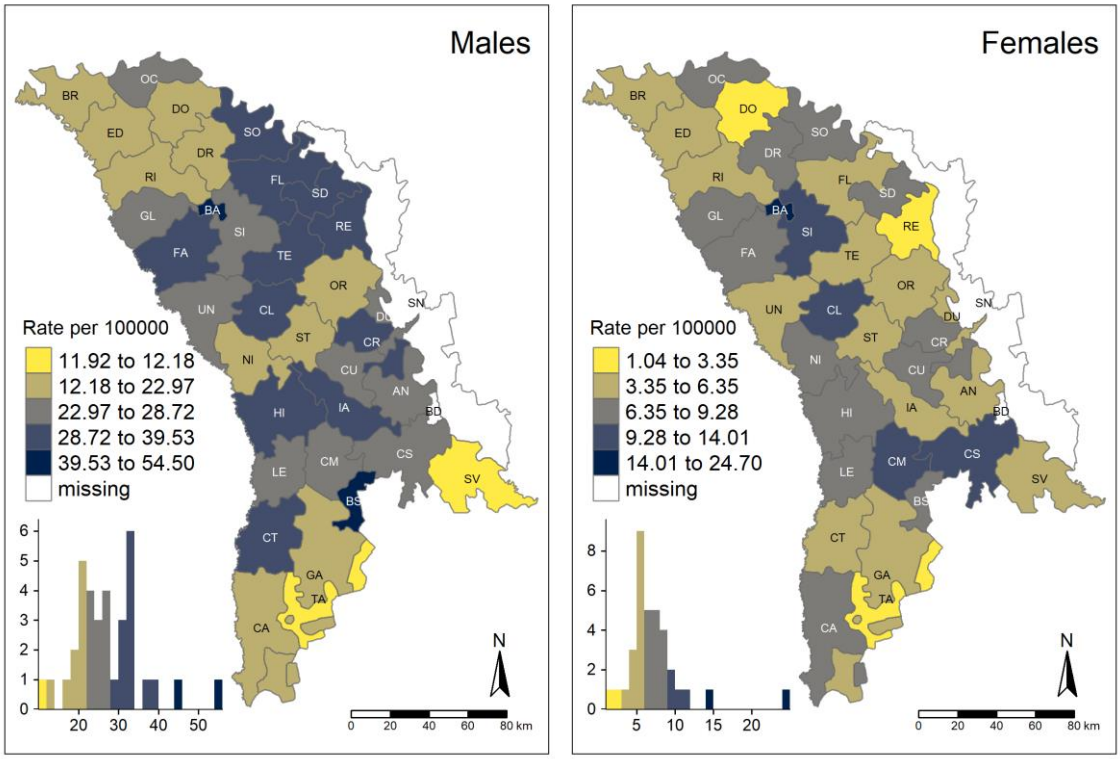


Fig. 6.21 Regional pattern of standardised mortality rates from infectious diseases by sex (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

6.1.4.3. Other diseases

The residual group of causes of death referred to as "other diseases" represented approximately 4% of total mortality. Mortality from this group of causes of death was "very low" in the country's capital and neighbouring districts, particularly among males. Mortality rates were also low in some northern districts for both sexes, while the female population in the southern districts (Cahul, Gagauzia) was more affected (Figure 6.22).

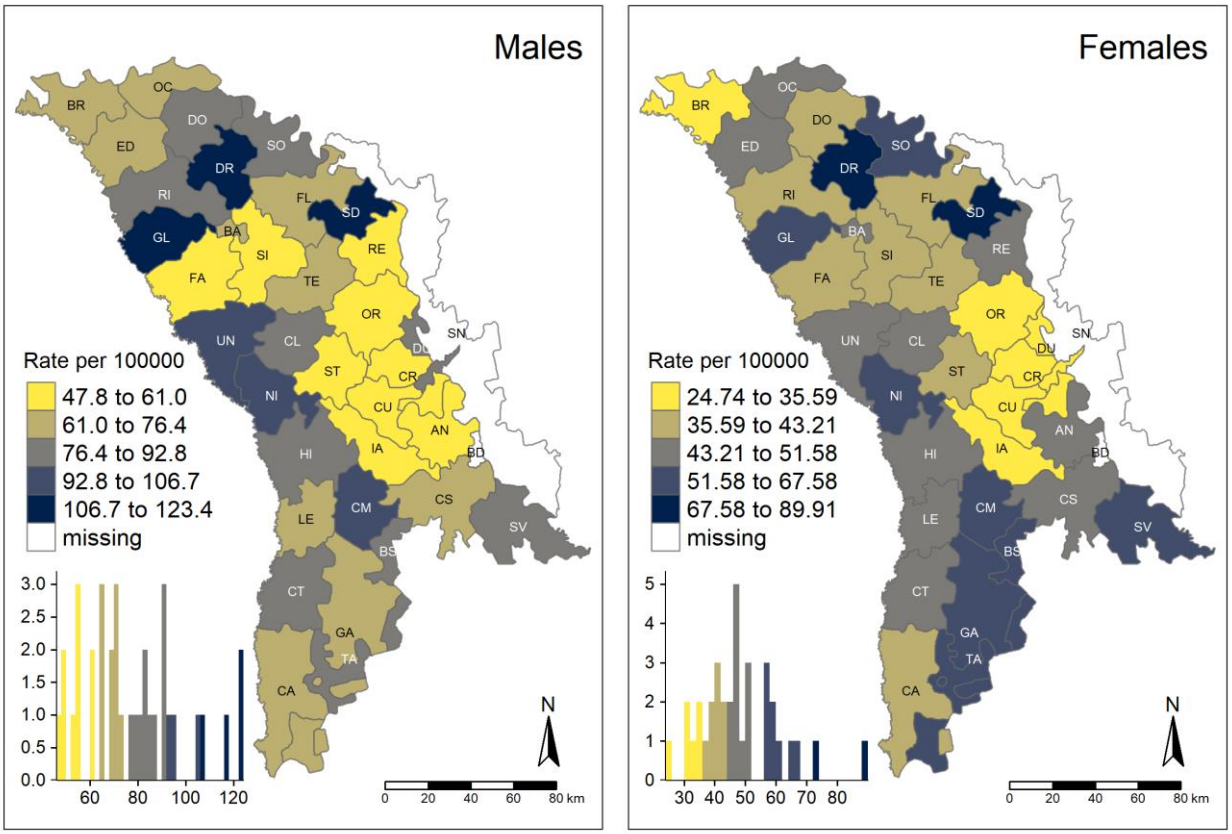


Fig. 6.22 Regional pattern of standardised mortality rates from other causes of death by sex (per 100000 population)

Source: author's calculations based on NBS and NAPH data.

6.3. Spatial mortality disparities

This section presents global and local spatial autocorrelation analysis for all-cause and cause-specific mortality.

6.3.4. Global spatial autocorrelation

6.3.4.1. Neighbourhood structure and spatial weights

Figure 6.25 shows two spatial matrices constructed for 35 administrative units of Moldova based on two different definitions of the neighbourhood: first-order queen's contiguity and four nearest neighbours (see section 2.2.7). Since the data on Transnistria are unavailable, this region was excluded from the spatial weights matrix. The average number of links in the queen's

contiguity method case was 4.4. Nine districts had three, and nine others had five connections. Seven districts had four connections, five had six, and one had two connections. The Stefan Voda district located in the southeast had only one connection. The Ialoveni, Singerei and Telenesti districts were the most connected, having seven links with the first-order neighbours. Data distribution according to the number of connections per district was normal (skewness=0.0).

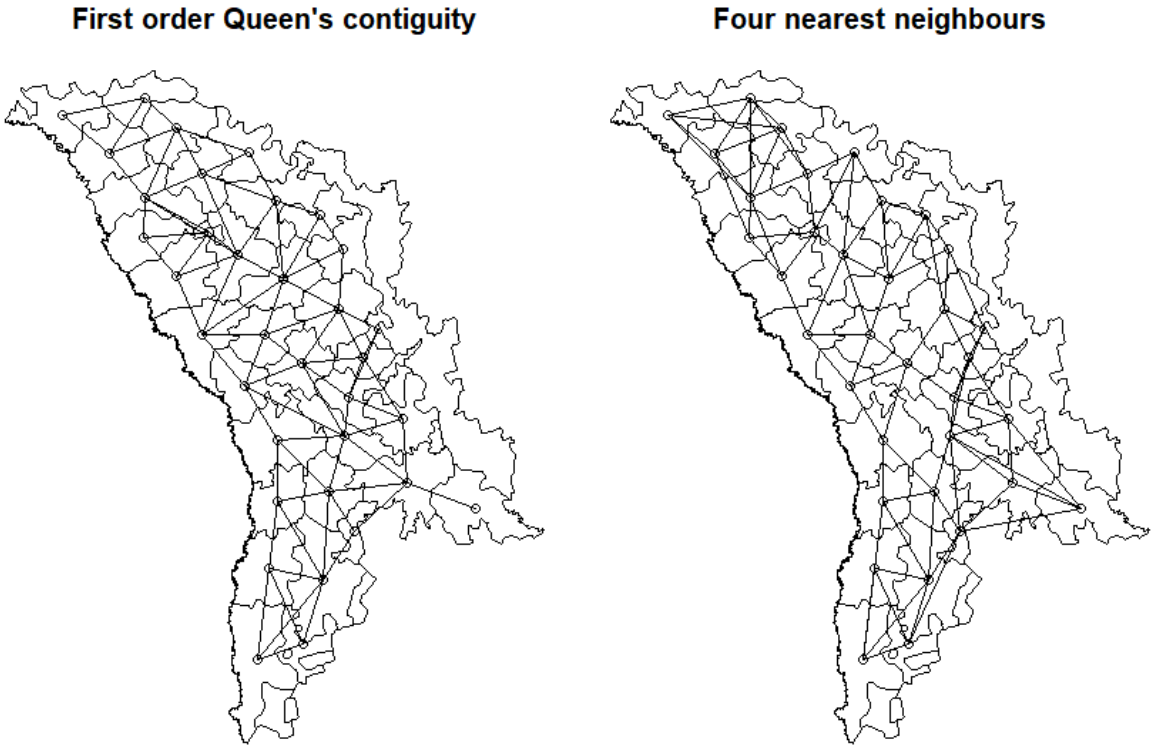


Fig. 6.23 Neighbourhood relation between the districts based on first order queen's contiguity method and four nearest neighbours' method in Moldova

Source: author's calculations based on NBS data.

Moran's index was computed for life expectancy by age to determine which type of spatial weights matrix (queen's contiguity matrix or four nearest neighbours' matrix) to use in the analysis (Figure 6.24). Moran's index, whatever the type of weights matrix applied, was systematically higher in females than in males. Furthermore, the global spatial autocorrelation index was closer to zero in older age groups and even negative in the oldest ages for the two types of matrices. Moran's index was consistently higher for the contiguity matrix than for the four nearest neighbours' matrix, except for the oldest age groups, where the values were nearly identical. For the contiguity matrix, Moran's index was positive and statistically significant (p-value < 0.05) for all age groups up to 75 years among men and 85 years among women. For the second matrix, Moran's index was positive and significant (p-value < 0.05) across all age groups up to 70 years among men and 80 years among women. It was decided to rely on the first-order queen's contiguity matrix for further analysis due to better results for the given matrix.

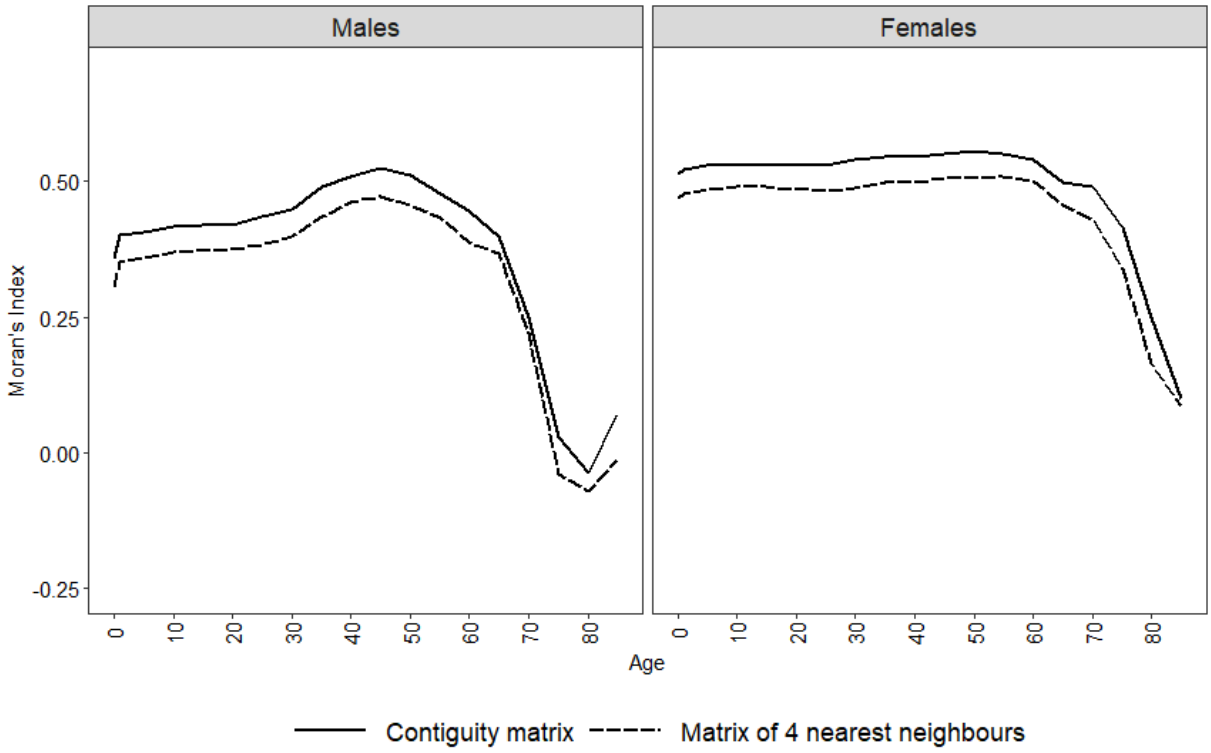


Fig. 6.24 Global Moran's index for life expectancy by age and sex depending on the type of spatial weights matrix

Source: author's calculations based on NBS data.

6.3.4.2. Global Moran's index

Moran's index of global spatial autocorrelation, which shows only the presence of clusters in the data, was computed for age-standardised death rates by main age groups and sex (Table 6.2) and standardised mortality rates by main causes of death and sex (Table 6.3). In the first case, the standardisation was produced by the direct method, while in the second by the indirect method. The identic age groups and groups of causes of death were used to analyse regional mortality patterns using thematic maps. For overall mortality, Moran's index was positive and statistically significant for men (0.426, $p<0.001$) and women (0.540, $p<0.001$). In other words, these results indicated the presence of "high-high" or "low-low" mortality clusters or both types of clusters. In such a way, we rejected the null hypothesis on the random distribution of mortality in space and accepted an alternative hypothesis on the presence of clusters in the all-cause mortality data.

Moran's index and significance test differed by age and sex. Firstly, the index of the global autocorrelation was positive and significant for all-cause mortality for both sexes in the 20-44, 45-64 and 65 and older age groups. For these age groups, as for mortality in all ages, it was possible to reject the null hypothesis on spatial randomness and draw a conclusion on the presence of clusters of similar values. The global spatial autocorrelation was especially strong in mature adults aged 45 to 64 years, more so in females (0.537, $p<0.001$) than in males (0.512, $p<0.001$). Secondly,

the clustering in all-cause mortality data among the older population was more pronounced among women (0.491, p<0.001) than among men (0.248, p<0.05). Furthermore, among young adults aged 20 to 44 years, the index of the global autocorrelation was higher among men (0.241, p<0.01) than among women (0.236, p<0.01). Thirdly, in the case of infant mortality and mortality among children and adolescents (1-19 years), there was insufficient evidence to reject the hypothesis on spatial randomness (p>0.05).

Table 6.2 Moran's index and p-value for standardised death rates by age and sex

Age group	Males	Females
1. Less than one year	0.071 (p-value>0.05)	0.087 (p-value>0.05)
2. 1-19 years	-0.088 (p-value>0.05)	0.077 (p-value>0.05)
3. 20-44 years	0.241 (p-value<0.01)	0.236 (p-value<0.01)
4. 45-64 years	0.512 (p-value<0.001)	0.537 (p-value<0.001)
5. 65 years and over	0.248 (p-value<0.01)	0.491 (p-value<0.001)
All ages groups	0.426 (p<0.001)	0.540 (p<0.001)

Note: Moran's I computed for standardised death rates (all ages) differs slightly from Moran's index computed for standardised mortality rates (all causes) presented in Table 6.3.
Source: author's calculations based on NBS and NAPH data.

Table 6.3 Moran's index and p-value for standardised mortality rates by main causes of death and sex

Cause of death	ICD-10	Males	Females
1. Infectious diseases	A00-B99	0.056 (p-value>0.05)	0.048 (p-value>0.05)
2. Neoplasms	C00-D48	0.005 (p-value>0.05)	0.093 (p-value>0.05)
3. Circulatory system diseases	I00-I99, G45	0.319 (p-value<0.01)	0.300 (p-value<0.01)
4. Respiratory system diseases	J00-J98, U04	0.041 (p-value>0.05)	0.235 (p-value>0.05)
5. Digestive system diseases	K00-K93	0.422 (p-value<0.001)	0.597 (p-value<0.001)
6. External causes of death	V01-Y98,	0.162 (p-value<0.05)	0.116 (p-value>0.05)
7. Other diseases and causes of death	D50-G44, G47-H95, L00-Q99	0.036 (p-value>0.05)	0.054 (p-value>0.05)
All causes of death combined	A00-Y98	0.474 (p<0.001)	0.441 (p<0.001)

Note: see Note in Table 6.2.
Source: author's calculations based on NBS and NAPH data.

Global spatial autocorrelation showed statistically significant results for only three broad groups of causes of death: circulatory and digestive system diseases for both sexes and external causes of death for men. For both sexes, digestive system diseases had the highest intensity of global spatial autocorrelation, more among women (MI=0.597, p<0.001) than among men (MI=0.422, p<0.001). The second group was diseases of the circulatory system that showed almost a similar effect on the

spatial disparities in mortality for males (MI=0.319, p<0.01) and females (MI=0.300, p<0.01). Lastly, Moran's index computed for the group of external causes of death had statistically significant results only among men (MI=0.162, p<0.05).

6.3.5. Local spatial autocorrelation

The location of clusters of similar values on a map was determined based on the Local Indicators of Spatial Association (LISA) computed for all-cause and cause-specific mortality rates.

6.3.5.1. Spatial variation in all-cause mortality

Moran's scatterplot in Figure 6.25 shows the relationship between the standardised values of indirectly standardised mortality rates and their spatially lagged values. The location of the districts in the "low-low" and "high-high" quadrants indicates a positive global spatial autocorrelation regarding all-cause mortality. The municipality of Chisinau is localized for both sexes in the "low-high" quadrant and represents a spatial outlier, i.e., a locality with low mortality rates surrounded by localities with high mortality rates.

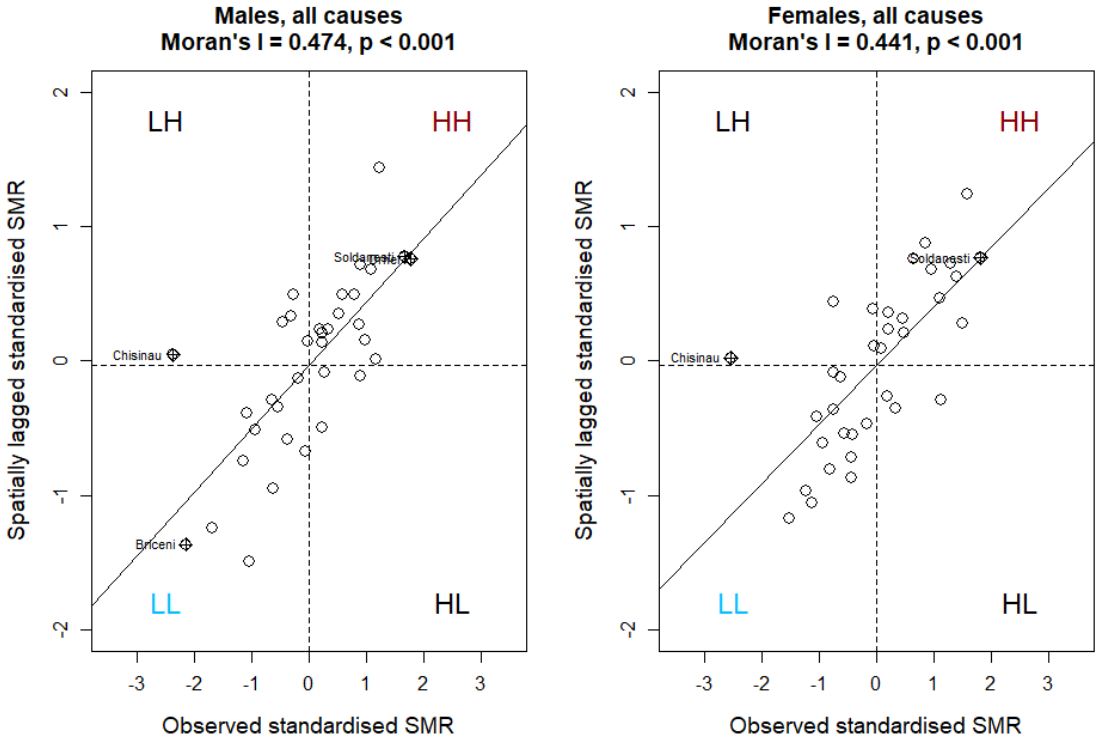


Fig. 6.25 Moran's scatterplot for standardised mortality rates from all causes by sex
Note: LH – Low-High; HH – High-High; HL – High-Low; LL – Low-Low quadrants.
Source: author's calculations based on NBS and NAPH data.

The location of the hot and cold clusters on the map, i.e., districts from the "high-high" and "low-low" quadrants in Moran's scatterplot, is shown with the help of the LISA map in Figure 6.26. The "hot" cluster of districts with high all-cause mortality includes the central districts of Soldanesti, Rezina, Orhei, and Calarasi for both sexes, the Telenesti district for men and the Hincesti district for women. In the "hot" cluster, districts with high mortality are surrounded by

districts with high mortality. Most of these districts lie within the red bel of high mortality determined for life expectancy based on the thematic maps. The "cold" cluster consists of districts with low mortality, surrounded by districts with low mortality, and includes the northern districts of Briceni, Ocnita, Edinet and Riscani.

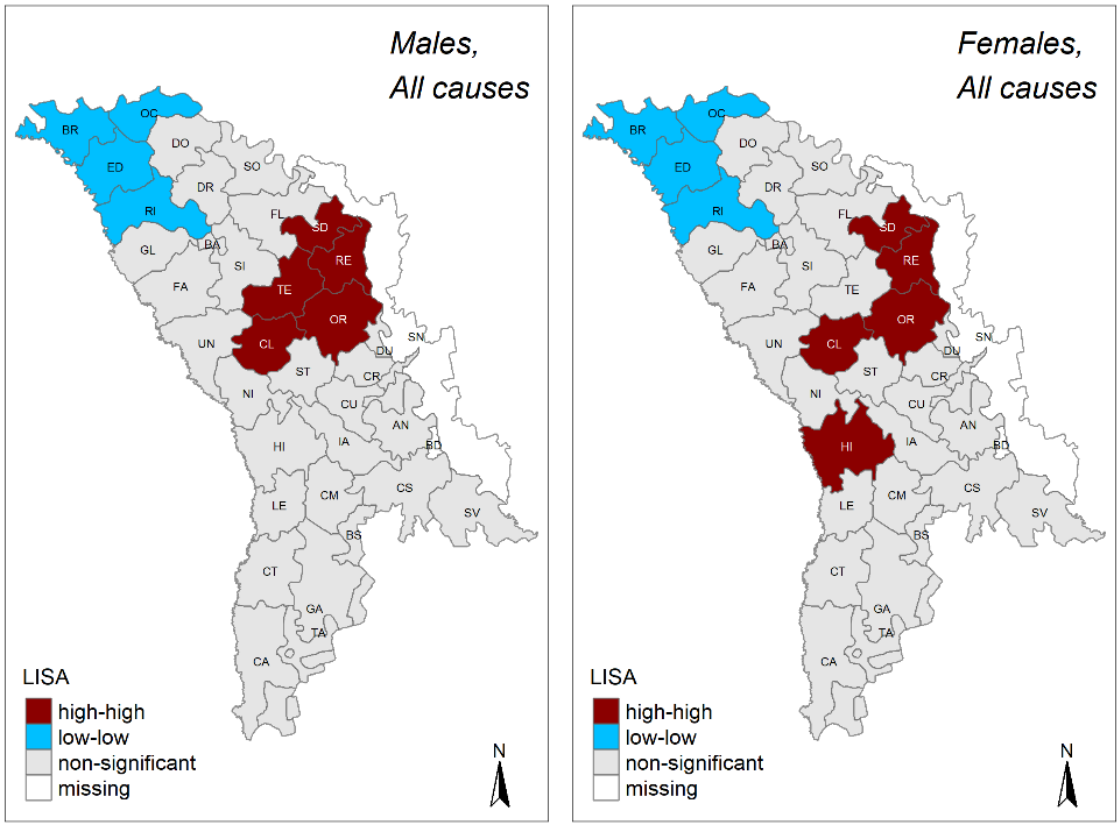


Fig. 6.26 LISA map for standardised mortality rates from all causes by sex

Note: p-value <0.001 (number of permutations = 9999)
Source: author's calculations based on NBS and NAPH data.

6.3.5.2. Spatial variation in cause-specific mortality

The northcentral mortality gradient detected for all-cause mortality was particularly impressive for *digestive system diseases*, especially among women (Figure 6.27). The "low-low" and "high-high" clusters for this cause of death were more prevalent among women than men. The subsequent districts of a high-mortality red belt formed a "high-high" cluster for digestive system diseases: Soldanesti, Rezina, Telenesti, Orhei, Calarasi, Straseni, Nisporeni and Hincesti. The cluster of "low-low" mortality for *circulatory system diseases* was also located in the north of the country and more extended in males than females (Briceni, Ocnita, Edinet, Donduseni and Riscani). The corresponding "high-high" mortality cluster was found in the central districts of Soldanesti, Rezina and Orhei. The number of districts involved in the "hot" cluster for cardiovascular mortality was much less widespread compared to diseases of the digestive system (Figure 6.28). Unlike the previous two groups of causes of death, where both "cold" and "hot"

clusters were detected, in the case of *external causes of death*, only the "hot cluster" was found. The latter included the districts of Hincesti, Leova and Cimislia, situated on the border between the central and southern regions (Figure 6.29).

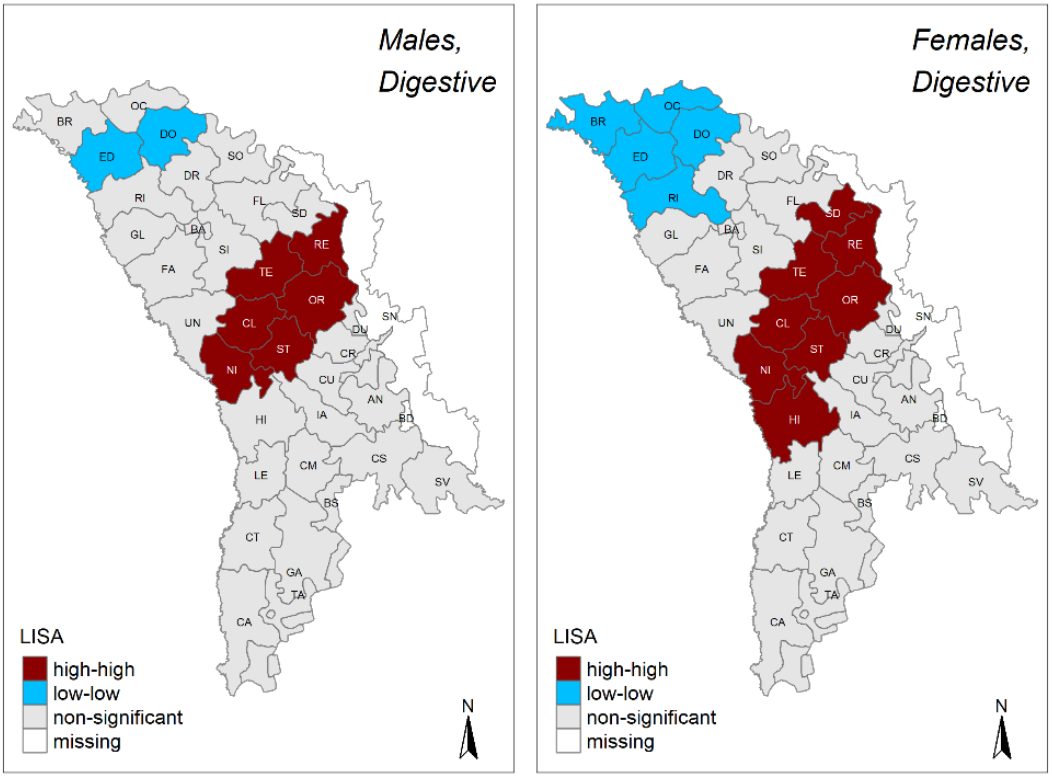


Fig. 6.27 LISA map for standardised mortality rates from diseases of the digestive system by sex

Note: p-value <0.001 (number of permutations = 9999)
Source: author's calculations based on NBS and NAPH data.

Annexe 14 presents the LISA maps produced for specific detailed causes of death for both sexes where the local autocorrelation was statistically significant. Liver cirrhosis was a cause of death with the highest impact on the north-centre mortality partition (MI=0.573, p<0.001). Two main types of cardiovascular mortality represented by heart and cerebrovascular diseases had different spatial patterns. If for heart diseases, a "high-high" mortality cluster was found in the central districts of Orhei and Rezina (MI=292, p<0.05), then for cerebrovascular diseases, it was detected in the southern districts of Leova, Cantemir, Gagauzia, Cahul and Taraclia (MI=0.281, p<0.05). Although the global autocorrelation index was not statistically significant for the entire group of neoplasms, a more detailed analysis detected a "high-high" cluster for digestive system cancer in the southern districts of Basarabeasca, Gagauzia, Cimislia (MI=0.21, p<0.05). High mortality rates associated with external causes of death in the lagging central districts were mainly attributable to deaths provoked by suicide, homicide and injury undetermined whether accidentally or purposely inflicted (MI=0.277, p<0.05).

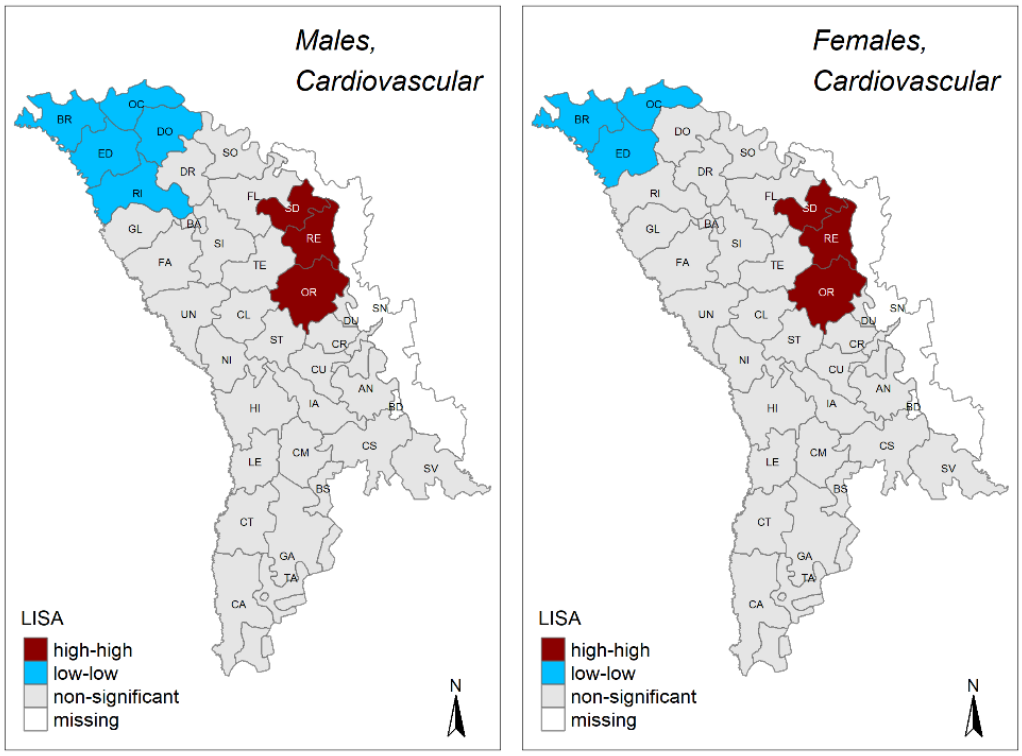


Fig. 6.28 LISA map for standardised mortality rates from diseases of the circulatory system by sex

Note: p-value <0.01 (number of permutations = 9999)
Source: author's calculations based on NBS and NAPH data.

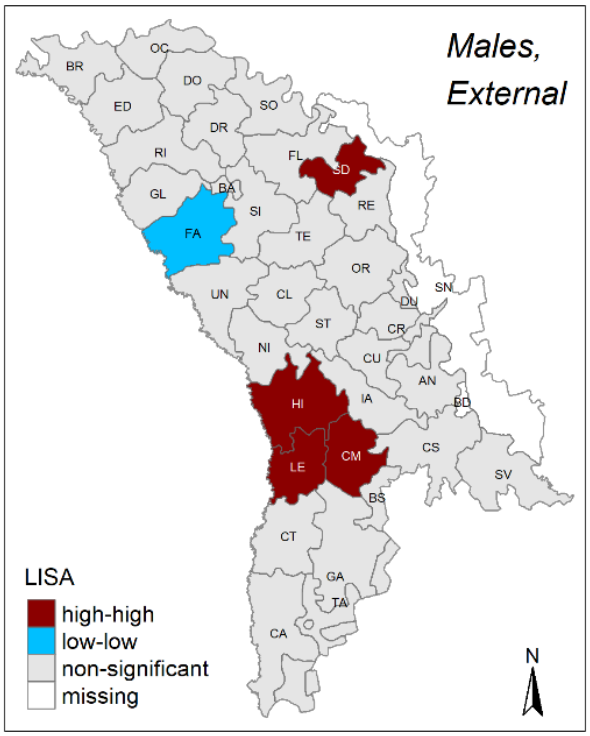


Fig. 6.29 LISA map for standardised mortality rates from external causes of death, males

Note: p-value <0.05 (number of permutations = 9999)
Source: author's calculations based on NBS and NAPH data.

6.4. Evolution of regional mortality disparities after independence

This section describes all-cause and cause-specific mortality changes since independence over 1991-1995, 2002-2006 and 2012-2016.

6.4.1. Interregional differentiation of life expectancy and causes of death after independence

Table 6.4 provides data on life expectancy at birth by geographic region over three periods. In 1991-1995, the period of the severe socioeconomic crisis, the indicator was higher than the national average only in the capital and the northern region. Life expectancy was near the national level among females in Transnistria and below that for other regional subgroups. At the beginning of the 1990s, the most unfavourable situation was observed in the country's centre, where life expectancy for both sexes was almost two years lower than the national average and four years lower than that in the capital.

Table 6.4 Life expectancy at birth and its changes by geographic region and sex in Moldova since 1991

Geographic region	Life expectancy			Changes in life expectancy		
	1991-1995	2002-2006	2012-2016	1991-1995 / 2002-2006	2002-2006 / 2012-2016	1991-1995 / 2012-2016
Males						
North	64.2±0.4	64.2±0.4	65.0±0.5	0.0	0.8	0.8
Centre	61.7±0.4	62.5±0.4	63.7±0.4	0.8	1.2	2.0
South	62.3±0.5	62.8±0.5	64.1±0.6	0.5	1.3	1.8
Transnistria	62.3±0.6	61.8±0.6	-	-0.5	-	-
Mun. Chisinau	65.3±0.5	64.8±0.5	68.6±0.5	-0.5	3.8	3.3
Moldova	*63.2±0.2*	*63.2±0.2*	*65.2±0.2*	*0.0*	*2.0*	*2.0*
Females						
North	72.0±0.4	72.6±0.4	74.3±0.4	0.6	1.7	2.3
Centre	68.6±0.4	69.3±0.4	71.6±0.4	0.7	2.3	3.0
South	69.6±0.5	70.4±0.5	72.5±0.5	0.8	2.1	2.9
Transnistria	71.0±0.5	71.7±0.6	-	0.7	-	-
Mun. Chisinau	72.7±0.5	73.5±0.5	76.7±0.5	0.8	3.2	4.0
Moldova	*70.6±0.2*	*71.4±0.2*	*73.7±0.2*	*0.8*	*2.3*	*3.1*

Source: author's calculations based on NBS and NAPH data.

Throughout the stagnation in 2002-2006, the situation was virtually unchanged in all regions and the country's capital. There were some improvements in the 2012-2016 period, especially in the capital, where life expectancy for both sexes rose by more than 3.0 years compared to the previous period. The increase was less substantial in other regions, around two years in females and one year in males. Apart from the municipality of Chisinau, which ranks first, recent progress was more marked in the central and southern regions than in the northern one. There was much less progress in the country's northern region, where life expectancy was as high as in the capital over the first two periods, especially among males. Nevertheless, disparities in life expectancy at birth between the leading north and the capital on the one hand and the backward central and

southern regions on the other remain apparent. The central region was the furthest behind during the three study periods.

Figure 6.30 shows life expectancy at birth with 95% confidence intervals for both sexes over three study periods relative to the national average. In the first half of the 1990s, life expectancy was above the national average (66.9 years) in the capital, a few northern districts and the municipality of Balti. In the country's north, life expectancy was two years higher than its average (e.g., Riscani, Briceni) or close to it (e.g., Soroca and Floresti). At the other extreme of the pole were central and some southern districts where the population's health was much worse than the national baseline. Most southern districts and Transnistria had life expectancies closer to the national average. Life expectancy in the worst-performing districts (Calarasi, Straseni, Soldanesti, Dubasari, Basarabeasca) was about three years lower than in Moldova and even five years lower than in the capital.

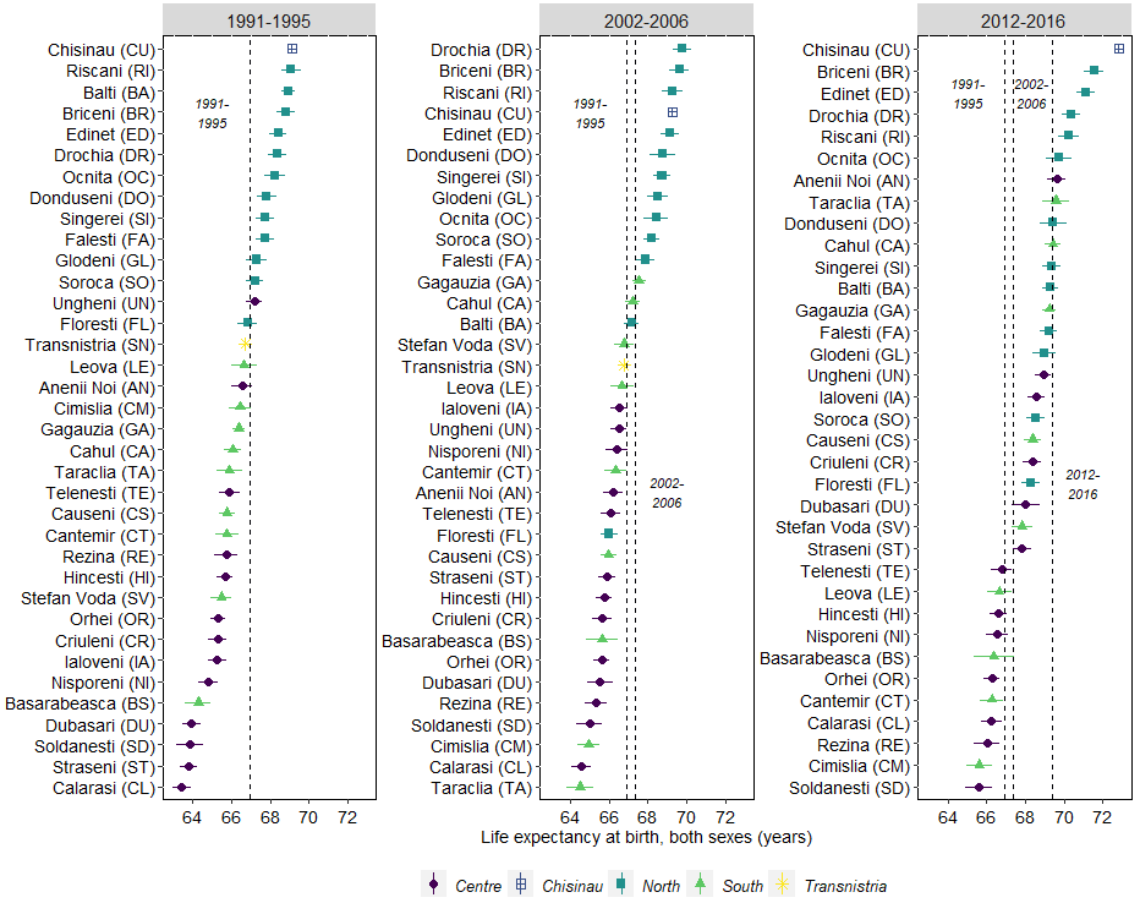


Fig. 6.30 Life expectancy at birth by the district in 1991-1995, 2002-2006 and 2012-2016, Moldova, both sexes

Note: Vertical lines refer to life expectancy in Moldova over three periods.
Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

In 2004-2006, the situation remained almost unchanged at the national level (67.3 years) and across districts compared to the early 1990s. Changes in life expectancy in 2002-2006 broadly

fell within the confidence limits in 1991-1995 for most districts, including the capital. The municipality of Balti was an exception, where the situation worsened considerably (68.9±0.3 years in 1991-1995 vs 67.2±0.4 in 2002-2006).

In 2012-2016, life expectancy increased by two years in Moldova (69.4 years), but the progress was not consistent geographically. The most significant gains (more than four years) were achieved in some southern and central districts, which held one of the lowest positions in the early 1990s and at the beginning of the millennium (e.g., Taraclia, Dubasari, Straseni). Life expectancy increased by more than three years in the municipality of Chisinau and some neighbouring districts (e.g., Anenii Noi, Ialoveni). In the municipality of Balti, the recent increase (more than two years) has offset the deterioration in the first 15 years of independence. On the contrary, most northern districts that occupied the leading position during the previous two periods alongside the municipality of Chisinau made little or no progress, with a few exceptions (Briceni, Edinet).

Figures 6.31 and 6.32 show the evolution of the geographical profile of life expectancy at birth in Moldova among men and women. The maps were produced using the statistical categories common to the three study periods. In this way, it is possible to observe how the geography of mortality evolved from one period to the next. One can see a radical transformation throughout independence. In the 1990s, mortality was much lower in the northern districts and the capital than elsewhere. In men, the municipalities of Chisinau and Balti and the districts of Riscani and Drochia were in the most favourable position. In women, the situation in the Briceni, Ocnita and Riscani districts was even better than that in the capital. At the same time, in most central and southern districts, life expectancy at birth was low and very low. Even in the districts bordering the capital, the socioeconomic crisis of the 1990s seriously affected the population's health. This fact was particularly evident with the map for women, where districts with very low life expectancies encircled the country's capital.

In 2003-2006, the situation somewhat improved in the north and remained unchanged in the rest of the country. The homogenization process continued slowly over the next decade, resulting in a completely different picture in 2012-2016. The situation has improved not just in the north and south but also in the centre, especially in the districts directly next to the capital (Ialoveni, Anenii Noi, Criuleni). As a result, a high mortality belt extended from Soldanesti in the northeast to Cantemir in the southwest. Within this belt, life expectancy at birth in 2012-2016 was at the 1991-1995 national level or lower for males (63.2 years) and below the 2002-2006 national level for females (71.2 years). The following eleven districts were identified as the most lagging: Soldonesti, Rezina, Orhei, Telenesti, Calarasi, Hincesti, Nisporeni, Cimislia, Basarabeasca, Leova

and Cantemir. The last four districts referring to the southern region are directly adjacent to the central region.

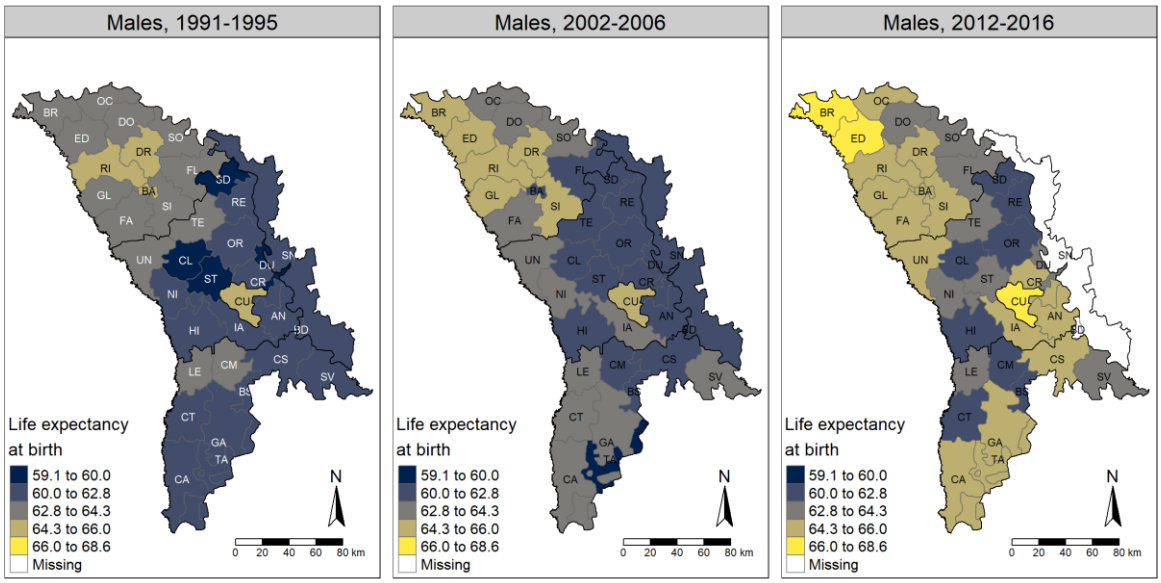


Fig. 6.31 Evolution of male life expectancy at birth at the district level in Moldova over three periods

Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

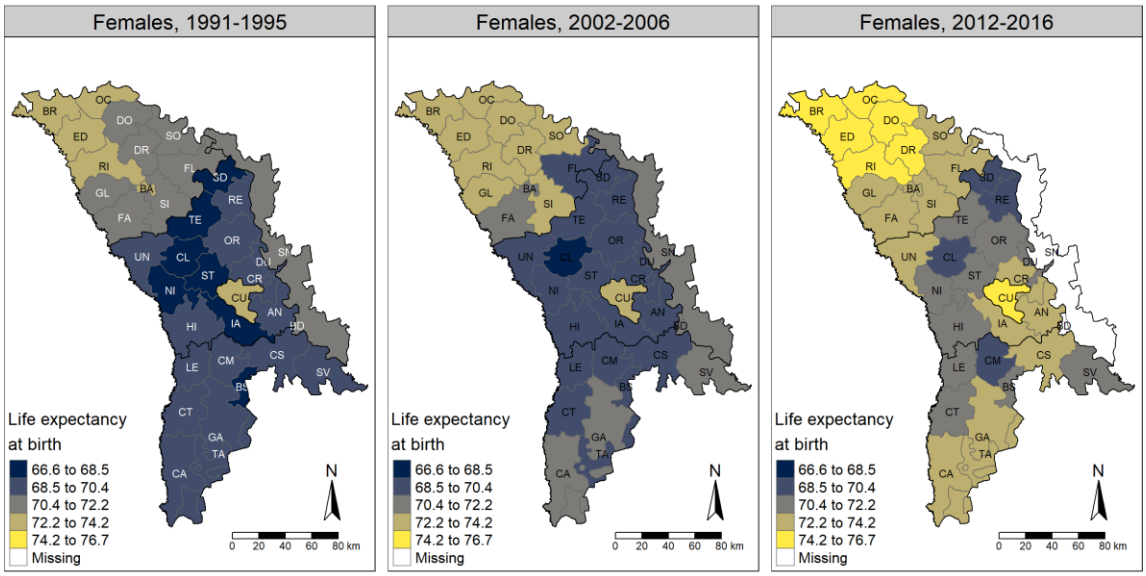


Fig. 6.32 Evolution of female life expectancy at birth at the district level in Moldova over three periods

Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

Figure 6.33 shows the hierarchical analysis of life expectancies by age carried out for 36 administrative units over three periods, excluding Transnistria in the last period. For all three periods, three clusters were detected. The capital of the country and all northern districts except for the Floresti district represented the cluster with the highest life expectancy during the first period. In the second period, the municipality of Balti was excluded from the best-performing cluster. In the third period, the leading cluster was represented only by the municipality of Chisinau

and the two northern districts of Edinet and Briceni. Conversely, the worst-performing cluster widened from four districts in 1991-1995 to eleven in 2012-2016. Further, if in the first two periods, the first-level partition was between the best-off group and the rest of the districts, then in the third period, between the worst-off group and the rest of the districts.

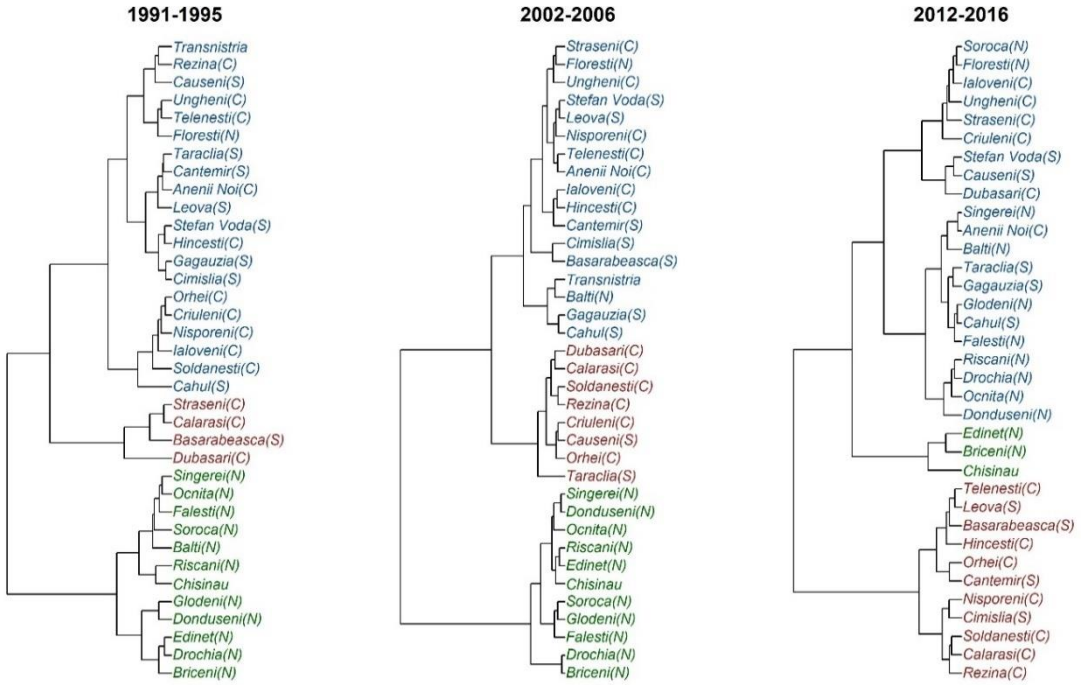


Fig. 6.33 Dendrograms based on the hierarchical analysis of life expectancy by age in 36 administrative units in Moldova over three periods, both sexes

Note: Data for Transnistria are missing for 2012-2016. N=North, C=Centre, S=South.
Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

Three population subgroups were identified based on the hierarchical analysis results for 2012-2016 (Table 6.5).

Table 6.5 Population size and life expectancy at birth in three geographical clusters in Moldova over three periods, both sexes

Period	Cluster 1 "Lagging"	Cluster 2 "Leading"	Cluster 3 "Other"	Moldova
Population (thousands, %)				
1991-1995	815 (19%)	910 (21%)	2621 (60%)	4346 (100%)
2002-2006	697 (18%)	851 (22%)	2251 (60%)	3799 (100%)
2012-2016	568 (20%)	809 (29%)	1445 (51%)	2821 (100%)
Life expectancy at birth (years)				
1991-1995	65.2±0.4	69.0±0.3	66.8±0.2	66.9±0.1
2002-2006	65.6±0.4	69.3±0.3	67.1±0.2	67.3±0.2
2012-2016	66.3±0.4	72.5±0.3	69.1±0.2	69.4±0.2

Note: three clusters were defined based on the hierarchical analysis of life expectancy in 2012-2016 (except for Transnistria, included in cluster 3 based on the results for 2002-2006). Population and mortality data do not cover Transnistria for 2012-2016.
Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

The "Lagging" cluster consisted of eleven districts with the lowest life expectancy at birth, where 20% of the Moldovan population lives, according to the 2014 census. Life expectancy

stagnated in this cluster in the first 15 years of independence, while later growth was relatively modest (+1.1 years). Cluster "Leading", represented by the municipality of Chisinau and two northern districts of Briceni and Edinet, had the highest life expectancy and was home to 29% of the population. Here, the increase in life expectancy between 1991-1995 and 2012-2016 was 3.5 years. The "Others" cluster covered the remaining districts where life expectancy was close to the national average over the three periods since more than 50% of the Moldovan population lived there.

Figure 6.34 illustrates the results of the decomposition of the difference in life expectancy at birth between 1991-1995 and 2012-2016 for the three population subgroups described above. The life expectancy difference between the two periods was broken down into differences in mortality rates across age and cause of death.

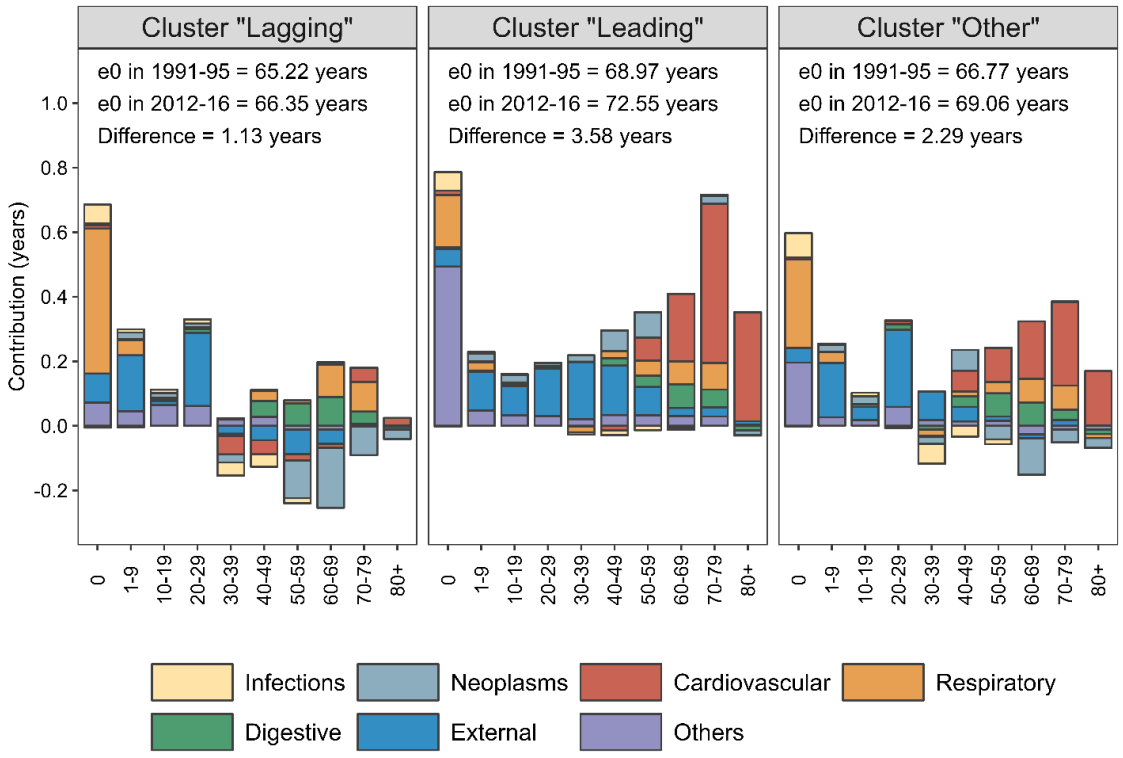


Fig. 6.34 Contributions of changes in mortality by age and cause to the difference in life expectancy at birth (e_0) between 1991-1995 and 2012-2016 in three geographical clusters, Moldova, both sexes

Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

In the *lagging cluster*, life expectancy increased (1.1 years) primarily due to the decline in mortality from respiratory system diseases among infants and older adults and mortality from external causes among young adults. The decrease in mortality from respiratory diseases was responsible for 0.74 years of total gains or 66%. The impact of infant mortality decline was the most significant, accounting for 1.1 years. However, these improvements were offset by increased mortality among adults due to neoplasms and external causes of death.

In *the leading cluster*, life expectancy at birth rose by 3.5 years after independence. This progress was mainly associated with a decline in mortality from cardiovascular diseases among the elderly, external causes of death among young and middle-aged adults and the residual group of causes of death among infants. These three causes of death accounted for over 75% of total life expectancy growth. The age groups where the reduction in mortality contributed most to the increase in life expectancy were less than one year (0.8 years or 22%) and 60 years and older (1.4 years or 40%). In *the residual cluster*, life expectancy at birth increased by 2.3 years throughout the study period. The decomposition results were similar to those of the leading cluster, but the scale of the gains was much smaller, especially for cardiovascular mortality.

Table 6.6 Age- and cause-specific components of the difference in life expectancy at birth between the "Lagging" and "Leading" clusters over three periods, Moldova

Component	1991-1995	2002-2006	2012-2016
Cause-specific components of the difference in life expectancy at birth (years)			
Infectious diseases	-0.08	0.02	-0.11
Neoplasms	0.32	0.09	-0.31
Circulatory system diseases	-1.03	-1.13	-2.24
Respiratory system diseases	-0.83	-0.67	-0.43
Digestive system diseases	-1.31	-0.99	-1.31
External causes of death	-0.71	-0.72	-1.28
Other causes	-0.09	-0.29	-0.54
Age-specific components of the difference in life expectancy at birth (years)			
0-19	-0.60	-0.61	-0.62
20-39	-0.88	-0.48	-1.09
40-59	-1.53	-1.11	-2.40
60+	-0.73	-1.49	-2.10
The difference in life expectancy at birth (years)			
Total	-3.73	-3.69	-6.21

Note: see Table 1.
Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

The difference in life expectancy at birth between the leading and lagging clusters in the three periods was also decomposed by age and cause of death (Table 6.6). The life expectancy difference between the two extreme subgroups was 3.7 years in the first two periods, while in the third period, the gap widened to 6.2 years, an increase of 70%. Inequalities in life expectancy were mainly attributable to the differences in mortality among the middle-aged (40-59 years) and the elderly (60 years and over). These two age groups explained 60-70% of the life expectancy gap, depending on the period. The intergroup differentiation increased in the third period primarily due to the health deterioration in middle-aged and older adults. The effect of mortality differentials among children (0-19 years) and young adults (20-39 years) was negative but much less significant than in the other two age groups.

Diseases of the circulatory and digestive system diseases and external causes of death primarily explained the intergroup mortality differentiation over three periods. In the early 1990s,

the impact of respiratory disease mortality was also noticeable, especially among infants. The increase in the life expectancy gap between the worst-performing and the best-performing clusters in 2012-2016 was mainly attributed to increased mortality from circulatory system diseases. The contribution of cardiovascular mortality doubled between 2002-2006 (-1.1 years) and 2012-2016 (-2.2 years).

6.4.2. Changes in regional differences in cause-specific mortality after independence

This section focuses on the evolution of regional mortality patterns by cause of death over three periods (1991-1995, 2002-2006 and 2012-2016). Attention is given to four leading causes of death: circulatory system diseases, neoplasms, digestive system diseases and external causes. To track the evolution of mortality in the territorial profile, we used the fixed classification of statistical classes of standardised mortality rates over the three periods. The analysis is also based on figures in Annexe 15 showing the standardised mortality rates with 95% CIs across districts relative to the national level. A particular focus was on liver diseases, significantly impacting interregional mortality differentiation.

During the socio-economic crisis of the 1990s, standardised mortality rates for *circulatory system diseases* were more or less the same across districts, being close to the reference rate (Figure 6.35, Annexe 15). Only in the municipality of Chisinau and some districts were the upper confidence limits of the standardised indicators below the national baseline. In 2002-2006, cardiovascular mortality remained unchanged at the national level (about 600 deaths per 100000), but the regional pattern underwent marked changes. While the situation aggravated in the central region, especially in the districts around the capital, the standardised indicators decreased in most northern districts and Transnistria. The earlier improvement continued in the capital and some northern districts in the third period, especially in the municipality of Chisinau, where mortality from circulatory system diseases was the lowest (418.2 deaths per 100000). At the same time, in the central and southern districts, the elevated cardiovascular mortality also declined somewhat, approaching the 1991-1995 reference level. However, it is primarily in the districts of the red belt of high mortality referred to above that the progress has been the weakest (especially, Rezina, Dubasari, Soldanesti, Orhei and Calarasi). In these problematic districts, the risk of dying from cardiovascular diseases remains higher nowadays than the national 1991-1995 baseline. Overall, the reduction in cardiovascular mortality at the national level was only 17% (612.5 in 1991-1995 to 522.4 in 2012-2016). The upper limits of the standardised cardiovascular mortality rates were lower than the national level in 2012-2016 in the municipalities of Chisinau and Balti, a few northern districts (Bricieni, Drochia, Edinet, Ocnita and Riscani) and the central district of Anenii Noi (Annexe 15).

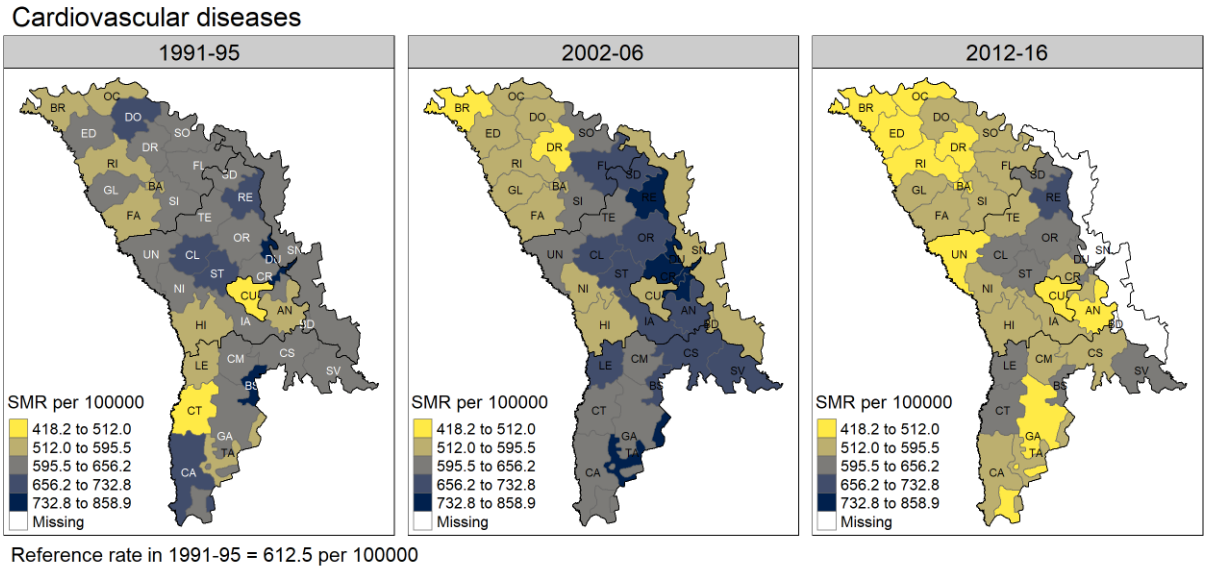


Fig. 6.35 Regional profile of indirectly standardised mortality rates from cardiovascular diseases over three periods, Moldova, both sexes

Notion: reference rate – the crude death rate from cardiovascular diseases in 1991-1995 in Moldova, both sexes
Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

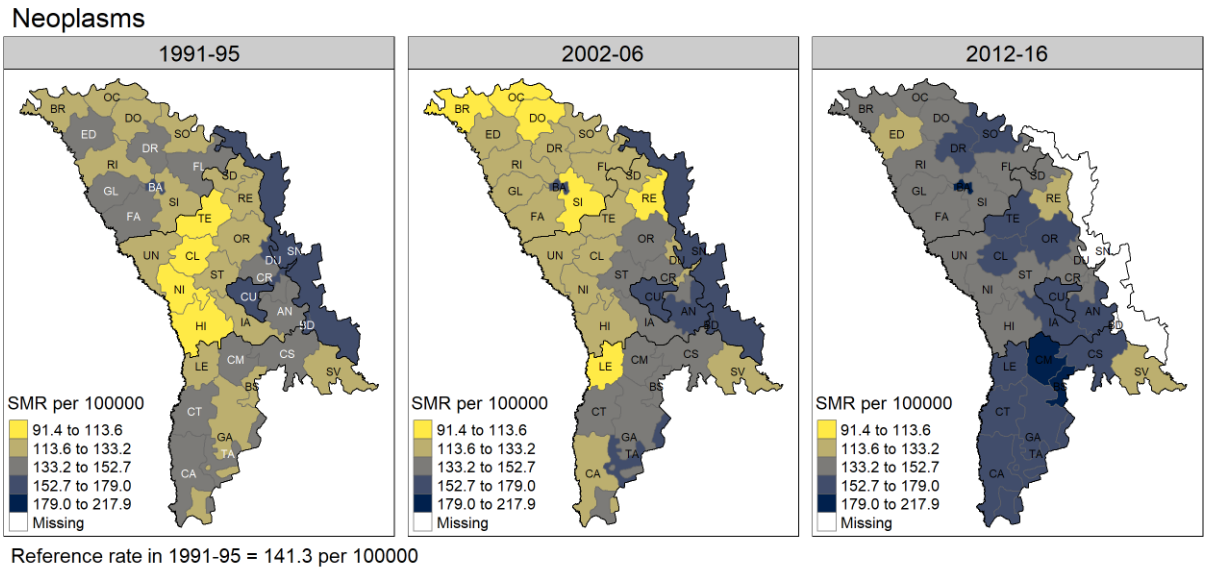


Fig. 6.36 Regional profile of indirectly standardised mortality rates from neoplasms over three periods, Moldova, both sexes

Notion: reference rate – the crude death rate from cardiovascular diseases in 1991-1995 in Moldova, both sexes
Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

The evolution of the regional mortality pattern for *neoplasms* differs from that observed for cardiovascular mortality (Figure 6.36, Annexe 15). In the early 1990s, the districts with the lowest life expectancy had the lowest cancer mortality. Conversely, the worst situation at that time was in the municipalities of Chisinau and Balti, where life expectancy at birth registered the highest values, the district of Duasari adjacent to the capital and Transnistria. In the early 2000s, the situation remained primarily unchanged at the national and district levels. In the third period,

the regional profile in cancer mortality underwent essential changes, characterized by growth across all districts, particularly in the south. The municipality of Balti was the most affected unit during all three periods, with an increase in standardised mortality indicator from 161.6 to 206.9 deaths per 100000 population.

The mortality gradient for *digestive system diseases* between the north, where the risk of dying was lower than the national reference, and the centre, where the situation was much more unfavourable, was detected for all three periods (Figure 6.37). In the southern districts adjacent to the centre (Cantemir, Leova, Cimislia, Causeni), standardised mortality indicators were similar to those found in the centre, especially during the second period. In the third period, the situation was statistically worse than the national 1991-1995 baseline in eight central districts, all falling into the red belt of high mortality.

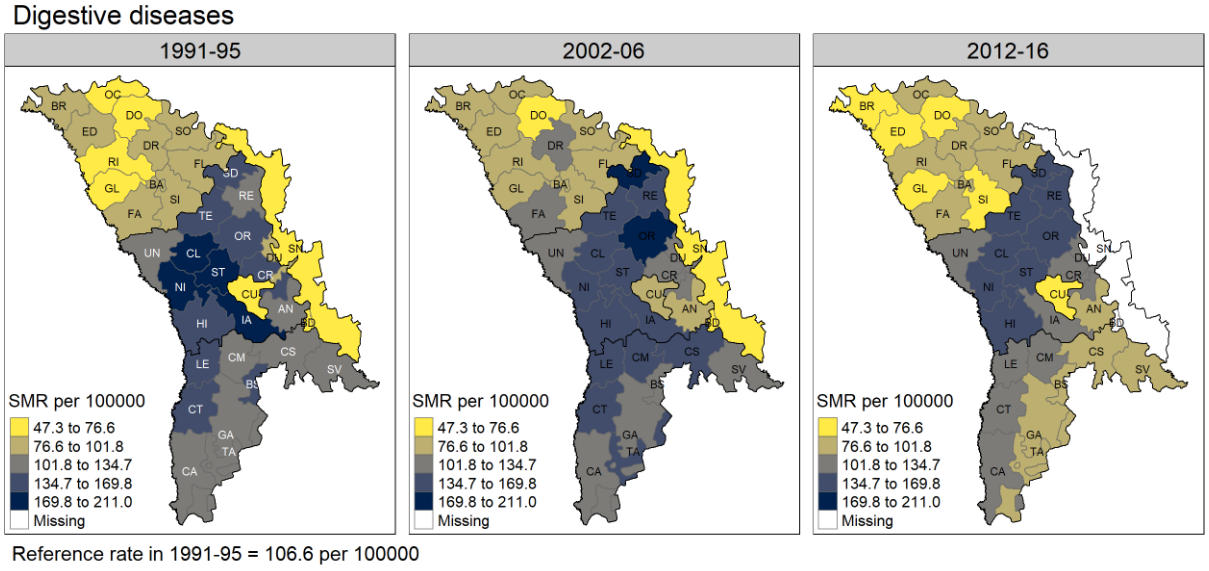


Fig. 6.37 Regional profile of indirectly standardised mortality rates from diseases of the digestive system over three periods, Moldova, both sexes

Notion: reference rate – the crude death rate from digestive diseases in 1991-1995 in Moldova, both sexes
Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

Given the confidence limits, mortality from digestive system diseases was higher in 2012-2016 than the national average in 1991-1995 in the following eight central districts: Orhei, Calarasi, Rezina, Soldanesti, Hincesti, Telenesti, Nisporeni and Straseni. In these districts, the lower limits of standardised mortality rates were still higher than the average level in 1991-1995 or 2002-2006. The upper confidence limits of standardised mortality rates were lower than the 2012-2016 national level only in the two municipalities and most northern districts (Annexe 15). As a result of the contrasting geographic patterns, the national level of mortality from digestive diseases has not changed significantly since independence (106.6 deaths in 1991-1995 vs 95.5 deaths per 100000 in 2012-2016).

Liver diseases represent more than 90% of deaths from digestive system diseases. Moran's index computed for this cause of death was positive and statistically significant throughout all three periods. Among women, the global index of autocorrelation was consistently stronger than among men (Table 6.7). The spatial autocorrelation results let us reject the null hypothesis on the random distribution of mortality from liver diseases across districts and accept the alternative one on the presence of clusters.

Table 6.7 Evolution of Moran's index for standardised mortality rates from liver disease by sex in Moldova after independence

Sex	1991-1995	2002-2006	2012-2016
Males	0.441 (p<0.001)	0.351 (p<0.05)	0.455 (p<0.001)
Females	0.534 (p<0.001)	0.485 (p<0.001)	0.578 (p<0.001)
Both sexes	0.51 (p<0.001)	0.478 (p<0.001)	0.576 (p<0.001)

Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

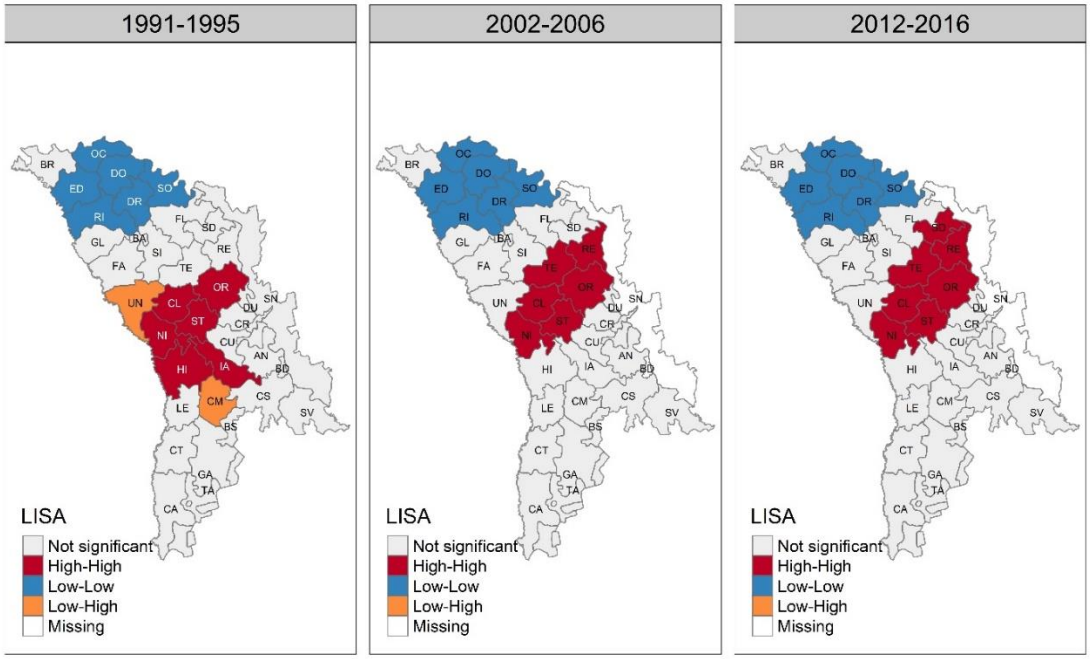


Fig. 6.38 LISA map for standardised mortality rates from liver diseases in Moldova over three periods, both sexes

Notion: reference rate – the crude death rate from digestive diseases in 1991-1995 in Moldova, both sexes
Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

Figure 6.38 shows the location of clusters on the LISA maps for standardised mortality rates from liver disease over three periods. The number of districts referring to the "low-low" cluster in the northern region and the "high-high" cluster in the central region was relatively stable, especially during the last two periods. Statistical outliers were found only for the first period ("low-high" cluster).

Nationally, the male-to-female mortality ratio for liver diseases increased from 1.1 in 1991-1995 to 1.4 in 2012-2016. Across districts, the ratio ranged from 0.7 in the Leova district in 1991-1995 to 2.4 in the Ocnita district in 2012-2016. Figure 6.39 illustrates the correlation between the

male-to-female ratio (SMR from liver diseases in males to SMR from liver diseases in females) and the standardised mortality rate in women. The districts were grouped into three groups ("high-high", "low-low", and "other") based on the LISA results for the three periods. The correlation was negative and statistically significant for all three groups, i.e., the higher the standardised mortality rate in females, the lower the ratio. However, in the districts from the "low-low" cluster, the ratio was always higher than one, i.e., mortality from liver diseases was higher in males than in females. Conversely, in the "high-high" cluster, the sex ratio was closer to one or lower.

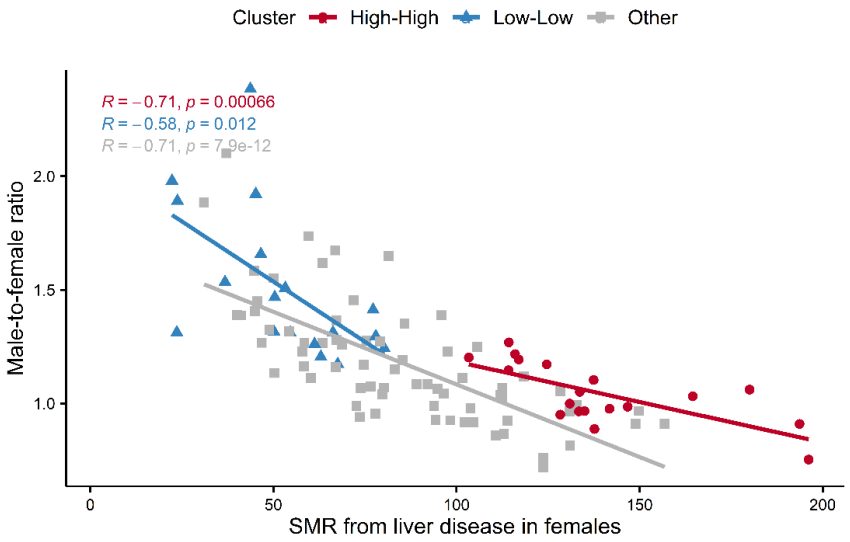


Fig. 6.39 Correlation between male-to-female mortality ratio and standardised mortality rate from liver diseases in females in Moldova by three spatial clusters

Source: author's calculations based on NBS and NAPH data.

External causes of death contributed to the regional differentiation of life expectancy, mainly among males. This type of mortality represented 7-13% of all-cause mortality, depending on the period and district. In 1991-1995, the districts around the municipality of Chisinau, most southern districts and Transnistria had standardised indicators for external causes close to the national level or higher. Transnistria and neighbouring districts (Dubasari, Anenii Noi, Soldanesti) were the most affected. The two municipalities and the northern districts were in a more favourable position. A decade later, the situation was not much different. The overall stagnation in mortality due to external causes was accompanied by the absence of significant regional changes, with the worst position held by the central districts, certain southern districts adjacent to the central region and Transnistria. In 2012-2016, the standardised indicators fell below the 1991-1995 reference rate in remote southern districts (Gagauzia, Cahul, Taraclia) and central districts, especially those adjacent to the capital (Anenii Noi, Ialoveni, Straseni). The most significant changes in mortality associated with external deaths occurred in the municipality of Chisinau, where the mortality rate has decreased by 70% (96.4 in 1991-1995 vs 56.2 in 2012-2016). This uneven progress in time

and space led to a modest decline in external mortality nationally after 30 years of independence, with a 30% decrease (114.9 in 1991-1995 vs 89.9 in 2012-2016).

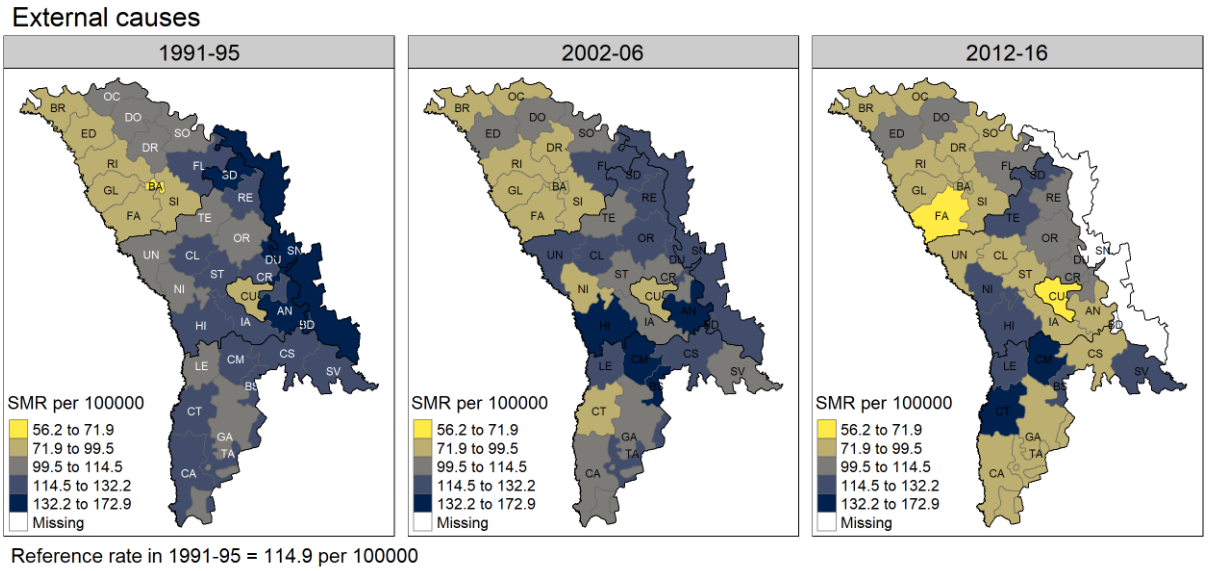


Fig. 6.40 Regional profile of standardised mortality rates from external causes of death in Moldova over three periods, both sexes

Notion: reference rate – the crude death rate from external causes in 1991-1995 in Moldova, both sexes
Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

6.5. Discussion for Chapter 6

The study presented in Chapter 6 was dedicated to regional mortality disparities and *aimed* to investigate the interregional variations in all-cause and cause-specific mortality at present and since independence. The study *hypothesised* that the high mortality level at the national level in Moldova coexists with high regional inequalities in all-cause and cause-specific mortality. First, the current geographical mortality profile was examined for the five-year period around the 2014 census (2012-2016). The interregional differentiation in life expectancy and cause-specific mortality was investigated for this period, followed by spatial data analysis. Finally, the changes in regional mortality inequalities for the period of independence were studied for three five-year periods: the socioeconomic crisis (1991-1995), stagnation (2002-2006) and improvements (2012-2016). The data analysis was carried out using demographic tools such as abridged life tables with 95% confidence intervals, mortality rates standardised by direct or indirect methods with 95% confidence intervals, the decomposition of the difference in life expectancy by age and cause, global and spatial autocorrelation techniques and descriptive and inferential statistics. Our results relied on the preliminary corrected population and vital statistics data described in Chapter 3.

The study's main *limitation* was the absence of reliable population counts for the period of independence. Producing intercensal population estimates in the regional profile is problematic and subject to a numerator-denominator bias due to the absence of reliable internal and external

migration flows. To overcome this issue, we preferred to rely on the corrected results of the 2014 population census. At the same time, to follow the changes in regional mortality disparities after independence, we selected three five-year periods; the last two were around population censuses conducted in 2004 and 2014. In the absence of annual population counts in the territorial profile, the focus on the period around the population census is often used [91].

Main findings and discussion

A) Regional disparities in the period around the 2014 census

The study results indicated the differences between the municipality of Chisinau and the northern districts, where high life expectancies were recorded, and the districts mainly located in the centre with low life expectancy values [208]. The districts where life expectancy recorded the lowest values in males and the lowest and low values in females were identified as *the red belt of high mortality*, stretching from the district of Soldanesti in the northeast to the district of Cantemir in the southwest [207]. The most affected area covered eleven districts, seven in the central (Soldanesti, Rezina, Telenesti, Orhei, Calarasi, Nisporeni and Hincesti) and four in the southern (Cantemir, Leova, Cimislia and Basarabeasca.) regions. The unfavourable situation in the red belt of high mortality contrasted sharply with the country's north, where the picture was radically different. This marked difference was referred to as *the north-centre mortality gradient*. The mortality gradient was particularly pronounced for life expectancy at ages 25 and 45 for both males and females. The interregional differentiation in life expectancy at age 65 was less marked in males but evident in females [209, 210].

Our findings showed that even for a country as small as Moldova, with a total population of under three million, the proximity of the capital does not improve the population's health but rather aggravates the situation [211]. Most lagging districts were second-order or even first-order neighbours relative to the capital, where the population health was the best in terms of mortality and life expectancy indicators. Women from the municipality of Chisinau lived on average four years longer than women from the districts of Ialoveni or Criuleni (first-order neighbours) and even more than six years longer than women from the districts of Orhei or Hincesti (second-order neighbours). The maximum discrepancy in life expectancy at birth was between the municipality of Chisinau and the Soldonesti district in males (7 years) and the Cimislia district in females (7.5 years). At the same time, the difference in female life expectancy between the capital and the northern districts of Briceni and Edinet was not statistically significant. The impact of capital on interregional mortality differentiation is not new, however. Similar studies for the FSU countries indicated the importance of the capital or big cities for regional variations in life expectancy [92, 94].

The decomposition of the difference in life expectancy at birth between each administrative unit and Moldova identified age groups and causes of death where mortality contributed most to interregional differentiation. Among women, regional variations in life expectancy were mainly attributable to mortality differences in older ages (65 years and over) and middle-aged groups (45-64 years). The exception was the Cimislia district, where the impact of mortality differences among young adult females was pretty marked. The regional profile of male life expectancy at birth was chiefly attributable to mortality differences among young (20-44 years) and middle-aged adults. At the level of leading causes of death, the geographical variation in total mortality was explained by disparities in mortality from circulatory and digestive system diseases in both sexes and external causes of death in males. The difference in life expectancy at birth between the districts falling in the red belt of high mortality and the municipality of Chisinau was broken down to examine the combined effect of mortality differences by age and cause. In both sexes, the lag in life expectancy was more than six years and was related to inequalities in cardiovascular mortality in older ages, digestive system diseases among the middle-aged and external causes of death among young adult males.

The north-central mortality gradient, detected for all-cause mortality, was most pronounced for digestive system diseases primarily represented by liver cirrhosis. Mortality from circulatory system diseases was also systematically higher in the centre, including districts directly adjacent to the capital and southern districts bordering the central region. A more detailed analysis pointed out that higher cardiovascular mortality was mainly associated with heart diseases in the centre, while in the south, with cerebrovascular disorders. Neoplasm mortality tended to be higher in the southern and the lower central regions, including the municipality of Chisinau and lower in the northern and upper central regions. Except for respiratory cancer, the same partition was depicted for cancer of different locations (digestive, breast, genitourinary and other locations). The municipality of Balti recorded the highest cancer mortality and was detected as a statistical outlier [207]. The lack of regional differences in smoking, a major risk factor for lung cancer, can explain the low geographical variation of respiratory cancer mortality. In contrast, regional differences in digestive neoplasms may be attributable to regional food preparation and eating habits disparities.

The absence of sex differentiation in standardised mortality from liver cirrhosis in the red belt of high mortality indicates that the risk factors, such as excessive alcohol consumption, affect men and women equally in this area. Our results concerning regional disparities in mortality from liver cirrhosis confirm our hypothesis at the national level that the dangerous wine-drinking culture had the same negative impact on men's and women's health [187]. We can further develop this

idea and postulate that hazardous patterns of wine consumption are more prevalent in the country's central districts than in the northern or southern districts.

Our findings for spatial autocorrelation were based on the first-order queen's contiguity matrix that gave a more significant global index than the four nearest neighbours matrix. The comparative analysis of different weight matrices for other countries pointed to similar conclusions [92]. The study results identified positive and statistically significant Moran's index for all-cause mortality in all ages, young and middle-aged and older adults. At the level of leading causes of death, the results were statistically significant for the digestive system and cardiovascular diseases for both sexes and external causes of death for males. The strongest global autocorrelation was detected for middle-aged females and digestive system diseases. Local spatial autocorrelation techniques detected "high-high" and "low-low" mortality clusters, i.e., districts with high/low mortality rates surrounded by districts with high/low mortality rates. The "hot" spots were detected in the centre for all causes of death combined, including digestive and circulatory system diseases. The corresponding "cold" spots were found in the north. The municipality of Chisinau was detected as a spatial outlier for all-cause mortality in a "low-high" quadrant, i.e., a location with low mortality surrounded by locations with high mortality [211].

The "high-high" mortality cluster with the highest Moran's index was detected for liver cirrhosis in the centre: Soldanesti, Rezina, Telenesti, Orhei, Calarasi, Straseni and Nisporeni. The "high-high" mortality cluster for cerebrovascular diseases was found in the south, whereas that for heart diseases was in the centre. Clustering of male mortality from external causes of death was primarily attributed to deaths from suicide, homicide and undetermined injuries. The districts with "high-high" mortality from this group of external causes of death were mainly localized on the border between the central and southern regions (Hincesti, Leova and Cimislia districts).

Studies on regional mortality disparities in the FSU countries demonstrated that the causes of death responsible for the temporal changes in life expectancy accounted for interregional differentiation. For Ukraine, the Baltic countries, Belarus or Russia, these causes were cardiovascular diseases and external causes of death [9, 37, 92, 96]. External causes of death, closely associated with harmful alcohol consumption, played a more crucial role in the interregional mortality inequalities than cardiovascular mortality. For Moldova, we confirmed this observation. Circulatory and digestive system diseases among males and females and external causes of death among males were the three leading causes that explained the long-term and short-term temporary fluctuations in life expectancy and interregional differentiation. Liver cirrhosis, closely related to a hazardous Mediterranean drinking culture, had the most substantial impact on regional disparities in the country [212].

B) Changes in regional mortality disparities after independence

The fourth section of Chapter 6 was dedicated to the evolution of regional disparities and causes of death in Moldova since independence. The selected three periods reflected the general trend in Moldovan life expectancy: the socio-economic crisis of the 1990s, the population's health stagnation in the millennium's first decade and the period of improvements. In the 1990s, the health indicators were much better in the north and the capital than in the south, centre and Transnistria. At the turn of the new millennium, Moldovan population health has not considerably changed at the national level compared to the early 1990s in terms of life expectancy at birth. In the regional profile, the national stagnation was accompanied by modest positive changes in the backward districts (centre and south). Like at the national level, we attribute this to a temporary post-crisis recovery rather than sustainable improvements [17]. The population in the most affected central districts, which experienced a profound health deterioration in the early 1990s, merely adapted to new social and economic conditions in the late 1990s and the early 2000s. The changes in life expectancy between the first and the second periods were not substantial in the municipality of Chisinau. In the country's north, the stagnation period was associated with moderate health improvements in the districts contrasted with a sharp deterioration in the municipality of Balti, particularly in males.

The growth of life expectancy observed after 2005 in women and 2010 in men at the national level was not uniform geographically. The recent improvements were primarily related to the mortality decline among men and women living in the capital and, to a lesser degree, among women in a few northern districts. The recent life expectancy progress in most northern districts after independence was moderate or absent. Life expectancy stagnated rather than improved in this traditional leading area, particularly for men. However, due to better initial positions, the population health situation in the north was still better than in the southern or central regions. On the other hand, the recent progress almost untouched the districts falling into the red belt of high mortality, where life expectancy at birth corresponded to the level observed in the 1990s.

Three population subgroups or clusters were determined based on the hierarchical analysis of age-specific life expectancies. Over the first two study periods, the best-off group included most northern districts and the capital, while the worst-off group covered mainly the central and a few southern districts. In the third period, the best-performing group was limited to the capital and two northern districts (Briceni and Edinet), where the lower limits of life expectancy at birth were higher than the national level. At the same time, the worst-performing group expanded into eleven districts, forming the red belt of high mortality. The third group covering other districts widened during the third period because most northern districts were included.

Throughout independence, the progress in the backward subgroup was primarily associated with reducing infant mortality from respiratory diseases and external mortality among young adults. However, this amelioration was partly offset by cancer mortality growth among middle-aged adults. Concurrently, in the most advanced population subgroup, the life expectancy growth resulted from the decline in cardiovascular mortality among older adults. In this subgroup, life expectancy growth over the independence period was also related to infant mortality decline from the residual group of causes of death, mainly represented by conditions originating in the perinatal period and external mortality among young and middle-aged adults. Cardiovascular mortality decline among the older population in the best-off population subgroup gives evidence of the beginning of the cardiovascular revolution in this geographical area. On the other hand, no similar changes occurred over the three decades in the laggard area, where high cardiovascular mortality among adults continues to remain the principal component of low life expectancy.

Changes in regional mortality from neoplasms did not significantly impact the interregional life expectancy differentiation throughout independence. Our findings pointed to the growing inequality for this type of mortality. Medical advances in cancer diagnosis and treatment accounted moderately for life expectancy growth in the best-performing group over the independence period. However, in two other clusters, particularly in the worst-performing group, adverse cancer mortality trends contributed negatively to total gains in life expectancy at birth.

6.6. Conclusions for Chapter 6

1. The mortality gradient between the northern districts and the municipality of Chisinau, where life expectancy is relatively high, and the central districts, where life expectancy is relatively low, was found. The lagging districts with life expectancy lower than the 1991-1995 national average fall into the red belt of high mortality. This most laggard geographical area stretches from the Soldanesti district in the northeast to the Cantemir district in the southwest. The north-centre gradient was observed for life expectancy at birth and ages 25, 45 and 65. The gradient was less marked among older males than females.
2. The impact of cardiovascular mortality on regional differences in life expectancy at birth was more significant in women than men, while the regional inequalities in male life expectancy were more sensitive to external causes of death. The negative impact of digestive system diseases was significant for both genders. Other causes of death, including neoplasms, had a much less effect on regional differentiation of life expectancy.
3. Regional disparities in life expectancy at birth were mainly attributable to mortality differences among young and middle-aged adult males and middle-aged and older adult females.

4. At the level of detailed causes of death, the mortality gradient between the advanced north and the backward centre was found for heart disease, while southern districts were more affected by cerebrovascular diseases. The north-centre gradient was most pronounced for liver cirrhosis, particularly in females. The districts along the border between the central and southern regions experienced the highest standardised mortality from suicide, homicide and undetermined injuries. The municipality of Balti was an outlier with the highest mortality rates for infectious diseases and malignant neoplasms of different sites.

5. Moran's index computed based on the first-order queen's contiguity matrix was positive and statistically significant for all causes of death combined, digestive system diseases, circulatory system diseases and external causes of death. The highest values among adults aged 45 to 64 and digestive system diseases were found.

6. The location of "high-high" and "low-low" mortality clusters was determined using the LISA maps. The north-centre gradient was found for all causes of death, digestive system diseases, circulatory system diseases, liver cirrhosis and heart diseases. In the south, the "high-high" mortality cluster was detected for cerebrovascular diseases and cancer of the digestive system. In the districts along the border between the central and southern regions, the "high-high" cluster was found for external causes, including deaths from suicides, homicides and undetermined injuries.

7. Two extreme population subgroups were detected based on the hierarchical analysis of age-specific life expectancies. The best-off group included the municipality of Chisinau and the districts of Briceni and Edinet. Most northern districts, including the municipality of Balti, have lost their leadership position regarding post-independence life expectancy. Eleven districts falling within the high mortality belt represented the worst-off group.

8. Differences in mortality from circulatory system diseases among the elderly, digestive system diseases among the middle-aged and external causes of death among young and middle-aged adults accounted for disparities in life expectancy at birth between the best-performing and the worst-performing subgroups. Infant mortality from respiratory diseases markedly impacted mortality differentiation in the 1990s.

9. The recent progress in life expectancy at the national level was accompanied by a widening gap between the two extreme population subgroups. The most advanced group benefited from effective control over mortality from cardiovascular diseases among older adults and external causes of death among young and middle-aged adults. In the laggard subgroup, the moderate progress in life expectancy due to reducing infant mortality was offset by rising mortality from external causes and neoplasms in the middle-aged.

FINAL CONCLUSIONS

According to the study's objectives, the following results were obtained:

1) At the national level, the intercensal population estimates according to the HMD methodology for 1959-2003 (in collaboration with D. Jdanov and P. Grigoriev) were supplemented with intercensal population estimates for 2004-2013 and official post-census population estimates for 2014-2020. The use of official "de jure" population estimates leads to a progressive underestimation of post-independence mortality rates, thereby distorting the overall trend. In 2019, the difference in life expectancy at birth computed based on the "de jure" and usual resident population reached 3.24 years for males and 2.58 years for females. Population estimates by place of residence, marital status and level of education were adjusted using census and HMD-like data.

To address data quality issues, infant and old-age mortality were adjusted at the national level, particularly due to severe problems observed in the 1960s and 1970s. The combined impact of corrections for infant and old-age mortality on life expectancy at birth amounted to 4.5 years for males and 5.6 years for females in 1960. However, after 1977, the effect of these corrections was less than 0.2 years.

The continuous series of deaths were reconstructed according to ICD-10 for the period 1965-2020 at the national level, covering 211 causes of death. A special distribution method was introduced for deaths coded as "Senility" within the categories of cardiovascular diseases in the 1990s, and this approach was replicated at both sub-national and district levels. The resulting database was then integrated into the international HCD database. The primary practical value of this study lies in providing researchers with reliable data on population and causes of mortality, essential for analysing the long-term trends in mortality in Moldova since 1965 (*objectives 1 and 2, sections 3.1 and 3.2, Implementation acts in Annexes 16, 17 and 18*).

2) Despite the large fluctuations in mortality induced by the 1985 anti-alcohol campaign and the socio-economic crisis of the 1990s, life expectancy at birth declined for males (-2.3 years) or stagnated for females (+1.9 years) from 1965 until 2005, followed by moderate improvements (+3.9 years for males; +4.1 years for females between 2005 and 2019). The decomposition of the difference in life expectancy at birth showed that the period of deterioration (1965-2005) was associated with a substantial increase in mortality among adults aged 15 years and over, especially in males (-5.3 years), partly offset by progress in infant mortality (+2.5 years). The improvement period (2005-2019) was mainly attributable to a decrease in mortality from cardiovascular diseases (+0.9 years for males and +2.0 years for females) and external causes of death for males (+1.1 years). Between 1965 and 2020, the standardised death rates among the middle-aged increased for

ischaemic heart diseases (2.4 times in males), suicide (2.0 times in males), homicide (2.6 times in males), undetermined injury (16 times in males), liver cirrhosis (4.4 times in males and females), malignant neoplasms of the lung (50% in males), breast (2.2 times in females) and intestine (3.4 times in males). At the same time, visible reductions were achieved in mortality from stomach cancer (2.7 times in males), uterus cancer (48%) and tuberculosis (4.9 times). In contrast to Ukraine or Romania, in Moldova, where a hazardous type of Mediterranean drinking culture is widespread, cirrhosis of the liver had a significant negative impact on life expectancy during the Soviet period, especially among middle-aged women. The COVID-19 pandemic reduced life expectancy at birth by about one year and impacted the cause-of-death mortality pattern in 2020. Based on standardised weekly death rates, four waves were detected with peak values in mid-December 2020, March 2021, October 2021 and February 2022.

The study's theoretical significance lies in the fact that, based on the reconstructed mortality series, we have examined long-term mortality trends through the prism of health transition theory. The high adult mortality from non-communicable diseases and "man-made" diseases, as defined by A. Omran (cardiovascular diseases, neoplasms, external causes of death), indicates that the second stage of the health transition in Moldova is still incomplete. The cardiovascular revolution has not yet occurred at the national level (*objective 3, sections 4.1, 4.2 and 4.3*).

3) Excess mortality in Moldova, compared to the European model, was concentrated between the ages of 40 and 70 in men and 50 and 80 in women. In 2019, 27% of deaths under the age of 70 in males and 13% in females were excessive compared to the model. Circulatory system diseases accounted for 45% of excess deaths in men and 55% in women under age 70. Digestive system diseases accounted for 17% of excess deaths in males and 26% in females. Excess mortality before age 70 from external causes of death was 17% among men. The influence of other causes, including neoplasms, was 10% or less. Between 2001 and 2019, excess mortality increased by 17% in males and declined by 28% in females. In males, the increase in excess mortality was primarily due to the cardiovascular component, fully offsetting the moderate progress in external causes of death (*objective 4, section 4.4*).

4) During the period of independence, the urban population, on average, lived 2.5 years longer than the rural population, except for the period 2003-2005 and the COVID-19 pandemic (2020), when the advantage of living in urban areas decreased. A positive rural-urban mortality gradient was found for all major causes of death except neoplasms. Inequalities regarding all-cause mortality were highest among young adults and decreased with age. Diseases of the circulatory and digestive systems in both men and women, external causes of death and respiratory system

diseases in men were the main factors contributing to the absolute differences in mortality between rural and urban areas.

Between 1991-1993 and 2017-2019, the rural-urban gradient in all-cause mortality decreased for women (RD was reduced by 24.7%, p-value<0.05), but it stagnated for men. For both sexes, a more rapid reduction in mortality from circulatory system diseases and a more rapid increase in mortality from neoplasms in rural areas compared to urban areas narrowed the gap between the two settings. Conversely, faster improvements in mortality from respiratory system diseases and external causes of death in urban males compared to rural males accentuated the rural-urban mortality differentials. During the 1990s, the socio-economic crisis had a more significant impact on the urban population, primarily leading to an increase in cardiovascular mortality (RD decreased by 66% in males and 41% in females between 1991-1993 and 2003-2005, p<0.05). Conversely, the rural population experienced a notable rise in mortality from respiratory system diseases during the same period (RR increased by 30% in males and 45% in females, p<0.05).

The recent improvement in life expectancy observed at the national level since 2005 was accompanied by growing health inequalities between rural and urban populations. The reduction in cardiovascular mortality and external causes of death between 2003-2005 and 2014-2016 was more significant in urban areas than in rural ones. While cancer mortality consistently remained higher in urban areas, both absolute and relative differences have been decreasing recently due to a faster deterioration in rural areas. However, the COVID-19 pandemic levelled absolute and relative differences in all-cause mortality between the two settings *(objective 5, section 5.1)*.

5) Marital status and level of education had significant effects on all-cause and cause-specific mortality for both men and women. The most disadvantaged groups were divorced men, never-married women and those with primary education or less. Conversely, marital status and higher education had a protective effect for both sexes. In 2013-2014, the difference in life expectancy at age 30 between divorced men or never-married women and their married counterparts was more than 12 years. On the other hand, the difference between those with a higher education and those with a primary or lower education was more than ten years for men and nine years for women. Mortality disparities by marital status and education were most pronounced among young adults and diminished with age.

The *absolute differences* in all-cause mortality by marital status were primarily attributable to a higher risk of dying from circulatory system diseases among non-married males (40-63%) and females (64-77%). The impact of external causes of death and respiratory system diseases was especially pronounced for never-married males. Excess mortality from neoplasms was more strongly associated with divorced status for both sexes (13% in males and 18% in females) than

with other non-married categories. The absolute differences in all-cause mortality by level of education were explained by higher mortality from circulatory system diseases for both sexes, external causes of death and respiratory system diseases for men and digestive system diseases for women. Neoplasm mortality was not differentiated statistically significantly by the level of education, except for lung cancer in males. The most striking *relative differences* in mortality were attributable to infectious diseases (RR exceeded 7.0 times in 2013-2014, $p<0.05$), respiratory system diseases and external causes of death in divorced males, never-married females and the population with primary or lower education.

In the period between the two censuses, the increase in life expectancy at 30 years, observed at the national level, was registered among married and widowed persons, as well as among men with higher education and the population with primary education or less. At the same time, the situation worsened significantly for divorced women (-2.36 years, $p<0.05$), while it remained virtually unchanged for the other marital and educational categories *(objective 6, sections 5.2 and 5.3)*.

6) The mortality gradient was evident between the northern districts and the municipality of Chisinau, where life expectancy was relatively high, and the central districts, where life expectancy was relatively low. The north-central mortality gradient was more pronounced in females than males and decreased with age. The following eleven backward districts, where life expectancy at birth in 2012-2016 was lower than the national average in 1991-1995, fall into the *red belt of high mortality*: Soldanesti, Rezina, Telenesti, Orhei, Calarasi, Nisporeni and Hincesti (central region) and Cantemir, Leova, Cimislia and Basarabeasca (southern region). Interregional differentiation of life expectancy at birth was mainly attributed to mortality differences among young and middle-aged adult males and middle-aged and older adult females. Diseases of the circulatory and digestive systems for both sexes and external causes of death for men contributed to the regional variation in life expectancy *(objective 7, sections 6.1 and 6.2)*.

7) The hierarchical analysis of life expectancies by age identified three geographical subgroups of the population. The two extreme subgroups each contained around 20% of the population. In 2012-2016, the best-off group was represented by the municipality of Chisinau and the two northern districts of Briceni and Edinet (e_0=72.5±0.3 years). The worst-off group included eleven districts falling into the red belt of high mortality (e_0=66.3±0.4 years). In 2012-2016, compared to 1991-1995, most of the northern districts and the municipality of Balti lost their leading position in terms of life expectancy and were classified as a residual subgroup of the population. The increase in life expectancy at the national level after 2005 was accompanied by an increase in interregional inequalities in mortality. The difference in life expectancy at birth

between the two extreme population subgroups increased from 3.69 years in 2002-2006 to 6.21 years in 2012-2016, mainly due to the cardiovascular mortality component (from 1.13 years vs 2.24 years).

Between 1991-1995 and 2012-2016, the growth of life expectancy at birth in the best-off group (change in e0=+3.58 years) was due to reductions in cardiovascular mortality among older adults and in external causes of death among young and middle-aged adults. In the worst-off group (change in e0=+1.13 years), the moderate decrease in infant mortality associated with respiratory diseases was offset by increased mortality from external causes and neoplasms in middle-aged people. There has been no progress in cardiovascular mortality in the laggard population subgroup *(objective 7, section 6.4).*

8) The global spatial autocorrelation index was positive and statistically significant for standardised mortality rates from all causes of death combined (Moran's I was 0.474 in males and 0.441 in females, $p<0.001$), from diseases of the digestive system and diseases of the circulatory system for both sexes and from external causes of death for men. The highest values were found for females aged 45-64 years (MI=0.537, $p<0.001$) and for diseases of the digestive system (MI=0.597 in women, $p<0.001$). In the central region, "high-high" mortality clusters were found for all causes of death, diseases of the digestive system, diseases of the circulatory system, cirrhosis of the liver and heart diseases. "Low-low" mortality clusters for the same causes of death were found in the northern region. In the south, a "high-high" mortality cluster was found for cerebrovascular disease and cancer of the digestive system. In the districts on the border between the central and southern regions (Hâncești, Leova, Cimislia), a "high-high" mortality cluster was found for external causes of death, including deaths from suicide, homicide and undetermined injuries. The municipality of Balti was found to be a spatial outlier for infectious diseases and cancers of various sites *(objective 8, section 6.3)*.

9) The *scientific problem addressed in the thesis* is the presentation of a new direction in the analysis of long-term trends and social and interregional differentiation of mortality by cause of death in the Republic of Moldova, taking into account the assessment of the quality of primary data. The time series of deaths, reconstructed according to ICD-10 for the period 1965-2020, meet the international requirements of comparability, completeness and regularity of data. Comparative analysis of the reconstructed series ensures data compatibility across countries over time.

RECOMMENDATIONS

The following recommendations to monitor/investigate mortality data and to reduce the social and regional disparities in mortality in Moldova were elaborated *(objective 9)*.

To the National Bureau of Statistics, NAPH, MH, interested scientific institutions:

1) The reconstructed mortality series in the HCD Database are recommended to monitor/analyse all-cause and cause-specific mortality in Moldova. The population counts provided in the database are recommended to be used to analyse demographic and social phenomena in the country since 1965 (based on the results presented in Chapter 3, implementing acts in annexes 16-18).

2) Reducing excess mortality up to the age of 70 in Moldova compared to European countries, and consequently reducing the gap in life expectancy at birth, can be achieved by reducing adult mortality from diseases of the circulatory system, cirrhosis of the liver (in both sexes), external causes of death (in men), and neoplasms (based on the results presented in subchapter 4.4).

To NAPH and MH

3) Disparities by place of residence can be narrowed by reducing mortality in rural areas from circulatory and digestive system diseases among men and women and external causes of death and respiratory system diseases among men (based on the results presented in subchapter 5.1).

4) Social disparities by marital status and by the level of education can be addressed by reducing mortality among social groups identified as most vulnerable: divorced men, never-married women and the adult population with primary education or less aged 30 and over. In these social groups, especially between 30 and 49 years of age, attention should be paid to preventive measures to combat risk factors for infectious diseases, respiratory diseases, liver cirrhosis and external causes of death (based on the results presented in subchapters 5.2 and 5.3).

5) Regional disparities in life expectancy at birth can be lessened by reducing adult mortality in the following districts identified as „the red belt of high mortality": Soldanesti, Rezina, Telenesti, Orhei, Calarasi, Nisporeni and Hincesti, Cantemir, Leova, Cimislia and Basarabeasca. In this group of districts, it is necessary to strengthen preventive measures targeting the main risk factors for cardiovascular disease and liver cirrhosis for both sexes and external causes of death for men. The municipality of Balti must be a priority administrative unit in the health programs aimed at reducing cancer mortality (based on the results presented in Chapter 6).

Suggestions for future research:

6) Long-term mortality series reconstructed according to ICD-10 can be used for the analysis of other aspects of mortality in the Republic of Moldova, such as avoidable mortality, analysis of mortality by demographic cohorts and demographic forecasting of life expectancy.

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Annexe 1. Life expectancy at birth before and after two infant mortality corrections and old-age mortality corrections and their effect in Moldova in 1959-2020 by sex (years)

Year	Crude	After the 1st IM correction	After the 2nd IM correction	After old-age mortality correction	Effect of the 1st IM correction	Effect of the 2nd IM correction	Effect of the old-age mortality correction	Total effect
				MALES				
1959	65.29	63.56	63.33	61.13	1.73	0.23	2.20	4.16
1960	67.29	65.78	65.57	62.82	1.51	0.21	2.75	4.47
1961	67.66	66.32	66.12	63.74	1.34	0.20	2.38	3.92
1962	66.37	65.03	64.84	63.73	1.34	0.19	1.11	2.64
1963	67.19	65.89	65.71	64.32	1.30	0.18	1.39	2.87
1964	67.88	66.55	66.35	64.54	1.33	0.20	1.81	3.34
1965	68.04	66.87	66.69	65.57	1.17	0.18	1.12	2.47
1966	67.76	66.74	66.56	65.62	1.02	0.18	0.94	2.14
1967	66.73	65.64	65.45	64.93	1.09	0.19	0.52	1.80
1968	66.45	65.32	65.14	64.89	1.13	0.18	0.25	1.56
1969	65.97	65.00	64.84		0.97	0.16		1.13
1970	66.32	65.46	65.28		0.86	0.18		1.04
1971	66.07	65.24	65.04		0.83	0.20		1.03
1972	66.25	65.40	65.18		0.85	0.22		1.07
1973	64.86		64.64			0.22		0.22
1974	64.17		63.94			0.23		0.23
1975	63.04		62.80			0.24		0.24
1976	63.77		63.49			0.28		0.28
1977	62.61		62.31			0.30		0.30
1978	62.86		62.60			0.26		0.26
1979	62.11		61.86			0.25		0.25
1980	62.87		62.57			0.30		0.30
1981	62.62		62.30			0.32		0.32
1982	62.92		62.64			0.28		0.28
1983	62.38		62.10			0.28		0.28
1984	62.18		61.86			0.32		0.32
1985	62.72		62.37			0.35		0.35
1986	64.92		64.57			0.35		0.35
1987	65.56		65.21			0.35		0.35
1988	65.32		64.99			0.33		0.33
1989	65.56		65.26			0.30		0.30
1990	65.08		64.80			0.28		0.28
1991	64.25		63.99			0.26		0.26
1992	64.03		63.73			0.30		0.30
1993	64.22		63.96			0.26		0.26
1994	62.44		62.12			0.32		0.32
1995	62.14		61.75			0.39		0.39
1996	63.11		62.83			0.28		0.28
1997	63.13		62.78			0.35		0.35
1998	64.00		63.67			0.33		0.33
1999	63.53		63.28			0.25		0.25
2000	63.68		63.37			0.31		0.31
2001	64.14		63.91			0.23		0.23
2002	63.92		63.68			0.24		0.24
2003	63.82		63.61			0.21		0.21
2004	63.88		63.69			0.19		0.19
2005	62.91		62.70			0.21		0.21
2006	63.41		63.21			0.20		0.20
2007	63.68		63.54			0.14		0.14
2008	63.94		63.89			0.05		0.05
2009	63.66		63.64			0.02		0.02
2010	62.96							
2011	64.85							
2012	64.97							
2013	65.86							
2014	65.21							
2015	65.11							
2016	65.57							
2017	66.65							
2018	66.24							
2019	66.60							
2020	65.85							

Source: author's calculations based on NBS and NAPH data [17].

Annexe 1 (continued)

Year	Crude	After the 1st IM correction	After the 2nd IM correction	After old-age mortality correction	Effect of the 1st IM correction	Effect of the 2nd IM correction	Effect of the old-age mortality correction	Total effect
FEMALES								
1959	69.62	67.72	67.55	64.39	1.90	0.17	3.16	5.23
1960	72.08	70.41	70.25	66.43	1.67	0.16	3.82	5.65
1961	72.00	70.50	70.36	67.31	1.50	0.14	3.05	4.69
1962	71.05	69.54	69.40	67.63	1.51	0.14	1.77	3.42
1963	71.98	70.59	70.44	68.25	1.39	0.15	2.19	3.73
1964	73.38	71.99	71.85	69.26	1.39	0.14	2.59	4.12
1965	73.05	71.77	71.63	69.91	1.28	0.14	1.72	3.14
1966	73.35	72.18	72.05	70.19	1.17	0.13	1.86	3.16
1967	72.56	71.39	71.25	69.90	1.17	0.14	1.35	2.66
1968	72.61	71.37	71.23	70.03	1.24	0.14	1.20	2.58
1969	71.96	70.89	70.75	70.43	1.07	0.14	0.32	1.53
1970	72.32	71.42	71.28	70.92	0.90	0.14	0.36	1.40
1971	72.22	71.39	71.24	71.02	0.83	0.15	0.22	1.20
1972	72.28	71.39	71.23	70.89	0.89	0.16	0.34	1.39
1973	71.04		70.88	70.60		0.16	0.28	0.44
1974	70.64		70.49	70.07		0.15	0.42	0.57
1975	69.52		69.32	69.08		0.20	0.24	0.44
1976	70.20		70.03	69.75		0.17	0.28	0.45
1977	69.53		69.34	69.21		0.19	0.13	0.32
1978	69.51		69.30			0.21		0.21
1979	68.54		68.35			0.19		0.19
1980	69.39		69.21			0.18		0.18
1981	69.59		69.38			0.21		0.21
1982	69.96		69.77			0.19		0.19
1983	69.20		69.00			0.20		0.20
1984	69.06		68.83			0.23		0.23
1985	69.30		69.05			0.25		0.25
1986	71.32		71.10			0.22		0.22
1987	71.49		71.23			0.26		0.26
1988	71.85		71.63			0.22		0.22
1989	72.35		72.12			0.23		0.23
1990	72.10		71.89			0.21		0.21
1991	71.13		70.89			0.24		0.24
1992	72.00		71.81			0.19		0.19
1993	71.25		71.03			0.22		0.22
1994	69.92		69.76			0.16		0.16
1995	69.87		69.72			0.15		0.15
1996	70.57		70.35			0.22		0.22
1997	70.57		70.42			0.15		0.15
1998	71.47		71.26			0.21		0.21
1999	71.22		70.99			0.23		0.23
2000	71.22		70.97			0.25		0.25
2001	71.69		71.45			0.24		0.24
2002	71.45		71.27			0.18		0.18
2003	71.21		71.05			0.16		0.16
2004	71.92		71.76			0.16		0.16
2005	71.07		70.92			0.15		0.15
2006	71.59		71.43			0.16		0.16
2007	71.67		71.47			0.20		0.20
2008	72.16		72.07			0.09		0.09
2009	72.34		72.32			0.02		0.02
2010	72.11							
2011	73.61							
2012	73.38							
2013	73.89							
2014	73.59							
2015	73.61							
2016	74.08							
2017	74.85							
2018	74.93							
2019	74.99							
2020	73.86							

Source: author's calculations based on NBS and NAPH data [17].

Annexe 2. Extract of the correspondence table between the 1965 Classification and 1970 Classification

A) Extract of the correspondence table 1 (from 1965 Classification to 1970 Classification)

	1965 Soviet Classification		***1970 Soviet Classification***
Item	Title	Item	Title
……..			
53	Malignant neoplasm of the intestine (excluding rectum)	49	Malignant neoplasm of intestine excluding rectum
54	Malignant neoplasm of rectum	50	Malignant neoplasm of rectum and rectosigmoid junction
……..			
124	Bronchitis and lung emphysema	108	Chronic bronchitis, lung emphysema
125	Other and unspecified forms of bronchitis	108	“
……..			
130	Chronic abscess lung diseases, pneumosclerosis and lung emphysema	108 113	“ Chronic form of pneumonia and bronchiectasis
……..			
137	Intestinal obstructions and hernia	120 121	Hernia of the abdominal cavity Intestinal obstruction without mention of hernia
……..			
167	Arthritis and spondylitis	147	Other diseases of the musculoskeletal system and connective tissue
168	Muscular and unspecified rheumatism	147	“

B) Extract of the correspondence table 2 (from 1970 Classification to 1965 Classification)

	1970 Soviet Classification		***1965 Soviet Classification***
Item	Title	Item	Title
……..			
49	Malignant neoplasm of intestine excluding rectum	53	Malignant neoplasm of intestine (excluding rectum)
50	Malignant neoplasm of rectum and rectosigmoid junction	54	Malignant neoplasm of rectum
……..			
108	Chronic bronchitis, lung emphysema	124 125 130	Bronchitis and lung emphysema Other and unspecified forms of bronchitis Chronic abscess lung diseases, pneumosclerosis and lung emphysema
……..			
113	Chronic forms of pneumonia and bronchiectasis	130	Chronic abscess lung diseases, pneumosclerosis and lung emphysema
……..			
120	Inguinal hernia and other types of hernia of the abdominal cavity with obstruction	137	Intestinal obstructions and hernia
121	Intestinal obstruction without mention of hernia	137	“
……..			
147	Other diseases of the musculoskeletal system and connective tissue	167 168 170 171	Arthritis and spondylitis Muscular and unspecified rheumatism Ankylosis and deformities of the spine Other diseases of the musculoskeletal system

Source: author's elaboration [17].

Annexe 3. Algorithm of calculation of distribution coefficients for deaths codified as *Senility* among circulatory system diseases

Deaths codified under ICD-10 item R54 were attributed to *Senility* and were distributed among circulatory system diseases. Distribution coefficients were computed for three groups of circulatory system diseases: heart diseases (group 1), cerebrovascular diseases (group 2) and a residual group (group 3). Calculations were produced by sex for ages 80 years and over.

1. Correction coefficient *K* was computed as a ratio of total deaths in 1991 to total deaths in 1989:

$$K = \frac{D_{tot}^{1991}}{D_{tot}^{1989}} \qquad (1)$$

D_{tot}^{1991}: total deaths in 1991

D_{tot}^{1989}: total deaths in 1989

2. Estimated deaths in 1991 for group 2 $D'^{1991}_{gr.2}$ were computed according to equation (2). Estimated deaths in 1991 for group 3 were calculated similarly.

$$D'^{1991}_{gr.2} = D_{gr.2}^{1989} \times K \qquad (2)$$

$D_{gr.2}^{1989}$: observed deaths from cerebrovascular diseases at age 80 years and over in 1989

K: correction coefficient

3. Calculation of the distribution coefficient for group 2. The difference between the estimated and observed deaths in 1991 for group 2 was "missing deaths". The ratio of "missing deaths" for group 2 in 1991 to senility deaths in 1991 was the distribution coefficient for group 2. Distribution coefficients for group 3 were calculated similarly.

$$M_{gr.2} = \frac{D'^{1991}_{gr.2} - D_{gr.2}^{1991}}{D_s^{1991}} = \frac{\Delta D_{gr.2}^{1991}}{D_s^{1991}} \qquad (3)$$

$D'^{1991}_{gr.2}$: estimated deaths in 1991 for group 2

$D_{gr.2}^{1991}$: registered deaths in 1991 for group 2

D_s^{1991} : deaths from senility in 1991

4. Calculation of the distribution coefficient for group 1.

$$M_{gr.1} = 1 - M_{gr.2} - M_{gr.3} \qquad (4)$$

$M_{gr.2}$: distribution coefficient for group 2

$M_{gr.3}$: distribution coefficient for group 3

Senility deaths were redistributed according to coefficients $M_{gr.1}$, $M_{gr.2}$ and $M_{gr.3}$ among the specific cardiovascular diseases in ages 80 years and over in 1989-2020. In ages 60-79, senility deaths were proportionally redistributed among the specific items of circulatory system diseases. The distribution of senility deaths was produced after the reconstruction process and old age mortality corrections.

Source: Penina O., Meslé F., Vallin J. [17].

Annexe 4. Standardised death rates by sex, age and cause of death in 1965 and 2020 (per 100000)

A4.1. Infant mortality rate by main causes of death and selected ICD-10 items in Moldova in 1965 and 2020, both sexes (per 100000)

Group	ICD - 10	IMR per 100000	
		1965	2020
Infectious diseases	**A00-B99, U071**	**1251.29**	**29.39**
Acute infectious intestinal diseases	A00-A09	1125.04	0.00
Septicaemia	A40, A41	23.63	26.14
Other infectious diseases	A15-A39, A42-B99, U071	102.62	3.25
Respiratory system diseases	**J00-J98**	**2217.36**	**88.20**
Acute respiratory diseases	J00-J06, J20-J22	232.07	0.00
Influenza	J10, J11	94.78	0.00
Pneumonia	J12-J18	1868.84	88.20
Other respiratory diseases	J30-J98	21.68	0.00
Neoplasms	**C00-D48**	**8.21**	**6.51**
Circulatory system diseases	**G45, I00-I99**	**71.04**	**0.00**
Digestive system diseases	**K00-K92**	**44.68**	**22.81**
External causes of death	**V01-Y89**	**136.67**	**39.13**
Accidental inhalation	W78-W84	68.78	19.55
Homicide, deaths from injury undetermined, whether accidentally or purposely inflicted	X85-Y36	0.84	6.53
Other external deaths	V01-V99, W00-W77, W85-W99, X00-X84, Y40-Y89	67.05	13.04
Other diseases	**D50-G44, G47-H95, L00-Q99**	**1552.13**	**695.84**
Diseases of the nervous system	G00-G44, G47-G98, H00-H95	137.84	9.79
Congenital anomalies, *including*:	Q00-Q99	433.82	297.15
Congenital anomalies of the heart	Q20-Q24	167.22	101.27
Other congenital anomalies	Q00-Q18, Q25-Q99	266.60	195.88
Conditions originating in the perinatal period, *incl.*:	P00-P96	855.30	372.52
Obstetric trauma	P10-P15	270.53	3.25
Congenital pneumonia	P23, P24	228.58	45.69
Other respiratory diseases of the newborn	P20-P22, P25-P28	185.63	91.46
Other perinatal conditions	P00-P08, P29-P96	170.56	232.12
Other diseases	D50-E90, F01-F99, L00-N99, R95	125.17	16.38
All causes of deaths	**A00-Y89, U071**	**5281.39**	**881.87**

Source: author's calculations based on NBS and NAPH data [17].

Annexe 4 (continued)

A4.2. Standardised death rates at ages 1-14 by selected ICD-10 items in 1965 and 2020 in Moldova, both sexes (per 100000)

Group	ICD - 10	SMR per 100000	
		1965	2020
Infectious diseases	**A00-B99, U071**	**16.21**	**1.26**
Neoplasms	**C00-D48**	**7.35**	**2.14**
Leukaemia and lymphomas	C81-C96	3.41	1.06
Other neoplasms	C00-C80, C97, D00-D48	3.94	1.08
Circulatory system diseases	**G45, I00-I99**	**4.46**	**1.74**
Respiratory system diseases	**J00-J98**	**28.22**	**3.70**
Acute respiratory diseases	J00-J06, J20-J22	0.46	0.00
Influenza	J10, J11	1.95	0.22
Pneumonia	J12-J18	21.94	3.48
Other respiratory system diseases	J30-J98	3.87	0.00
Digestive system diseases	**K00-K92**	**2.58**	**0.41**
External causes of death	**V01-Y89**	**42.20**	**8.91**
Transport accidents	V01-V99	8.63	2.38
Falls and drowning	W00-W19, W65-W74	10.52	2.63
Accidental poisoning	X40-X49	5.05	1.28
Accidents caused by fire, electric current or firearm	W32-W34, W85-W87, X00-X09	10.71	0.40
Suicide, homicide, deaths from injury undetermined whether accidentally or purposely inflicted	X60-Y36	1.39	0.95
Other external deaths	W20-W31, W35-W64, W75-W84, W88-W99, X10-X39, X50-X59, Y40-Y89	5.91	1.27
Other diseases	**D50-G44, G47-H95, L00-Q99**	**14.23**	**6.95**
Endocrine diseases, diseases of the blood	D50-D89, E00-E90	1.52	0.84
Nervous system diseases	G00-G44, G47-G98, H00-H95	3.70	2.74
Congenital anomalies	Q00-Q99	4.28	2.66
Other diseases	F01-F99, L00-N99, O00-O99	4.72	0.71
All causes of death	**A00-Y89, U071**	**115.26**	**25.11**

Source: author's calculations based on NBS and NAPH data [17].

Annexe 4 (continued)

A4.3. Standardised death rates at ages 15-39 by selected ICD-10 items in 1965 and 2020 in Moldova, by sex (per 100000)

Group	ICD - 10	SMR per 100000			
		1965		2020	
		Males	Females	Males	Females
Infectious diseases	**A00-B99, U071**	**30.04**	**18.14**	**16.98**	**11.29**
Tuberculosis	A15-A19, B90	24.79	13.62	3.98	1.63
AIDS	B20-B24	0.00	0.00	6.57	4.72
Other infectious diseases	A00-A09, A20-B19, B25-B89, B91-B99, U071	5.25	4.53	6.43	4.95
Neoplasms	**C00-D48**	**18.10**	**20.57**	**14.75**	**17.99**
Circulatory system diseases	**G45, I00-I99**	**28.04**	**21.63**	**41.45**	**12.23**
Respiratory system diseases	**J00-J98**	**6.79**	**3.39**	**13.32**	**6.27**
Digestive system diseases	**K00-K92**	**12.10**	**4.97**	**29.23**	**13.41**
External causes of death	**V01-Y89**	**108.40**	**27.17**	**88.82**	**17.79**
Transport accidents	V01-V99	38.64	4.90	23.28	4.89
Falls and drowning	W00-W19, W65-W74	18.10	3.66	9.04	1.65
Accidental poisoning	X40-X49	9.09	2.26	6.46	0.70
Accidents caused by fire, electric current or firearm	W32-W34, W85-W87, X00-X09	8.49	3.23	3.29	0.22
Suicide	X60-X84	14.16	7.35	29.24	6.71
Homicide	X85-Y09, Y35, Y36	5.23	2.52	6.73	1.72
Deaths from injury undetermined, whether accidentally or purposely inflicted	Y10-Y34	0.70	0.27	3.44	0.96
Other accidents	W20-W31, W35-W64, W75-W84, W88-W99, X10-X39, X50-X59, Y40-Y89	13.98	2.99	7.34	0.95
Other diseases	**D50-G44, G47-H95, L00-Q99**	**17.26**	**18.93**	**11.43**	**8.56**
Endocrine and blood diseases	D50-D89, E00-E90	2.20	1.71	1.77	0.88
Mental disorders and nervous system diseases	F01-F99, G00-G44, G47-G98, H00-H95	7.78	3.15	6.60	4.14
Genitourinary system diseases	N00-N99	5.47	2.61	1.21	0.74
Other diseases, *incl.:*	L00-M99, O00-O99, Q00-Q99	1.80	1.15	1.85	1.64
Complications of pregnancy, childbirth and puerperium	O00-O99	-	10.30	-	1.17
All causes of death	**A00-Y89**	**220.73**	**114.80**	**215.97**	**87.55**

Source: author's calculations based on NBS and NAPH data [17].

Annexe 4 (continued)

A4.4. Standardised death rates at ages 40-64 by selected ICD-10 items in 1965 and 2020 in Moldova, by sex (per 100000)

Group	ICD - 10	SMR per 100000			
		1965		2020	
		Males	Females	Males	Females
Infectious diseases	**A00-B99, U071**	**100.11**	**23.81**	**152.25**	**102.41**
Tuberculosis	A15-A19, B90	77.69	12.65	16.09	2.13
AIDS	B20-B24	-	-	8.99	4.67
Other infectious and parasitic diseases	A00-A09, A20-B19, B25-B89, B91-B99	22.43	11.17	2.29	1.93
COVID-19	U071	-	-	124.88	93.69
Neoplasms	**C00-D48**	**234.37**	**189.47**	**368.43**	**201.92**
Cancer of the lip, oral cavity and pharynx	C00-C14	6.01	1.47	47.09	3.31
Cancer of oesophagus	C15	6.35	2.70	9.71	0.56
Cancer of stomach	C16	64.11	27.98	24.21	10.32
Cancer of intestine, rectum and anus	C17-C21	12.35	12.07	40.81	22.55
Cancer of liver	C22	10.77	9.03	35.56	10.88
Cancer of other organs of the digestive system	C23-C26	12.81	10.73	23.35	10.89
Cancer of the respiratory system	C30-C39	71.14	12.36	109.13	12.09
Cancer of breast	C50	0.29	20.02	0.49	43.61
Cancer of uterus	C53-C55	-	46.04	-	30.72
Cancer of prostate	C61	3.33	0.00	10.73	0.00
Cancer of other genital organs	C51, C52, C56-C60, C62, C63	0.91	17.53	1.44	13.74
Cancer of the urinary tract	C64-C68	7.31	3.37	15.12	5.86
Leukaemia and lymphomas	C81-C96	14.46	7.69	13.84	11.81
Cancer of bone, cartilage and skin	C40-C44, C49	7.21	3.85	8.66	4.82
Other malignant neoplasms	C45-C48, C69-C80, C97	11.36	9.36	26.56	19.32
Other neoplasms	D00-D48	5.97	5.25	1.74	1.46
Circulatory system diseases	**G45, I00-I99**	**336.92**	**256.55**	**628.62**	**217.91**
Heart diseases, *incl.*:	I00-I51	210.66	167.06	482.09	153.05
Rheumatic diseases	I00-I09	32.06	40.51	3.25	2.23
Hypertension	I10-I15	18.58	12.54	31.30	15.93
Ischaemic heart diseases *incl.*:	I20-I25	157.74	110.59	384.96	117.91
Myocardial infarction	I21-I23	41.27	10.07	135.67	32.83
Atherosclerotic cardiosclerosis	I25.0, I25.1	72.38	62.63	15.08	6.70
Other ischaemic heart diseases	I20, I24, I25.2-.9	44.08	37.89	234.22	78.38
Other heart diseases	I26-I28, I30-I38, I40-I51	2.29	3.42	62.59	16.97
Cerebrovascular diseases	G45, I60-I67, I69	123.22	87.25	137.11	61.61
Other circulatory system diseases	I70-I99	3.04	2.24	9.42	3.26
Respiratory system diseases	**J00-J98**	**112.75**	**40.33**	**111.49**	**30.02**
Influenza	J10, J11	0.39	1.03	0.51	0.39
Pneumonia	J12-J18	24.35	10.14	83.99	25.25
Chronic obstructive pulmonary disease	J40-J47	66.26	23.20	21.01	2.91

Group	ICD - 10	SMR per 100000			
		1965		2020	
		Males	Females	Males	Females
Pulmonary empyema and lung abscess	J85, J86	6.35	1.00	2.47	0.44
Other respiratory system diseases	J00-J06, J20-J39, J60-J84, J90-J98	15.40	4.95	3.50	1.03
Digestive system diseases	**K00-K92**	**86.07**	**45.23**	**247.32**	**137.47**
Gastric and duodenal ulcer	K25-K28	17.14	4.47	17.97	1.81
Diseases of intestine	K29, K35-K63	11.45	5.99	10.05	3.95
Liver cirrhosis	K70, K74	44.93	27.80	199.84	123.13
Other diseases of the liver and biliary tract	K71-K73, K75, K76-K83	4.78	4.88	3.71	3.86
Diseases of pancreas	K85, K86	6.72	1.74	14.33	3.73
Other digestive system diseases	K00-K22, K30, K31, K65, K66, K90-K92	1.06	0.35	1.42	0.99
External causes of death	**V01-Y89**	**126.75**	**47.78**	**203.42**	**32.49**
Transport accidents	V01-V99	33.16	8.36	22.66	4.19
Falls and drowning	W00-W19, W65-W74	21.06	5.64	18.72	2.95
Accidental poisoning	X40-X49	13.46	6.46	18.17	3.00
Accidents caused by fire, electric current or firearm	W32-W34, W85-W87, X00-X09	8.85	6.13	6.75	1.50
Suicide	X60-X84	24.69	9.35	50.33	6.48
Homicide	X85-Y09, Y35, Y36	6.46	3.79	17.13	3.19
Deaths from injury undetermined, whether accidentally or purposely inflicted	Y10-Y34	0.94	0.30	15.74	2.99
Other accidents	W20-W31, W35-W64, W75-W84, W88-W99, X10-X39, X50-X59, Y40-Y89	18.14	7.75	53.92	8.18
Other diseases	**D50-G44, G47-H95, L00-Q99**	**47.66**	**32.88**	**77.93**	**36.45**
Endocrine and blood diseases	D50-D89, E00-E90	6.47	9.32	15.59	13.43
Nervous system and mental diseases, *incl.*:	F01-F99, G00-G44, G47-G98, H00-H95	24.89	13.68	47.06	10.60
Mental and behavioural disorders due to the alcohol use	F10	11.30	5.08	20.34	2.01
Epilepsy	G40, G41	5.23	1.15	5.07	1.14
Other nervous system and mental diseases	F01-F09, F11-F99, G00-G44, G47-G98, H00-H95	8.36	7.46	21.65	7.44
Genitourinary system diseases	N00-N99	12.67	5.93	11.41	10.06
Other diseases	L00-M99, Q00-Q99	3.62	3.95	3.88	2.36
All causes of death	**A00-Y89**	**1044.64**	**636.05**	**1789.45**	**758.67**

Source: author's calculations based on NBS and NAPH data [17].

Annexe 4 (continued)

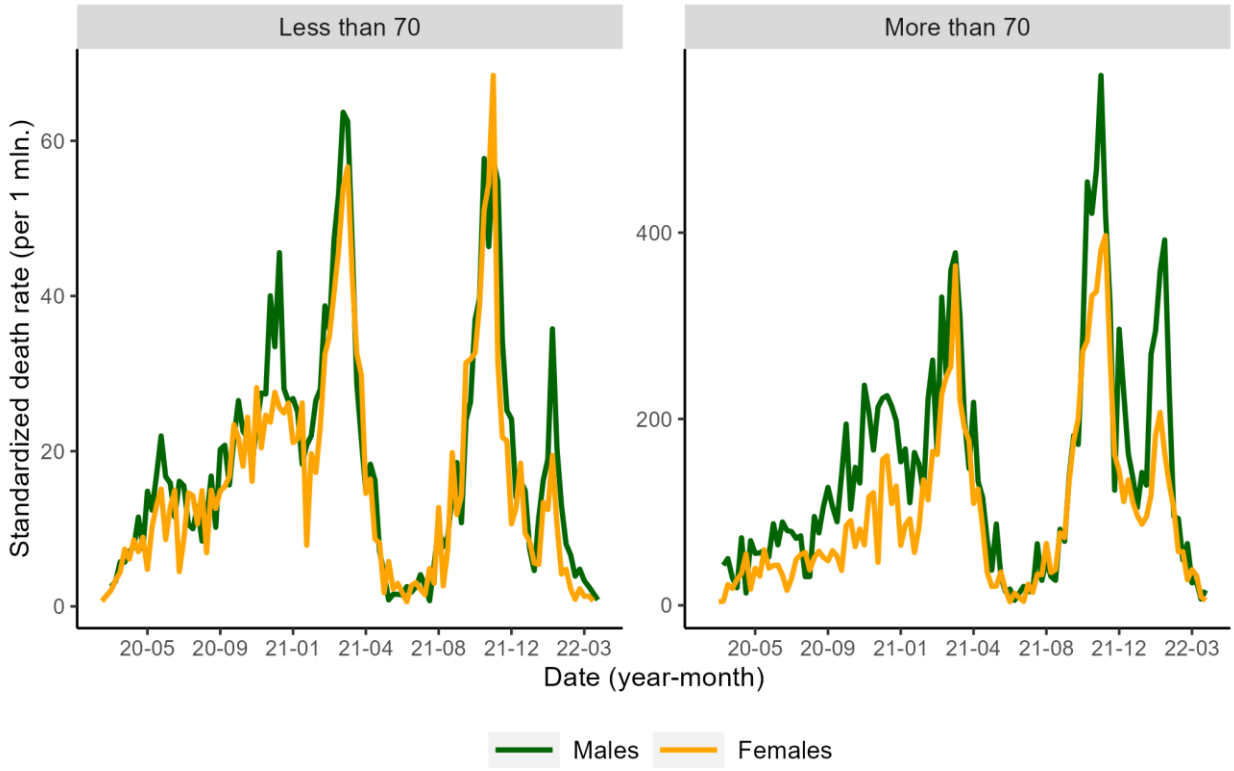
A4.5. Standardised death rates at ages 65 years and over by selected ICD-10 items in 1965 and 2020 in Moldova, by sex (per 100000)

Group	ICD -10	SMR per 100000			
		1965	2020	1965	2020
		Males	Females	Males	Females
Infectious diseases	**A00-B99, U071**	**103.77**	**44.98**	**725.58**	**373.85**
Tuberculosis	A15-A19, B90	78.95	22.11	8.28	1.58
Other infectious and parasitic diseases	A00-A09, A20-B89, B91-B99	24.83	22.87	10.45	5.58
COVID-19	U071	-	-	706.85	366.69
Neoplasms	**C00-D48**	**811.24**	**427.96**	**1261.71**	**642.45**
Cancer of stomach	C16	210.02	102.76	88.46	34.19
Cancer of intestine, rectum and anus	C17-C21	51.52	34.52	226.01	126.29
Cancer of other organs of the digestive system	C00-C15, C22-C26	174.34	111.81	227.05	99.82
Cancer of respiratory organs	C30-C39	136.62	24.36	260.40	54.60
Cancer of breast	C50	1.65	29.76	4.15	113.66
Cancer of uterus	C53-C55	-	42.38	-	57.83
Cancer of prostatis	C61	68.13	-	179.15	-
Cancer of other genital organs	C51, C52, C56-C60, C62, C63	0.00	17.92	2.52	32.03
Cancer of the urinary tract	C64-C68	58.71	13.91	103.72	29.40
Leukaemia and lymphomas	C81-C96	31.39	14.73	56.82	31.60
Other neoplasms	C40-C49, C69-C80, C97, D00-D48	78.87	35.81	113.44	63.04
Circulatory system diseases	**G45, I00-I99**	**6981.43**	**6726.73**	**7943.89**	**6305.28**
Rheumatic diseases	I00-I09	196.98	139.29	3.20	6.41
Hypertension	I10-I15	529.18	509.61	1007.25	836.58
Myocardial infarction	I21-I23	138.72	92.52	426.67	183.61
Atherosclerotic cardiosclerosis	I25.0, I25.1	2072.16	2035.74	715.63	621.53
Other ischaemic heart diseases	I20, I24, I25.2-.9	1189.37	1161.07	4057.79	3281.06
Other heart diseases	I26-I28, I30-I38, I40-I51	24.64	19.25	100.54	58.99
Cerebrovascular diseases	G45, I60-I67, I69	2742.29	2692.91	1582.04	1281.57
Other circulatory system diseases	I70-I99	88.09	76.34	50.77	35.54
Respiratory system diseases	**J00-J98**	**956.09**	**608.47**	**442.01**	**201.42**
Influenza	J10, J11	3.37	3.77	1.08	0.55
Pneumonia	J12-J18	84.39	88.88	182.55	91.47
Chronic obstructive pulmonary disease	J40-J44, J47	695.78	410.00	238.69	101.55
Asthma	J45, J46	21.88	16.24	3.71	3.43
Pulmonary empyema and lung abscess	J85, J86	9.16	2.62	1.87	1.58
Other respiratory system diseases	J00-J06, J20-J39, J60-J84, J90-J98	141.52	86.97	14.13	2.84
Digestive system diseases	**K00-K92**	**267.21**	**169.76**	**402.62**	**274.23**
Gastric and duodenal ulcer	K25-K28	23.30	9.22	40.01	18.85
Liver cirrhosis and other diseases of the liver and biliary tract	K70-K83	182.91	135.83	257.90	185.07
Diseases of pancreas	K85, K86	3.28	6.42	15.27	12.81
Other digestive system diseases	K00-K22, K29-K66, K90-K92	57.72	18.30	89.43	57.50
External causes of death	**V01-Y89**	**180.77**	**95.22**	**208.70**	**65.76**

Group	ICD -10	SMR per 100000			
		1965	2020	1965	2020
		Males	Females	Males	Females
Transport accidents	V01-V99	34.82	17.10	18.17	8.13
Falls and drowning	W00-W19, W65-W74	26.81	19.91	24.24	6.09
Accidental poisoning	X40-X49	20.99	16.60	24.13	15.84
Accidents caused by fire, electric current or firearm	W32-W34, W85-W87, X00-X09	35.33	12.71	7.77	7.80
Suicide	X60-X84	25.40	11.93	44.56	7.06
Homicide	X85-Y09, Y35, Y36	4.72	0.80	3.24	4.10
Deaths from injury undetermined, whether accidentally or purposely inflicted	Y10-Y34	3.70	0.72	19.99	2.27
Other accidents	W20-W31, W35-W64, W75-W84, W88-W99, X10-X39, X50-X59, Y40-Y89	28.99	15.45	66.61	14.48
Other diseases	**D50-G44, G47-H95, L00-Q99**	**174.64**	**109.48**	**208.31**	**156.82**
Endocrine and blood diseases	D50-D89, E00-E90	31.61	35.46	94.25	90.39
Nervous system and mental diseases	F01-F99, G00-G44, G47-G98, H00-H95	45.69	36.06	37.25	11.57
Genitourinary system diseases, *incl.:*	N00-N99	82.60	20.75	69.68	47.99
Renal tubulointerstitial diseases	N00-N15	31.32	16.66	49.83	34.05
Hyperplasia of prostate	N40	46.24	0.00	5.08	0.00
Other diseases of the genitourinary system	N17-N39, N41-N99	5.03	4.09	14.76	13.94
Other diseases	L00-M99, Q00-Q99	14.74	17.21	7.14	6.88
All causes of death	**A00-Y89, U071**	**9475.15**	**8182.61**	**11192.83**	**8019.82**

Source: author's calculations based on NBS and NAPH data [17].

Annexe 5. Weekly standardised death rates by sex and age from COVID-19 based on hospital death records in Moldova between 18/03/2020 and 19/04/2022 (per 1 mln.)



Note: see Figure 4.18.
Source: author's calculations based on MH and NBS data.

Annexe 6. Standardised death rates by place of residence over four periods and change in mortality differences between rural and urban areas. Moldova, by main cause of death and sex

A6.1. Standardised death rates by place of residence in 1991-1993 and 2003-2005 and change in mortality differences between rural and urban areas. Moldova, by cause and sex

	1991-1993		2003-2005		Change (per 100000) [1]
	SDR, rural (95% CI)	SDR, urban (95% CI)	SDR, rural (95% CI)	SDR, urban (95% CI)	
Males					
Infectious diseases	18.87 (17.16; 20.69)	18.28 (15.89; 20.84)	**39** (36.54; 41.58)*	**48.47** (44.7; 52.45)	-10.06
Neoplasms	260.3 (252.75; 268)*	375.47 (361.64; 389.62)	274.24 (266.21; 282.44)*	404.33 (386.95; 422.15)	-14.92
Circulatory system diseases	1930.74 (1900.27; 1961.52)*	1518.88 (1481.99; 1556.3)	1908.92 (1878.66; 1939.47)*	**1770.43** (1722.7; 1818.88)	-273.37
Respiratory system diseases	163.4 (156.64; 170.34)*	137.41 (127.71; 147.5)	**268.78** (258.4; 279.41)*	**170.65** (158.13; 183.69)	72.14
Digestive system diseases	188.02 (181.78; 194.4)*	148.33 (140.18; 156.76)	**229.3** (221.84; 236.92)*	**198.34** (187.16; 209.89)	-8.73
External causes	225.51 (219.18; 231.96)*	203.46 (195.03; 212.08)	226.25 (219.63; 232.99)	218.62 (208.51; 229.01)	-14.42
Other diseases	72.42 (68.64; 76.32)*	98.51 (91.57; 105.7)	**84.06** (79.47; 88.82)	88.91 (81.89; 96.25)	21.25
All causes	2859.25 (2825.62; 2893.13)*	2500.34 (2457.35; 2543.73)	**3030.55** (2995.64; 3065.71)*	**2899.75** (2844.56; 2955.5)	-228.11
Females					
Infectious diseases	5.39 (4.67; 6.19)*	4.89 (4; 5.9)	**8.92** (7.82; 10.13)	**10.44** (8.82; 12.25)	-2.03
Neoplasms	137.16 (132.82; 141.61)*	212.83 (205.44; 220.4)	145.41 (140.67; 150.26)*	228.58 (219.65; 237.76)	-7.50
Circulatory system diseases	1536.62 (1517.79; 1555.62)*	1211.53 (1189.64; 1233.69)	1554.65 (1534.83; 1574.64)*	**1362.96** (1334.58; 1391.73)	-133.40
Respiratory system diseases	66.64 (63.37; 70.01)*	51.29 (47.39; 55.39)	**113.47** (108.28; 118.83)*	58.64 (53.38; 64.23)	39.48
Digestive system diseases	155.56 (150.95; 160.27)*	102.15 (97.06; 107.42)	**189.73** (184.17; 195.42)*	**121.31** (114.94; 127.91)	15.02
External causes	70.33 (67.2; 73.56)*	62.31 (58.51; 66.25)	65.18 (61.97; 68.51)	62.7 (58.2; 67.42)	-5.55
Other diseases	47.7 (45.33; 50.16)*	63.59 (59.95; 67.37)	**53.97** (51.01; 57.04)	57.23 (53.21; 61.46)	12.63
All causes	2019.41 (1998.85; 2040.12)*	1708.58 (1683.96; 1733.44)	**2131.33** (2109.07; 2153.74)*	**1901.86** (1870.28; 1933.78)	-81.36

SDR-standardised death rate per 100000 population. CI-confidence interval. * p-value < 0.05 compared to urban areas. Statistically significant differences compared to 1991-1993 are marked in bold (p<0.05).

[1]Change in mortality difference between rural and urban areas was calculated:
$(SDR_{2003\text{-}2005,\ rural} - SDR_{1991\text{-}1993,\ rural}) - (SDR_{2003\text{-}2005,\ urban} - SDR_{1991\text{-}1993,\ urban})$, per 100000 population. If mortality decreases between the two periods (green cells), a negative value means a decline is greater in rural than urban areas. If mortality increases (red cells), a positive value means an increase is higher in rural than urban areas. Values near zero indicate similar changes in rural and urban areas.

Source: author's calculations based on NBS and NAPH data.

Annexe 6 (continued)

A6.2. Standardised death rates by place of residence in 2003-2005 and 2014-2016 and change in mortality differences between rural and urban areas. Moldova, by cause and sex

	2003-2005		**2014-2016**		Change (per 100000)[1]
	SDR, rural (95% CI)	SDR, urban (95% CI)	SDR, rural (95% CI)	SDR, urban (95% CI)	
Males					
Infectious diseases	39 (36.54; 41.58)*	48.47 (44.7; 52.45)	**25.56** (23.49; 27.76)	**25.59** (22.77; 28.64)	9.44
Neoplasms	274.24 (266.21; 282.44)*	404.33 (386.95; 422.15)	**361.92** (352.14; 371.87)*	**449.09** (433.49; 465.04)	42.92
Circulatory system diseases	1908.92 (1878.66; 1939.47)*	1770.43 (1722.7; 1818.88)	**1792.85** (1765.33; 1820.65)*	**1496.43** (1461.01; 1532.38)	157.93
Respiratory system diseases	268.78 (258.4; 279.41)*	170.65 (158.13; 183.69)	**168.24** (160.81; 175.89)*	**110.55** (102.2; 119.3)	-40.44
Digestive system diseases	229.3 (221.84; 236.92)*	198.34 (187.16; 209.89)	**205.17** (198.24; 212.26)*	**168.49** (159.79; 177.5)	5.72
External causes	226.25 (219.63; 232.99)	218.62 (208.51; 229.01)	**205.98** (199.59; 212.51)*	**151.22** (143.84; 158.85)	47.13
Other diseases	84.06 (79.47; 88.82)	88.91 (81.89; 96.25)	88.96 (84.29; 93.79)*	77.43 (71.33; 83.83)	16.38
All causes	3030.55 (2995.64; 3065.71)*	2899.75 (2844.56; 2955.5)	**2848.68** (2816.63; 2880.97)*	**2478.8** (2436.92; 2521.11)	239.07
Females					
Infectious diseases	8.92 (7.82; 10.13)	10.44 (8.82; 12.25)	7.19 (6.18; 8.33)*	9.88 (8.38; 11.56)	-1.17
Neoplasms	145.41 (140.67; 150.26)*	228.58 (219.65; 237.76)	**183.96** (178.32; 189.74)*	**248.16** (239.48; 257.05)	18.98
Circulatory system diseases	1554.65 (1534.83; 1574.64)*	1362.96 (1334.58; 1391.73)	**1414.73** (1396.77; 1432.86)*	**1111.61** (1090.04; 1133.48)	111.44
Respiratory system diseases	113.47 (108.28; 118.83)*	58.64 (53.38; 64.23)	**57.79** (54.29; 61.43)*	**34.37** (31.01; 37.98)	-31.41
Digestive system diseases	189.73 (184.17; 195.42)*	121.31 (114.94; 127.91)	**156.77** (151.65; 162.02)*	**103.93** (98.44; 109.63)	-15.58
External causes	65.18 (61.97; 68.51)	62.7 (58.2; 67.42)	**50.6** (47.73; 53.59)*	**39.07** (35.81; 42.53)	9.04
Other diseases	53.97 (51.01; 57.04)	57.23 (53.21; 61.46)	53.88 (50.88; 57.01)	52.68 (48.82; 56.74)	4.47
All causes	2131.33 (2109.07; 2153.74)*	1901.86 (1870.28; 1933.78)	**1924.93** (1904.6; 1945.4)*	**1599.69** (1574.93; 1624.73)	95.76

SDR-standardised death rate per 100000 population. CI-confidence interval. * p-value < 0.05 compared to urban areas. Statistically significant differences compared to 2003-2005 are marked in bold (p<0.05).

[1]Change in mortality difference between rural and urban areas was calculated:
$(SDR_{2014\text{-}2016,\ rural} - SDR_{2003\text{-}2005,\ rural}) - (SDR_{2014\text{-}2016,\ urban} - SDR_{2003\text{-}2005,\ urban})$. If mortality decreases between the two periods (green cells), a negative value means a decline is greater in rural than urban areas. If mortality increases (red cells), a positive value means an increase is higher in rural than urban areas. Values near zero indicate similar changes in rural and urban areas.

Source: author's calculations based on NBS and NAPH data

Annexe 6 (continued)

A6.3. Standardised death rates by place of residence in 2014-2016 and 2017-2019 and change in mortality differences between rural and urban areas. Moldova, by cause and sex

	2014-2016		**2017-2019**		Change (per 100000)[1]
	SDR, rural (95% CI)	SDR, urban (95% CI)	SDR, rural (95% CI)	SDR, urban (95% CI)	
Males					
Infectious diseases	25.56 (23.49; 27.76)	25.59 (22.77; 28.64)	21.62 (19.64; 23.73)	23.53 (20.48; 26.86)	-1.89
Neoplasms	361.92 (352.14; 371.87)*	449.09 (433.49; 465.04)	370.8 (360.79; 380.99)*	448.32 (433.03; 463.95)	9.64
Circulatory system diseases	1792.85 (1765.33; 1820.65)*	1496.43 (1461.01; 1532.38)	**1719.45** (1692.14; 1747.05)*	1428.49 (1394.39; 1463.11)	-5.47
Respiratory system diseases	168.24 (160.81; 175.89)*	110.55 (102.2; 119.3)	154.43 (147.2; 161.87)*	101.23 (93.51; 109.32)	-4.49
Digestive system diseases	205.17 (198.24; 212.26)*	168.49 (159.79; 177.5)	191.9 (185.13; 198.83)*	**147.45** (139; 156.22)	7.77
External causes	205.98 (199.59; 212.51)*	151.22 (143.84; 158.85)	**175.47** (169.47; 181.62)*	**128.45** (121.17; 136.01)	-7.74
Other diseases	88.96 (84.29; 93.79)*	77.43 (71.33; 83.83)	**78.86** (74.33; 83.56)	75.26 (69.29; 81.54)	-7.93
All causes	2848.68 (2816.63; 2880.97)*	2478.8 (2436.92; 2521.11)	**2712.52** (2680.75; 2744.52)*	**2352.74** (2312.3; 2393.62)	-10.11
Females					
Infectious diseases	7.19 (6.18; 8.33)*	9.88 (8.38; 11.56)	7.28 (6.21; 8.48)*	11.44 (9.69; 13.38)	-1.46
Neoplasms	183.96 (178.32; 189.74)*	248.16 (239.48; 257.05)	179.68 (174.08; 185.4)*	237.78 (229.35; 246.42)	6.09
Circulatory system diseases	1414.73 (1396.77; 1432.86)*	1111.61 (1090.04; 1133.48)	**1334.26** (1316.59; 1352.09)*	1112.67 (1090.63; 1135.03)	-81.55
Respiratory system diseases	57.79 (54.29; 61.43)*	34.37 (31.01; 37.98)	52.65 (49.29; 56.17)*	34.2 (30.72; 37.93)	-4.97
Digestive system diseases	156.77 (151.65; 162.02)*	103.93 (98.44; 109.63)	**134.24** (129.46; 139.15)*	**86.87** (81.78; 92.17)	-5.47
External causes	50.6 (47.73; 53.59)*	39.07 (35.81; 42.53)	**38.57** (36; 41.27)*	**28.34** (25.52; 31.36)	-1.30
Other diseases	53.88 (50.88; 57.01)	52.68 (48.82; 56.74)	51.21 (48.24; 54.31)	52.4 (48.57; 56.43)	-2.39
All causes	1924.93 (1904.6; 1945.4)*	1599.69 (1574.93; 1624.73)	**1797.88** (1777.99; 1817.93)*	1563.69 (1538.71; 1588.96)	-91.04

SDR-standardised death rate per 100000 population. CI-confidence interval. * p-value < 0.05 compared to urban areas. Statistically significant differences compared to 2003-2005 are marked in bold (p<0.05).

[1]Change in mortality difference between rural and urban areas was calculated:
($SDR_{2017\text{-}2019,\ rural}$-$SDR_{2014\text{-}2016,\ rural}$)-($SDR_{2017\text{-}2019,\ urban}$-$SDR_{2014\text{-}2016,\ urban}$). If mortality decreases between the two periods (green cells), a negative value means a decline is greater in rural than urban areas. If mortality increases (red cells), a positive value means an increase is higher in rural than urban areas. Values near zero indicate similar changes in rural and urban areas.

Source: author's calculations based on NBS and NAPH data

Annexe 6 (continued)

A6.4. Standardised death rates by place of residence in 2017-2019 and 2020 and change in mortality differences between rural and urban areas. Moldova, by cause and sex

	2017-2019		**2020**		
	SDR, rural (95% CI)	SDR, urban (95% CI)	SDR, rural (95% CI)	SDR, urban (95% CI)	Change (per 100000 population)[1]
Males					
Infectious diseases	21.62 (19.64; 23.73)	23.53 (20.48; 26.86)	**135.17** (124.2; 146.75)*	**303.34** (281.4; 326.35)	-166.26
Neoplasms	370.8 (360.79; 380.99)*	448.32 (433.03; 463.95)	354.07 (337.28; 371.4)*	407.34 (382.47; 433.23)	24.25
Circulatory system diseases	1719.45 (1692.14; 1747.05)*	1428.49 (1394.39; 1463.11)	**1827.58** (1778.33; 1877.71)*	**1648.62** (1585.41; 1713.35)	-111.99
Respiratory system diseases	154.43 (147.2; 161.87)*	101.23 (93.51; 109.32)	139.78 (128.05; 152.16)*	109.44 (95.83; 124.17)	-22.86
Digestive system diseases	191.9 (185.13; 198.83)*	147.45 (139; 156.22)	183.58 (172.23; 195.42)*	149.76 (136.15; 164.23)	-10.63
External causes	175.47 (169.47; 181.62)*	128.45 (121.17; 136.01)	**153.53** (143.75; 163.77)*	115.57 (104.29; 127.6)	-9.05
Other diseases	78.86 (74.33; 83.56)	75.26 (69.29; 81.54)	78.98 (71.27; 87.22)	77.09 (66.82; 88.31)	-1.70
All causes	2712.52 (2680.75; 2744.52)*	2352.74 (2312.3; 2393.62)	**2872.7** (2815.47; 2930.66)	**2811.16** (2735.26; 2888.32)	-298.23
Females					
Infectious diseases	7.28 (6.21; 8.48)*	11.44 (9.69; 13.38)	**82.4** (75.94; 89.24)*	**155.83** (144.53; 167.72)	-69.27
Neoplasms	179.68 (174.08; 185.4)*	237.78 (229.35; 246.42)	176.2 (166.62; 186.18)*	235.38 (221.1; 250.28)	-1.07
Circulatory system diseases	1334.26 (1316.59; 1352.09)*	1112.67 (1090.63; 1135.03)	1378.73 (1347.4; 1410.59)*	**1195.69** (1155.56; 1236.76)	-38.54
Respiratory system diseases	52.65 (49.29; 56.17)*	34.2 (30.72; 37.93)	52.74 (47.01; 58.95)	**52.36** (44.97; 60.51)	-18.06
Digestive system diseases	134.24 (129.46; 139.15)*	86.87 (81.78; 92.17)	**120.8** (112.99; 128.99)*	80.64 (72.37; 89.54)	-7.21
External causes	38.57 (36; 41.27)*	28.34 (25.52; 31.36)	34.87 (30.75; 39.38)*	24.22 (19.84; 29.22)	0.42
Other diseases	51.21 (48.24; 54.31)	52.4 (48.57; 56.43)	52.19 (47.1; 57.68)	56.56 (49.51; 64.27)	-3.18
All causes	1797.88 (1777.99; 1817.93)*	1563.69 (1538.71; 1588.96)	**1897.94** (1862.42; 1933.95)*	**1800.67** (1754.24; 1847.92)	-136.92

SDR-standardised death rate per 100000 population. CI-confidence interval. * p-value < 0.05 compared to urban areas. Statistically significant differences compared to 2003-2005 are marked in bold (p<0.05).

[1]Change in mortality difference between rural and urban areas was calculated:

$(SDR_{2020, rural} - SDR_{2017-2019, rural}) - (SDR_{2020, urban} - SDR_{2017-2019, urban})$. If mortality decreases between the two periods (green cells), a negative value means a decline is greater in rural than urban areas. If mortality increases (red cells), a positive value means an increase is higher in rural than urban areas. Values near zero indicate similar changes in rural and urban areas.

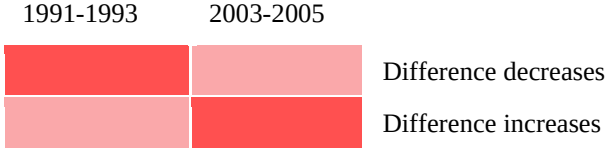
Source: author's calculations based on NBS and NAPH data

Annexe 7. Mortality rate ratio and rate difference between rural and urban areas over four periods and their changes in Moldova by main cause of death and sex

A7.1. Absolute and relative differences in mortality by main cause of death between rural and urban populations in 1991-1993 and 2003-2005 and their changes between 1991-1993 and 2003-2005. Moldova, by sex

	1991-1993		2003-2005		Change (%)	
	RD (95% CI)	RR (95% CI)	RD (95% CI)	RR (95% CI)	RD[1]	RR[2]
Males						
Infectious diseases	0.59 (-2.41;3.6)	1.03 (0.87;1.2)	-9.47 (-14.05;-4.89)	0.8 (0.7;0.91)	-1699.4**	-22.1
Neoplasms	-115.17 (-131.04;-99.3)*	0.69 (0.65;0.74)*	-130.09 (-149.39;-110.79)*	0.68 (0.63;0.73)*	13	-2.2
Circulatory system diseases	411.86 (363.82;459.9)*	1.27 (1.24;1.3)*	138.49 (81.73;195.26)*	1.08 (1.05;1.11)*	-66.4**	-15.2**
Respiratory system diseases	25.99 (14.02;37.95)*	1.19 (1.11;1.27)*	98.13 (81.68;114.58)*	1.57 (1.49;1.66)*	277.6**	32.5**
Digestive system diseases	39.69 (29.32;50.05)*	1.27 (1.2;1.33)*	30.96 (17.39;44.53)*	1.16 (1.09;1.22)*	-22	-8.8
External causes	22.05 (11.44;32.67)	1.11 (1.06;1.16)	7.63 (-4.56;19.81)	1.03 (0.98;1.09)	-65.4	-6.6
Other diseases	-26.09 (-34.08;-18.1)*	0.74 (0.65;0.82)*	-4.84 (-13.35;3.66)	0.95 (0.85;1.04)	-81.4**	28.6**
All causes	358.92 (304.18;413.65)*	1.14 (1.12;1.16)*	130.8 (65.3;196.31)	1.05 (1.02;1.07)	-63.6**	-8.6**
Females						
Infectious diseases	0.5 (-0.69;1.69)	1.1 (0.87;1.34)	-1.52 (-3.55;0.5)	0.85 (0.65;1.06)	-403.5	-22.5
Neoplasms	-75.67 (-84.31;-67.03)*	0.64 (0.6;0.69)*	-83.17 (-93.37;-72.97)*	0.64 (0.58;0.69)*	9.9	-1.3
Circulatory system diseases	325.1 (296.12;354.08)*	1.27 (1.25;1.29)*	191.69 (156.94;226.44)*	1.14 (1.12;1.17)*	-41**	-10.1**
Respiratory system diseases	15.35 (10.19;20.51)*	1.3 (1.21;1.39)*	54.83 (47.32;62.33)*	1.93 (1.83;2.04)*	257.2**	48.9**
Digestive system diseases	53.41 (46.48;60.34)*	1.52 (1.46;1.58)*	68.43 (59.89;76.97)*	1.56 (1.5;1.62)*	28.1	2.7
External causes	8.03 (3.05;13.01)	1.13 (1.05;1.21)	2.48 (-3.13;8.09)	1.04 (0.95;1.13)	-69.1	-7.9
Other diseases	-15.89 (-20.29;-11.49)*	0.75 (0.67;0.83)*	-3.26 (-8.33;1.8)	0.94 (0.85;1.03)	-79.5**	25.7**
All causes	310.83 (278.67;343)*	1.18 (1.16;1.2)*	229.47 (190.71;268.22)*	1.12 (1.1;1.14)*	-26.2**	-5.2**

RD-rate difference (rural-urban) per 100000 population. RR-rate ratio (rural/urban), times. CI-confidence interval.
* The difference is statistically significant compared to the urban population (p<0.05).
** The difference is statistically significant compared to the previous period (p<0.05).
[1]Change in RD was calculated: (RD 2003-2005-RD 1991-1993)/RD 1991-1993 x100
[2]Change in RR was calculated: (RR 2003-2005-RR 1991-1993)/RR 1991-1993 x100
Source: author's calculations based on NBS and NAPH data

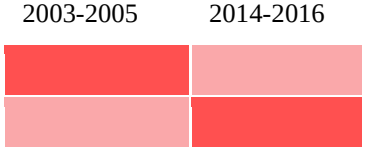


Annexe 7 (continued)

A7.2. Absolute and relative differences in mortality by main cause of death between rural and urban populations in 2003-2005 and 2014-2016 and their changes between 2003-2005 and 2014-2016. Moldova, by sex

	2003-2005		**2014-2016**		**Change (%)**	
	RD (95% CI)	RR (95% CI)	RD (95% CI)	RR (95% CI)	RD[1]	RR[2]
Males						
Infectious diseases	-9.47 (-14.05;-4.89)	0.8 (0.7;0.91)	-0.03 (-3.61;3.56)	1 (0.86;1.14)	-99.7**	24.1
Neoplasms	-130.09 (-149.39;-110.79)*	0.68 (0.63;0.73)*	-87.17 (-105.71;-68.63)*	0.81 (0.76;0.85)*	-33**	18.8**
Circulatory system diseases	138.49 (81.73;195.26)*	1.08 (1.05;1.11)*	296.42 (251.37;341.47)*	1.2 (1.17;1.23)*	114**	11.1**
Respiratory system diseases	98.13 (81.68;114.58)*	1.57 (1.49;1.66)*	57.69 (46.37;69.01)*	1.52 (1.43;1.61)*	-41.2**	-3.4
Digestive system diseases	30.96 (17.39;44.53)*	1.16 (1.09;1.22)*	36.68 (25.44;47.91)*	1.22 (1.16;1.28)*	18.5	5.3
External causes	7.63 (-4.56;19.81)	1.03 (0.98;1.09)	54.76 (44.9;64.61)*	1.36 (1.3;1.42)*	618.1**	31.6**
Other diseases	-4.84 (-13.35;3.66)	0.95 (0.85;1.04)	11.53 (3.74;19.32)	1.15 (1.05;1.24)	-338**	21.5**
All causes	130.8 (65.3;196.31)	1.05 (1.02;1.07)	369.88 (316.98;422.78)*	1.15 (1.13;1.17)*	182.8**	10**
Females						
Infectious diseases	-1.52 (-3.55;0.5)	0.85 (0.65;1.06)	-2.69 (-4.57;-0.81)	0.73 (0.51;0.94)	76.6	-14.8
Neoplasms	-83.17 (-93.37;-72.97)*	0.64 (0.58;0.69)*	-64.19 (-74.63;-53.75)*	0.74 (0.69;0.79)*	-22.8	16.5**
Circulatory system diseases	191.69 (156.94;226.44)*	1.14 (1.12;1.17)*	303.13 (274.95;331.31)*	1.27 (1.25;1.3)*	58.1**	11.6**
Respiratory system diseases	54.83 (47.32;62.33)*	1.93 (1.83;2.04)*	23.41 (18.47;28.35)*	1.68 (1.56;1.8)*	-57.3**	-13.1**
Digestive system diseases	68.43 (59.89;76.97)*	1.56 (1.5;1.62)*	52.84 (45.26;60.43)*	1.51 (1.45;1.57)*	-22.8	-3.6
External causes	2.48 (-3.13;8.09)	1.04 (0.95;1.13)	11.53 (7.11;15.95)*	1.29 (1.19;1.4)*	364.5	24.6**
Other diseases	-3.26 (-8.33;1.8)	0.94 (0.85;1.03)	1.2 (-3.76;6.17)	1.02 (0.93;1.12)	-136.9	8.5
All causes	229.47 (190.71;268.22)*	1.12 (1.1;1.14)*	325.23 (293.1;357.37)*	1.2 (1.18;1.22)*	41.7**	7.4**

RD-rate difference (rural-urban) per 100000 population. RR-rate ratio (rural/urban), times. CI-confidence interval.
* The difference is statistically significant compared to the urban population (p<0.05).
** The difference is statistically significant compared to the previous period (p<0.05).
[1]Change in RD was calculated: (RD 2014-2016-RD 2003-2005)/RD 2003-2005 x100
[2]Change in RR was calculated: (RR 2014-2016-RR 2003-2005)/RR 2003-2005 x100
Source: author's calculations based on NBS and NAPH data



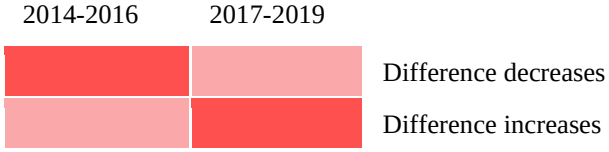
Annexe 7 (continued)

A7.3. Absolute and relative differences in mortality by main cause of death between rural and urban populations in 2014-2016 and 2017-2019 and their changes between 2014-2016 and 2017-2019. Moldova, by sex

	2014-2016		**2017-2019**		**Change (%)**	
	RD (95% CI)	RR (95% CI)	RD (95% CI)	RR (95% CI)	RD[1]	RR[2]
Males						
Infectious diseases	-0.03 (-3.61;3.56)	1 (0.86;1.14)	-1.92 (-5.65;1.82)	0.92 (0.76;1.08)	6791.7	-8
Neoplasms	-87.17 (-105.71;-68.63)*	0.81 (0.76;0.85)*	-77.53 (-95.93;-59.12)*	0.83 (0.78;0.87)*	-11.1	2.6
Circulatory system diseases	296.42 (251.37;341.47)*	1.2 (1.17;1.23)*	290.95 (247.08;334.83)*	1.2 (1.17;1.23)*	-1.8	0.5
Respiratory system diseases	57.69 (46.37;69.01)*	1.52 (1.43;1.61)*	53.2 (42.49;63.9)*	1.53 (1.43;1.62)*	-7.8	0.2
Digestive system diseases	36.68 (25.44;47.91)*	1.22 (1.16;1.28)*	44.45 (33.51;55.38)*	1.3 (1.23;1.37)*	21.2	6.9
External causes	54.76 (44.9;64.61)*	1.36 (1.3;1.42)*	47.02 (37.49;56.55)*	1.37 (1.3;1.43)*	-14.1	0.3
Other diseases	11.53 (3.74;19.32)	1.15 (1.05;1.24)	3.6 (-4.01;11.2)	1.05 (0.95;1.15)	-68.8	-8.8
All causes	369.88 (316.98;422.78)*	1.15 (1.13;1.17)*	359.77 (308.19;411.36)*	1.15 (1.13;1.17)*	-2.7	0.3
Females						
Infectious diseases	-2.69 (-4.57;-0.81)	0.73 (0.51;0.94)	-4.16 (-6.28;-2.03)	0.64 (0.42;0.86)	54.4	-12.5
Neoplasms	-64.19 (-74.63;-53.75)*	0.74 (0.69;0.79)*	-58.1 (-68.3;-47.91)*	0.76 (0.71;0.8)*	-9.5	1.9
Circulatory system diseases	303.13 (274.95;331.31)*	1.27 (1.25;1.3)*	221.58 (193.22;249.95)*	1.2 (1.18;1.22)*	-26.9**	-5.8**
Respiratory system diseases	23.41 (18.47;28.35)*	1.68 (1.56;1.8)*	18.45 (13.52;23.38)*	1.54 (1.42;1.66)*	-21.2	-8.4
Digestive system diseases	52.84 (45.26;60.43)*	1.51 (1.45;1.57)*	47.38 (40.32;54.43)*	1.55 (1.48;1.61)*	-10.3	2.5
External causes	11.53 (7.11;15.95)*	1.29 (1.19;1.4)*	10.23 (6.34;14.12)*	1.36 (1.24;1.48)*	-11.3	5.1
Other diseases	1.2 (-3.76;6.17)	1.02 (0.93;1.12)	-1.19 (-6.11;3.74)	0.98 (0.88;1.07)	-198.5	-4.4
All causes	325.23 (293.1;357.37)*	1.2 (1.18;1.22)*	234.19 (202.15;266.23)*	1.15 (1.13;1.17)*	-28**	-4.4**

RD-rate difference (rural-urban) per 100000 population. RR-rate ratio (rural/urban), times. CI-confidence interval.
* The difference is statistically significant compared to the urban population (p<0.05).
** The difference is statistically significant compared to the previous period (p<0.05).
[1]Change in RD was calculated: (RD 2017-2019-RD 2014-2016)/RD 2014-2016 x100
[2]Change in RR was calculated: (RR 2017-2019-RR 2014-2016)/RR 2014-2016 x100

Source: author's calculations based on NBS and NAPH data



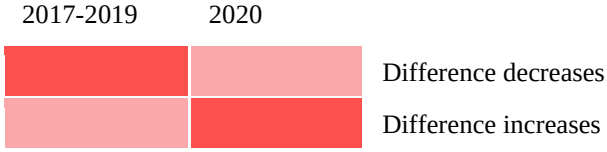
Annexe 7 (continued)

A7.4. Absolute and relative differences in mortality by main cause of death between rural and urban populations in 2017-2019 and 2020 and their changes between 2017-2019 and 2020. Moldova, by sex

	2017-2019		2020		Change (%)	
	RD (95% CI)	RR (95% CI)	RD (95% CI)	RR (95% CI)	RD[1]	RR[2]
Males						
Infectious diseases	-1.92 (-5.65;1.82)	0.92 (0.76;1.08)	-168.18 (-193.11;-143.24)*	0.45 (0.34;0.56)*	8677.9**	-51.5**
Neoplasms	-77.53 (-95.93;-59.12)*	0.83 (0.78;0.87)*	-53.27 (-83.65;-22.9)	0.87 (0.79;0.95)	-31.3	5.1
Circulatory system diseases	290.95 (247.08;334.83)*	1.2 (1.17;1.23)*	178.97 (98.26;259.67)*	1.11 (1.06;1.16)*	-38.5	-7.9**
Respiratory system diseases	53.2 (42.49;63.9)*	1.53 (1.43;1.62)*	30.34 (11.96;48.72)	1.28 (1.12;1.43)	-43	-16.3**
Digestive system diseases	44.45 (33.51;55.38)*	1.3 (1.23;1.37)*	33.82 (15.79;51.85)	1.23 (1.11;1.34)	-23.9	-5.8
External causes	47.02 (37.49;56.55)*	1.37 (1.3;1.43)*	37.97 (22.76;53.18)*	1.33 (1.21;1.45)*	-19.2	-2.7
Other diseases	3.6 (-4.01;11.2)	1.05 (0.95;1.15)	1.89 (-11.3;15.09)	1.02 (0.85;1.19)	-47.4	-2.2
All causes	359.77 (308.19;411.36)*	1.15 (1.13;1.17)*	61.54 (-33.99;157.07)	1.02 (0.99;1.06)	-82.9**	-11.4**
Females						
Infectious diseases	-4.16 (-6.28;-2.03)	0.64 (0.42;0.86)	-73.43 (-86.67;-60.19)*	0.53 (0.42;0.64)*	1667**	-16.9
Neoplasms	-58.1 (-68.3;-47.91)*	0.76 (0.71;0.8)*	-59.17 (-76.61;-41.73)*	0.75 (0.67;0.83)*	1.8	-0.9
Circulatory system diseases	221.58 (193.22;249.95)*	1.2 (1.18;1.22)*	183.04 (131.78;234.3)*	1.15 (1.11;1.19)*	-17.4	-3.8
Respiratory system diseases	18.45 (13.52;23.38)*	1.54 (1.42;1.66)*	0.38 (-9.26;10.03)	1.01 (0.82;1.19)	-97.9**	-34.6**
Digestive system diseases	47.38 (40.32;54.43)*	1.55 (1.48;1.61)*	40.16 (28.55;51.77)*	1.5 (1.37;1.62)*	-15.2	-3.1
External causes	10.23 (6.34;14.12)*	1.36 (1.24;1.48)*	10.65 (4.41;16.9)	1.44 (1.21;1.66)	4.1	5.8
Other diseases	-1.19 (-6.11;3.74)	0.98 (0.88;1.07)	-4.37 (-13.31;4.58)	0.92 (0.76;1.09)	268.1	-5.6
All causes	234.19 (202.15;266.23)*	1.15 (1.13;1.17)*	97.27 (38.5;156.04)	1.05 (1.02;1.09)	-58.5**	-8.3**

RD-rate difference (rural-urban) per 100000 population. RR-rate ratio (rural/urban), times. CI-confidence interval.
* The difference is statistically significant compared to the urban population (p<0.05).
** The difference is statistically significant compared to the previous period (p<0.05).
[1]Change in RD was calculated: (RD 2020-RD 2017-2019)/RD 2017-2019 x100
[2]Change in RR was calculated: (RR 2020-RR 2017-2019)/RR 2017-2019 x100

Source: author's calculations based on NBS and NAPH data



Annexe 8. Standardised death rates and the maximum absolute difference by marital status and cause of death in 2003-2005 and 2013-2014, Moldova, by sex

A8.1. Males aged 30 years and over, main causes of death

	SDR per 100000 population (95% CI)				Maximum absolute difference (RD)[1]
	Married (ref.)	Never-married	Divorced	Widowed	
All causes of death combined					
2003-2005	3811.66 (3748.71;3875.41)	4882.74 (4609.5;5167.95)	5865 (5512.51;6234.11)	6380.57 (6238.49;6525.07)	2568.91 (2412.68;2725.13)*
2013-2014	3150.33 (3090.26;3211.26)	4646.17 (4353.85;4952.96)	7736.72 (7203.74;8298.7)	5475.25 (5314.07;5640.08)	4586.39 (4040.63;5132.16)*
Infectious diseases					
2003-2005	54.3 (48.72;60.35)	146.5 (111.23;189.4)	201.1 (140.04;279.74)	215.12 (170.22;268.23)	160.82 (112.93;208.7)*
2013-2014	15.21 (13.05;17.63)	117.22 (95.12;142.93)	129.42 (95.83;170.98)	99.77 (62.3;151.48)	114.22 (78.01;150.42)*
Neoplasms					
2003-2005	476.83 (459.13;495.03)	592.25 (502.02;694.01)	731.14 (619.45;857.14)	568.13 (531.14;607.02)	254.31 (136.63;371.99)*
2013-2014	554.7 (535.05;574.88)	495.63 (408.13;596.33)	1145.25 (994.44;1312.47)	572.48 (513.36;636.55)	590.55 (433.18;747.93)*
Circulatory system diseases					
2003-2005	2269.9 (2217.23;2323.5)	2512.96 (2302.17;2737.86)	2899.04 (2627.43;3191.11)	3590.38 (3500.62;3681.86)	1320.48 (1215.77;1425.19)*
2013-2014	1950.86 (1898.79;2003.98)	2544.49 (2299.62;2808.33)	4523.12 (4056.37;5028.85)	3409.7 (3312.59;3508.93)	2572.27 (2090.01;3054.52)*
Respiratory system diseases					
2003-2005	308.39 (290.32;327.29)	431.62 (360.1;513.2)	456.47 (368.31;559.37)	570.42 (526.55;616.98)	262.03 (213.67;310.39)*
2013-2014	169.09 (154.72;184.45)	430.94 (350.56;524.24)	388.34 (305.41;486.83)	356.07 (316.58;399.13)	261.85 (176.03;347.66)*
Digestive system diseases					
2003-2005	306.01 (291.94;320.57)	438.68 (371.87;514.01)	476.19 (417.65;540.65)	556.73 (510.14;606.44)	250.72 (201.04;300.41)*
2013-2014	217.88 (206.6;229.61)	334.57 (282.97;392.87)	608.01 (486.79;750.26)	432.09 (370.94;500.44)	390.13 (261.64;518.63)*
External causes					
2003-2005	278.68 (264.73;293.16)	551.82 (469.65;644.23)	860.14 (752.35;979.04)	659.89 (601.77;722.11)	581.46 (469.19;693.74)*
2013-2014	159.59 (151.26;168.25)	532.89 (470.71;601)	718.33 (628.39;817.52)	461.33 (390.79;540.92)	558.74 (465.42;652.06)*
Other diseases					
2003-2005	117.56 (107.8;127.97)	209.52 (162.97;265.24)	244.72 (161.89;354.97)	221.87 (193.67;253.03)	127.16 (35.07;219.25)*
2013-2014	83.12 (74.44;92.55)	197.11 (151.68;251.89)	228.09 (155.36;323.1)	154.4 (125.99;187.31)	144.97 (64.64;225.29)*

SDR-standardised death rate. Reference group (ref.)-married population. CI-confidence interval.

[1]RD-rate difference was calculated: SDR in a group with the highest mortality-SDR in the reference group, per 100000 population.

* The difference is statistically significant ($p<0.05$)

Source: author's calculations based on NBS and NAPH data

Annexe 8 (continued)

A8.2. Females aged 30 years and over, main causes of death

	SDR per 100000 population (95% CI)				Maximum absolute difference (RD)[1]
	Married (ref.)	Never-married	Divorced	Widowed	
All causes of death combined					
2003-2005	2935.53 (2853.94;3018.86)	4457.86 (4293.02;4627.4)	2784.97 (2597.68;2982.2)	3196.39 (3155.7;3237.48)	1522.33 (1336.78;1707.88)*
2013-2014	2083.65 (2012.32;2156.86)	6776.36 (6526.71;7033.11)	4895.59 (4599.35;5205.9)	2673.89 (2629.54;2718.81)	4692.71 (4430.67;4954.74)*
Infectious diseases					
2003-2005	12.64 (8.99;17.27)	45.03 (30.75;63.66)	24.81 (14.75;39.13)	24.5 (19.62;30.22)	32.39 (16.24;48.55)*
2013-2014	4.4 (2.81;6.56)	34.94 (24.19;48.85)	27.33 (17.24;41.17)	11.16 (5.4;20.39)	30.55 (18.66;42.44)*
Neoplasms					
2003-2005	277.07 (258.67;296.42)	385.78 (342.79;432.67)	411.04 (358.96;468.55)	288.92 (275.5;302.83)	133.98 (76.98;190.97)*
2013-2014	272.08 (255;290)	557.23 (496.44;623.42)	792.68 (696.63;898.27)	273.18 (257.14;289.95)	520.6 (419.96;621.25)*
Circulatory system diseases					
2003-2005	2085.55 (2012.54;2160.54)	3037.76 (2897.8;3182.73)	1820.58 (1656.37;1996.67)	2213.69 (2183.56;2244.13)	952.21 (792.6;1111.81)*
2013-2014	1502.51 (1436.54;1570.73)	5128.03 (4902.99;5360.73)	3309.51 (3048.9;3586.45)	1939.29 (1906.76;1972.24)	3625.52 (3388.41;3862.63)*
Respiratory system diseases					
2003-2005	131.28 (114.46;149.87)	276.73 (234.37;324.54)	95.54 (59.9;144.6)	153.65 (144.22;163.54)	145.45 (98.02;192.88)*
2013-2014	47.42 (37.47;59.19)	280.03 (232.54;334.38)	127.91 (84.37;185.97)	71.65 (62.35;81.95)	232.62 (181.81;283.43)*
Digestive system diseases					
2003-2005	264.11 (244.86;284.47)	371.46 (330.83;415.72)	222.29 (182.69;267.93)	308.19 (293.45;323.49)	107.36 (61.17;153.54)*
2013-2014	160.68 (146.84;175.49)	396.85 (346.08;452.98)	359.34 (295.71;432.62)	249.04 (231.34;267.73)	236.17 (181.79;290.55)*
External causes					
2003-2005	84.48 (72.84;97.44)	189.23 (159.26;223.21)	128.78 (97.61;166.75)	121.33 (109.29;134.34)	104.76 (71.24;138.27)*
2013-2014	43.44 (36.27;51.61)	249.57 (210.42;293.89)	120.88 (89.05;160.38)	70.29 (58.51;83.76)	206.13 (164.63;247.63)*
Other diseases					
2003-2005	80.41 (69.56;92.46)	151.98 (125.76;182.05)	82.84 (59.72;111.95)	86.2 (77.77;95.3)	71.57 (41.9;101.24)*
2013-2014	53.33 (46.11;61.35)	130.7 (104.27;161.79)	159.35 (118.65;209.51)	61.64 (53.85;70.25)	106.02 (61.65;150.39)*

SDR-standardised death rate. Reference group (ref.)-married population. CI-confidence interval.

[1]RD-rate difference was calculated: SDR in a group with the highest mortality-SDR in the reference group, per 100000 population.

* The difference is statistically significant ($p<0.05$)

Source: author's calculations based on NBS and NAPH data

Annexe 9. Absolute differences in mortality by marital status and cause of death with 95% confidence intervals in 2003-2005 and 2013-2014 and their change, Moldova, by sex (per 100000 population)

A9.1. Males aged 30 years and over, main causes of death

	RD per 100000 population (95% CI)		
	Never-married	**Divorced**	**Widowed**
All causes of death combined			
2003-2005	1071.08 (786.82;1355.34)	2053.34 (1689.9;2416.77)	2568.91 (2412.68;2725.13)
2013-2014	1495.85 (1192.75;1798.95)	4586.39 (4040.63;5132.16)*	2324.92 (2151.7;2498.15)
Change (%)	39.66	123.36	-9.5
Infectious diseases			
2003-2005	92.19 (54.04;130.34)	146.79 (79.88;213.7)	160.82 (112.93;208.7)
2013-2014	102.01 (78.64;125.39)	114.22 (78.01;150.42)	84.56 (42.52;126.6)
Change (%)	10.65	-22.19	-47.42
Neoplasms			
2003-2005	115.42 (19.78;211.06)	254.31 (136.63;371.99)	91.3 (49.67;132.94)
2013-2014	-59.06 (-152.94;34.81)	590.55 (433.18;747.93)*	17.79 (-46.1;81.67)
Change (%)	-151.17	132.22	-80.52
Circulatory system diseases			
2003-2005	243.06 (21.27;464.85)	629.14 (345.89;912.4)	1320.48 (1215.77;1425.19)
2013-2014	593.63 (337.19;850.07)	2572.27 (2090.01;3054.52)*	1458.84 (1347.88;1569.8)
Change (%)	144.23	308.85	10.48
Respiratory system diseases			
2003-2005	123.23 (46.25;200.22)	148.08 (53.39;242.78)	262.03 (213.67;310.39)
2013-2014	261.85 (176.03;347.66)	219.24 (130.09;308.39)	186.98 (143.76;230.2)
Change (%)	112.48	48.05	-28.64
Digestive system diseases			
2003-2005	132.67 (61.67;203.67)	170.19 (108.08;232.3)	250.72 (201.04;300.41)
2013-2014	116.7 (61.73;171.66)	390.13 (261.64;518.63)*	214.21 (149.71;278.71)
Change (%)	-12.04	129.24	-14.56
External causes			
2003-2005	273.14 (186.51;359.78)	581.46 (469.19;693.74)	381.21 (320.11;442.32)
2013-2014	373.3 (308.65;437.96)	558.74 (465.42;652.06)	301.74 (227.79;375.69)
Change (%)	36.67	-3.91	-20.85
Other diseases			
2003-2005	91.96 (41.47;142.45)	127.16 (35.07;219.25)	104.31 (73.49;135.13)
2013-2014	113.99 (64.74;163.24)	144.97 (64.64;225.29)	71.28 (40.11;102.44)
Change (%)	23.96	14	-31.67

Reference group-married population. RD-rate difference. CI-confidence interval. SDR-standardised death rate.
RD was calculated: SDR in a study group-SDR in the reference group, per 100000 population.
Change in RD was calculated: $(RD_{2013-2014}-RD_{2003-2005}) / RD_{2003-2005} \times 100$.
* $p<0.05$ compared to the period 2003-2005

Source: author's calculations based on NBS and NAPH data

Annexe 9 (continued)

A9.2. Females aged 30 years and over, main causes of death

	RD per 100000 population (95% CI)		
	Never-married	**Divorced**	**Widowed**
All causes of death combined			
2003-2005	1522.33 (1336.78;1707.88)	-150.56 (-358.04;56.93)	260.87 (169.12;352.61)
2013-2014	4692.71 (4430.67;4954.74)*	2811.94 (2502.64;3121.25)*	590.25 (505.63;674.86)*
Change (%)	208.26	-1967.67	126.26
Infectious diseases			
2003-2005	32.39 (16.24;48.55)	12.17 (0.1;24.25)	11.86 (5.37;18.36)
2013-2014	30.55 (18.66;42.44)	22.93 (11.51;34.35)	6.76 (-0.3;13.83)
Change (%)	-5.71	88.37	-42.99
Neoplasms			
2003-2005	108.71 (60.67;156.76)	133.98 (76.98;190.97)	11.86 (-11.26;34.97)
2013-2014	285.16 (220.25;350.06)*	520.6 (419.96;621.25)*	1.1 (-22.69;24.89)
Change (%)	162.3	288.58	-90.73
Circulatory system diseases			
2003-2005	952.21 (792.6;1111.81)	-264.97 (-448.47;-81.47)	128.14 (48.52;207.76)
2013-2014	3625.52 (3388.41;3862.63)*	1807 (1532.84;2081.17)*	436.78 (362.51;511.05)*
Change (%)	280.75	-781.97	240.87
Respiratory system diseases			
2003-2005	145.45 (98.02;192.88)	-35.74 (-79.25;7.78)	22.37 (2.52;42.23)
2013-2014	232.62 (181.81;283.43)	80.5 (31.2;129.79)*	24.24 (9.97;38.51)
Change (%)	59.93	-325.25	8.33
Digestive system diseases			
2003-2005	107.36 (61.17;153.54)	-41.82 (-87.77;4.13)	44.09 (19.44;68.73)
2013-2014	236.17 (181.79;290.55)*	198.66 (130.43;266.89)*	88.36 (65.44;111.27)
Change (%)	119.99	-575.06	100.42
External causes			
2003-2005	104.76 (71.24;138.27)	44.31 (8.84;79.78)	36.86 (19.58;54.13)
2013-2014	206.13 (164.63;247.63)*	77.44 (42.35;112.53)	26.86 (12.43;41.28)
Change (%)	96.77	74.79	-27.14
Other diseases			
2003-2005	71.57 (41.9;101.24)	2.43 (-25.01;29.87)	5.79 (-8.39;19.97)
2013-2014	77.37 (48.46;106.28)	106.02 (61.65;150.39)*	8.32 (-2.68;19.31)
Change (%)	8.1	4261.54	43.53

Reference group-married population. RD-rate difference. CI-confidence interval. SDR-standardised death rate.
RD was calculated: SDR in a study group-SDR in the reference group, per 100000 population.
Change in RD was calculated: $(RD_{2013-2014}-RD_{2003-2005}) / RD_{2003-2005} \times 100$.
* $p<0.05$ compared to the period 2003-2005

Source: author's calculations based on NBS and NAPH data

Annexe 10. Mortality rate ratio by marital status and cause of death in 2003-2005 and 2013-2014, Moldova, by sex

A10.1. Males aged 30 years and over, main causes of death

	RR (95% CI)		
	2003-2005	**2013-2014**	**Change (%)[1]**
All causes of death combined			
Never-married	1.28 (1.22-1.34)*	1.47 (1.41-1.54)*	15.1**
Divorced	1.54 (1.48-1.6)*	2.46 (2.38-2.53)*	59.6**
Widowed	1.67 (1.65-1.7)*	1.74 (1.7-1.77)*	3.8**
Married (ref.)	1.0	1.0	
Infectious diseases			
Never-married	2.7 (2.42-2.98)*	7.71 (7.46-7.96)*	185.7**
Divorced	3.7 (3.36-4.05)*	8.51 (8.19-8.83)*	129.8**
Widowed	3.96 (3.72-4.21)*	6.56 (6.11-7.01)*	65.6**
Married (ref.)	1.0	1.0	
Neoplasms			
Never-married	1.24 (1.08-1.41)*	0.89 (0.7-1.08)	-28.1
Divorced	1.53 (1.37-1.7)*	2.06 (1.92-2.21)*	34.7**
Widowed	1.19 (1.12-1.27)*	1.03 (0.92-1.14)	-13.4
Married (ref.)	1.0	1.0	
Circulatory system diseases			
Never-married	1.11 (1.02-1.2)	1.3 (1.2-1.41)*	17.8**
Divorced	1.28 (1.18-1.38)*	2.32 (2.21-2.43)*	81.5**
Widowed	1.58 (1.55-1.62)*	1.75 (1.71-1.79)*	10.5**
Married (ref.)	1.0	1.0	
Respiratory system diseases			
Never-married	1.4 (1.22-1.58)*	2.55 (2.33-2.76)*	82.1**
Divorced	1.48 (1.27-1.69)*	2.3 (2.05-2.54)*	55.2**
Widowed	1.85 (1.75-1.95)*	2.11 (1.96-2.25)*	13.8**
Married (ref.)	1.0	1.0	
Digestive system diseases			
Never-married	1.43 (1.27-1.6)*	1.54 (1.37-1.7)*	7.1
Divorced	1.56 (1.42-1.69)*	2.79 (2.57-3.01)*	79.3**
Widowed	1.82 (1.72-1.92)*	1.98 (1.83-2.14)*	9
Married (ref.)	1.0	1.0	
External causes			
Never-married	1.98 (1.82-2.14)*	3.34 (3.21-3.47)*	68.6**
Divorced	3.09 (2.95-3.23)*	4.5 (4.36-4.64)*	45.8**
Widowed	2.37 (2.26-2.47)*	2.89 (2.72-3.06)*	22.1**
Married (ref.)	1.0	1.0	
Other diseases			
Never-married	1.78 (1.53-2.03)*	2.37 (2.1-2.64)*	33.1**
Divorced	2.08 (1.7-2.47)*	2.74 (2.38-3.11)*	31.8
Widowed	1.89 (1.73-2.04)*	1.86 (1.64-2.08)*	-1.6
Married (ref.)	1.0	1.0	

RR-rate ratio, times. Reference group (ref.)-married population. CI-confidence interval.

* p-value < 0.05 compared to the reference group. ** The difference in RR between the two periods is statistically significant (p<0.05)

[1]change in relative difference was calculated: ($RR_{2013-2014}$-$RR_{2003-2005}$) / $RR_{2003-2005}$ x 100

Source: author's calculations based on NBS and NAPH data

Annexe 10 (continued)

A10.2. Males aged 30 years and over, detailed causes of death

	RR (95% CI)		Change (%)[1]
	2003-2005	2013-2014	
Cancer of the digestive system			
Never-married	1.21 (0.99-1.44)	0.8 (0.52-1.07)	-34.3
Divorced	1.27 (1.07-1.47)	2.26 (2.03-2.48)*	77.2**
Widowed	1.22 (1.11-1.34)*	1.09 (0.91-1.26)	-11.2
Married (ref.)	1.0	1.0	
Cancer of the respiratory system			
Never-married	1.51 (1.19-1.82)*	1.24 (0.92-1.56)	-17.9
Divorced	1.78 (1.43-2.14)*	2.01 (1.78-2.23)*	12.4
Widowed	1.27 (1.12-1.41)*	1.04 (0.83-1.25)	-18.1
Married (ref.)	1.0	1.0	
Cancer of the genitourinary system			
Never-married	1.01 (0.46-1.56)	0.63 (NA-1.34)	-37.6
Divorced	1.67 (1.27-2.07)*	2 (1.62-2.38)*	19.8
Widowed	0.94 (0.69-1.19)	0.92 (0.61-1.24)	-1.7
Married (ref.)	1.0	1.0	
Other neoplasms			
Never-married	1.12 (0.64-1.6)	0.92 (0.4-1.44)	-18.2
Divorced	1.79 (1.26-2.31)*	1.73 (1.35-2.11)*	-3.3
Widowed	1.25 (1.04-1.46)	1.09 (0.76-1.41)	-13
Married (ref.)	1.0	1.0	
Heart diseases			
Never-married	1.12 (1.01-1.23)	1.37 (1.25-1.48)*	21.7**
Divorced	1.18 (1.07-1.29)*	2.32 (2.19-2.45)*	96.9**
Widowed	1.61 (1.57-1.65)*	1.85 (1.8-1.9)*	14.6**
Married (ref.)	1.0	1.0	
Cerebrovascular diseases			
Never-married	1.06 (0.92-1.21)	1.14 (0.93-1.35)	7.4
Divorced	1.53 (1.34-1.73)*	2.31 (2.11-2.52)*	50.8**
Widowed	1.5 (1.44-1.56)*	1.49 (1.42-1.57)*	-0.4
Married (ref.)	1.0	1.0	
Liver diseases			
Never-married	1.41 (1.21-1.61)*	1.52 (1.33-1.71)*	8.4
Divorced	1.56 (1.4-1.72)*	2.83 (2.59-3.07)*	81.4**
Widowed	1.81 (1.7-1.91)*	2.04 (1.86-2.23)*	13.1
Married (ref.)	1.0	1.0	
Other diseases of the digestive system			
Never-married	1.55 (1.26-1.83)*	1.61 (1.24-1.98)*	4.2
Divorced	1.59 (1.31-1.87)*	2.7 (2.22-3.19)*	69.8**
Widowed	1.88 (1.66-2.11)*	1.86 (1.56-2.16)*	-1.2
Married (ref.)	1.0	1.0	
Transport accidents			
Never-married	1.59 (0.99-2.19)	1.72 (1.16-2.29)	8.4
Divorced	2.18 (1.73-2.63)*	3.79 (3.35-4.23)*	73.7**

	RR (95% CI)		Change (%)[1]
	2003-2005	2013-2014	
Widowed	1.96 (1.55-2.37)*	1.36 (0.65-2.07)	-30.7
Married (ref.)	1.0	1.0	
Suicide, homicide, undetermined			
Never-married	1.81 (1.54-2.07)*	3.35 (3.12-3.57)*	85.2**
Divorced	3.85 (3.57-4.13)*	4.26 (3.95-4.57)*	10.5
Widowed	2.32 (2.15-2.5)*	2.52 (2.18-2.87)*	8.6
Married (ref.)	1.0	1.0	
Other external causes			
Never-married	2.19 (1.97-2.4)*	3.79 (3.62-3.97)*	73.4**
Divorced	2.85 (2.71-2.99)*	4.94 (4.77-5.1)*	73.1**
Widowed	2.5 (2.36-2.63)*	3.57 (3.37-3.77)*	42.9**
Married (ref.)	1.0	1.0	

RR-rate ratio, times. Reference group (ref.)-married population. CI-confidence interval.
* p-value < 0.05 compared to the reference group.
** The difference in RR between the two periods is statistically significant ($p<0.05$)
[1]change in relative difference was calculated: $(RR_{2013-2014}-RR_{2003-2005}) / RR_{2003-2005} \times 100$
Source: author's calculations based on NBS and NAPH data

Annexe 10 (continued)

A10.3. Females aged 30 years and over, main causes of death

	RR (95% CI)		Change (%)[1]
	2003-2005	2013-2014	
All causes of death combined			
Never-married	1.52 (1.47-1.57)*	3.25 (3.2-3.3)*	114.2**
Divorced	0.95 (0.87-1.02)	2.35 (2.28-2.42)*	147.7**
Widowed	1.09 (1.06-1.12)*	1.28 (1.24-1.32)*	17.9**
Married (ref.)	1.0	1.0	
Infectious diseases			
Never-married	3.56 (3.1-4.03)*	7.95 (7.42-8.47)*	123**
Divorced	1.96 (1.41-2.52)	6.21 (5.64-6.79)*	216.5**
Widowed	1.94 (1.56-2.32)*	2.54 (1.8-3.27)*	30.9
Married (ref.)	1.0	1.0	
Neoplasms			
Never-married	1.39 (1.26-1.53)*	2.05 (1.92-2.18)*	47.1**
Divorced	1.48 (1.34-1.63)*	2.91 (2.77-3.05)*	96.4**
Widowed	1.04 (0.96-1.13)	1 (0.92-1.09)	-3.7
Married (ref.)	1.0	1.0	
Circulatory system diseases			
Never-married	1.46 (1.4-1.52)*	3.41 (3.35-3.48)*	134.3**
Divorced	0.87 (0.77-0.97)	2.2 (2.11-2.29)*	152.3**
Widowed	1.06 (1.02-1.1)	1.29 (1.24-1.34)*	21.6**
Married (ref.)	1.0	1.0	
Respiratory system diseases			
Never-married	2.11 (1.9-2.32)*	5.91 (5.62-6.19)*	180.2**
Divorced	0.73 (0.29-1.17)	2.7 (2.26-3.13)*	270.7**
Widowed	1.17 (1.02-1.32)	1.51 (1.25-1.77)	29.1
Married (ref.)	1.0	1.0	
Digestive system diseases			
Never-married	1.41 (1.27-1.54)*	2.47 (2.31-2.63)*	75.6**
Divorced	0.84 (0.64-1.04)	2.24 (2.03-2.44)*	165.7**
Widowed	1.17 (1.08-1.26)	1.55 (1.44-1.66)*	32.8**
Married (ref.)	1.0	1.0	
External causes			
Never-married	2.24 (2.02-2.46)*	5.75 (5.51-5.98)*	156.5**
Divorced	1.52 (1.23-1.82)*	2.78 (2.45-3.11)*	82.5**
Widowed	1.44 (1.26-1.61)*	1.62 (1.37-1.86)*	12.7
Married (ref.)	1.0	1.0	
Other diseases			
Never-married	1.89 (1.66-2.12)*	2.45 (2.2-2.71)*	29.7**
Divorced	1.03 (0.7-1.36)	2.99 (2.68-3.3)*	190.1**
Widowed	1.07 (0.9-1.24)	1.16 (0.96-1.35)	7.8
Married (ref.)	1.0	1.0	

RR-rate ratio, times. Reference group (ref.)-married population. CI-confidence interval.
* p-value < 0.05 compared to the reference group. ** The difference in RR between the two periods is statistically significant (p<0.05)
[1]change in relative difference was calculated: ($RR_{2013-2014}$-$RR_{2003-2005}$) / $RR_{2003-2005}$ x 100

Source: author's calculations based on NBS and NAPH data

Annexe 10 (continued)

A10.4. Females aged 30 years and over, detailed causes of death

	RR (95% CI)		Change (%)[1]
	2003-2005	2013-2014	
Cancer of the digestive system			
Never-married	1.25 (1.03-1.48)	1.61 (1.38-1.84)*	28.7
Divorced	1.5 (1.23-1.77)*	3.26 (3.03-3.5)*	117.5**
Widowed	1.15 (1.02-1.28)	1.01 (0.87-1.14)	-12.4
Married (ref.)	1.0	1.0	
Cancer of the respiratory system			
Never-married	0.99 (0.46-1.52)	2.72 (2.3-3.15)*	174.5**
Divorced	1.87 (1.45-2.29)*	2.91 (2.38-3.45)*	56.1**
Widowed	0.97 (0.69-1.25)	1.14 (0.82-1.46)	17.3
Married (ref.)	1.0	1.0	
Breast cancer			
Never-married	1.89 (1.6-2.17)*	2.84 (2.57-3.1)*	50.4**
Divorced	1.1 (0.78-1.43)	3.22 (2.93-3.51)*	191.8**
Widowed	1.04 (0.84-1.25)	1.08 (0.88-1.28)	3.2
Married (ref.)	1.0	1.0	
Cancer of the genitourinary system			
Never-married	1.35 (1.04-1.66)	2.39 (2.12-2.66)*	76.6**
Divorced	1.62 (1.28-1.97)*	2.48 (2.22-2.75)*	52.9**
Widowed	0.96 (0.76-1.16)	1.09 (0.87-1.3)	12.7
Married (ref.)	1.0	1.0	
Other neoplasms			
Never-married	1.45 (1.15-1.76)	1.6 (1.24-1.95)*	9.9
Divorced	1.52 (1.2-1.84)	2.24 (1.88-2.59)*	47.5**
Widowed	0.96 (0.77-1.16)	0.81 (0.56-1.06)	-16
Married (ref.)	1.0	1.0	
Heart diseases			
Never-married	1.49 (1.42-1.56)*	3.59 (3.52-3.67)*	140.8**
Divorced	0.87 (0.75-0.99)	1.93 (1.82-2.04)*	120.9**
Widowed	1.08 (1.03-1.12)	1.34 (1.28-1.4)*	24.6**
Married (ref.)	1.0	1.0	
Cerebrovascular diseases			
Never-married	1.37 (1.26-1.47)*	2.96 (2.84-3.08)*	116.5**
Divorced	0.87 (0.7-1.05)	2.89 (2.73-3.04)*	231.3**
Widowed	1.03 (0.96-1.09)	1.17 (1.08-1.25)	13.8
Married (ref.)	1.0	1.0	
Liver diseases			
Never-married	1.41 (1.26-1.55)*	2.38 (2.2-2.55)*	68.7**
Divorced	0.79 (0.56-1.02)	1.65 (1.43-1.87)*	108**
Widowed	1.17 (1.08-1.27)	1.53 (1.41-1.66)*	30.8**
Married (ref.)	1.0	1.0	
Other diseases of the digestive system			
Never-married	1.39 (1.01-1.76)	2.91 (2.51-3.31)*	109.4**
Divorced	1.19 (0.77-1.61)	5.05 (4.61-5.49)*	322.9**

	RR (95% CI)		Change (%)[1]
	2003-2005	2013-2014	
Widowed	1.13 (0.89-1.37)	1.64 (1.35-1.93)	45.2
Married (ref.)	1.0	1.0	
Transport accidents			
Never-married	1.96 (1.31-2.61)	3.12 (2.2-4.03)*	59.2
Divorced	3.02 (2.24-3.8)*	3.83 (2.91-4.75)*	27
Widowed	1.28 (0.72-1.85)	0.97 (NA-1.99)	-24
Married (ref.)	1.0	1.0	
Suicide, homicide, undetermined			
Never-married	2.1 (1.74-2.46)*	7.09 (6.71-7.47)*	237.5**
Divorced	1.73 (1.33-2.13)*	2.55 (2.08-3.02)*	47.2
Widowed	1.45 (1.17-1.72)	1.29 (0.88-1.7)	-10.8
Married (ref.)	1.0	1.0	
Other external causes			
Never married	2.38 (2.08-2.67)*	5.66 (5.35-5.96)*	137.9**
Divorced	1.13 (0.68-1.58)	2.77 (2.31-3.24)*	146.2**
Widowed	1.47 (1.23-1.71)	1.9 (1.59-2.22)*	29.7
Married (ref.)	1.0	1.0	

RR-rate ratio, times. Reference group (ref.)-married population. CI-confidence interval.
* p-value < 0.05 compared to the reference group.
** The difference in RR between the two periods is statistically significant (p<0.05)
[1]change in relative difference was calculated: ($RR_{2013-2014}$-$RR_{2003-2005}$) / $RR_{2003-2005}$ x 100
Source: author's calculations based on NBS and NAPH data

Annexe 11. Standardised death rates and their absolute difference by the level of education and cause of death in 2003-2005 and 2013-2014, Moldova, by sex

A11.1. Males aged 30 years and over, main causes of death

	SDR per 100000 population (95% CI)			Absolute difference (RD)[1]
	Higher (ref.)	Secondary	Primary or lower	
All causes of death combined				
2003-2005	2920.27 (2792.68;3052.19)	3470.25 (3409.45;3531.86)	5420.67 (5332.66;5509.77)	2500.4 (2344.03;2656.77)*
2013-2014	2592.52 (2479.6;2709.26)	3582.78 (3521;3645.38)	5157.92 (5027.56;5290.8)	2565.39 (2391.49;2739.3)*
Infectious diseases				
2003-2005	34.66 (23.72;48.91)	67.73 (61.5;74.43)	127.4 (109.54;147.34)	92.74 (70.66;114.82)*
2013-2014	7.92 (4.29;13.37)	44.04 (39.81;48.59)	59.5 (41.44;82.76)	51.58 (31.42;71.74)*
Neoplasms				
2003-2005	501.67 (452.29;554.98)	507.11 (485.99;528.91)	513.26 (486.72;540.87)	11.59 (-45.76;68.94)
2013-2014	503.72 (462.51;547.63)	590.74 (569.71;612.36)	536.74 (492.24;584.18)	87.02 (39.88;134.16)
Circulatory system diseases				
2003-2005	1786.36 (1680.68;1896.94)	1888.63 (1839.63;1938.6)	3199.27 (3136.99;3262.48)	1412.91 (1288.72;1537.11)*
2013-2014	1610.23 (1514.83;1710.07)	2129.36 (2076.09;2183.65)	3345.64 (3251.65;3441.65)	1735.41 (1599.99;1870.82)*
Respiratory system diseases				
2003-2005	135.92 (111.59;163.98)	249.05 (233.92;264.91)	509.79 (482.28;538.46)	373.87 (336.06;411.68)*
2013-2014	79.27 (59.48;103.54)	180.03 (167.48;193.26)	375.03 (338.29;414.67)	295.76 (252.51;339)*
Digestive system diseases				
2003-2005	174.79 (152.08;199.94)	315.49 (300.37;331.17)	426.29 (400.15;453.69)	251.5 (216.04;286.96)*
2013-2014	184.84 (159.87;212.61)	266.71 (254.81;279.02)	336.45 (297.23;379.42)	151.61 (103.6;199.62)*
External causes				
2003-2005	166.35 (144.66;190.37)	316.78 (302.43;331.63)	454.09 (424.03;485.71)	287.74 (249.81;325.66)*
2013-2014	125.2 (107.01;145.6)	268.19 (257.28;279.45)	333.46 (291.61;379.63)	208.26 (161.05;255.46)*
Other diseases				
2003-2005	120.55 (95.29;150.44)	125.46 (114.75;136.9)	190.68 (171;212.01)	70.13 (36.61;103.66)
2013-2014	82.02 (63.4;104.4)	103.71 (95.03;112.97)	171.24 (143;203.42)	89.22 (53.67;124.77)*

SDR-standardised death rate. Reference group (ref.)-a population with higher education. CI-confidence interval.

[1]RD-rate difference was calculated: SDR in a group with the highest mortality-SDR in the reference group, per 100000 population.

* The difference is statistically significant ($p<0.05$)

Source: author's calculations based on NBS and NAPH data

Annexe 11 (continued)

A11.2. Females aged 30 years and over, main causes of death

	SDR per 100000 population (95% CI)			Absolute difference (RD)[1]
	Higher (ref.)	Secondary	Primary or lower	
All causes of death combined				
2003-2005	1581.4 (1500.71;1665.3)	2193.64 (2149.22;2238.76)	3650.78 (3597.56;3704.59)	2069.38 (1971.74;2167.02)*
2013-2014	1685.07 (1602.73;1770.54)	2338.09 (2292.68;2384.18)	3262.41 (3187.78;3338.34)	1577.34 (1465.17;1689.5)*
Infectious diseases				
2003-2005	21.1 (11.92;34.57)	21.17 (17.13;25.86)	20.33 (15.05;26.86)	0.07 (-11.29;11.42)
2013-2014	2.46 (0.68;6.27)	10.69 (8.9;12.73)	18.75 (9.06;34.3)	16.29 (4.52;28.05)*
Neoplasms				
2003-2005	291.71 (261.3;324.7)	307.55 (292.35;323.33)	278.02 (262.87;293.81)	15.84 (-19;50.67)
2013-2014	349.42 (318.87;382.11)	315.96 (302.52;329.85)	263.17 (236.62;291.88)	-33.46 (-67.53;0.61)
Circulatory system diseases				
2003-2005	1020.71 (952.41;1092.61)	1411.61 (1373.82;1450.17)	2597.92 (2557.03;2639.29)	1577.21 (1496.52;1657.9)*
2013-2014	1121.04 (1049.42;1196.26)	1623.34 (1582.66;1664.8)	2423.2 (2371.01;2476.26)	1302.16 (1212.43;1391.9)*
Respiratory system diseases				
2003-2005	42.48 (31.17;56.56)	77.37 (69.85;85.48)	188.21 (176.2;200.82)	145.72 (128.47;162.98)*
2013-2014	31.78 (21.7;44.91)	52.02 (45.77;58.88)	119.04 (100.24;140.35)	87.27 (64.76;109.78)*
Digestive system diseases				
2003-2005	103.78 (86.77;123.15)	219.51 (208.09;231.39)	331.05 (312.53;350.38)	227.27 (201.4;253.13)*
2013-2014	97.43 (80.9;116.35)	205.15 (194.93;215.77)	242.6 (216.56;270.92)	145.17 (113.29;177.05)*
External causes				
2003-2005	48.9 (38.46;61.3)	78.75 (72.12;85.83)	114.42 (102.71;127.11)	65.52 (49.17;81.87)*
2013-2014	38.18 (28.67;49.83)	67.17 (61.41;73.34)	89.76 (70.19;113.09)	51.58 (28.44;74.72)*
Other diseases				
2003-2005	52.98 (40.32;68.35)	77.68 (70.61;85.27)	120.96 (105.55;137.99)	67.99 (47.08;88.89)*
2013-2014	45.36 (34.12;59.11)	63.81 (58.03;70)	106.45 (85.79;130.58)	61.1 (36.21;85.98)*

SDR-standardised death rate. Reference group (ref.)-a population with higher education. CI-confidence interval.
[1]RD-rate difference was calculated: SDR in a group with the highest mortality-SDR in the reference group, per 100000 population.
* The difference is statistically significant ($p<0.05$)

Source: author's calculations based on NBS and NAPH data

Annexe 12. Absolute differences in mortality by the level of education and cause of death with 95% confidence intervals in 2003-2005 and 2013-2014 and their change, Moldova, by sex (per 100000 population)

A12.1. Males aged 30 years and over, main causes of death

	RD per 100000 population (95% CI)	
	Primary or lower	**Secondary**
All causes of death combined		
2003-2005	2500.4 (2344.03;2656.77)	549.97 (407.25;692.7)
2013-2014	2565.39 (2391.49;2739.3)	990.26 (860.32;1120.21)*
Change (%)	2.6	80.06
Infectious diseases		
2003-2005	92.74 (70.66;114.82)	33.07 (19.48;46.66)
2013-2014	51.58 (31.42;71.74)	36.12 (30.09;42.15)
Change (%)	-44.38	9.22
Neoplasms		
2003-2005	11.59 (-45.76;68.94)	5.43 (-49.54;60.41)
2013-2014	33.02 (-28.93;94.97)	87.02 (39.88;134.16)
Change (%)	184.92	1501.17
Circulatory system diseases		
2003-2005	1412.91 (1288.72;1537.11)	102.27 (-15.8;220.33)
2013-2014	1735.41 (1599.99;1870.82)*	519.13 (408.44;629.82)*
Change (%)	22.82	407.62
Respiratory system diseases		
2003-2005	373.87 (336.06;411.68)	113.14 (83.34;142.94)
2013-2014	295.76 (252.51;339)	100.76 (75.99;125.53)
Change (%)	-20.89	-10.94
Digestive system diseases		
2003-2005	251.5 (216.04;286.96)	140.7 (112.65;168.75)
2013-2014	151.61 (103.6;199.62)*	81.87 (53.33;110.41)*
Change (%)	-39.72	-41.81
External causes		
2003-2005	287.74 (249.81;325.66)	150.43 (123.71;177.15)
2013-2014	208.26 (161.05;255.46)	142.99 (121.11;164.88)
Change (%)	-27.62	-4.94
Other diseases		
2003-2005	70.13 (36.61;103.66)	4.91 (-23.99;33.81)
2013-2014	89.22 (53.67;124.77)	21.69 (-0.03;43.41)
Change (%)	27.21	341.79

Reference group-a population with higher education. RD-rate difference. CI-confidence interval. SDR-standardised death rate.
RD was calculated: SDR in a study group-SDR in the reference group, per 100000 population.
Change in RD was calculated: (RD2013-2014-RD2003-2005)/RD2003-2005 x 100.
* $p<0.05$ compared to the period 2003-2005

Source: author's calculations based on NBS and NAPH data

Annexe 12 (continued)

A12.2. Females aged 30 years and over, main causes of death

	RD per 100000 population (95% CI)	
	Primary or lower	**Secondary**
All causes of death combined		
2003-2005	2069.38 (1971.74;2167.02)	612.24 (519.11;705.38)
2013-2014	1577.34 (1465.17;1689.5)*	653.02 (557.99;748.05)
Change (%)	-23.78	6.66
Infectious diseases		
2003-2005	-0.77 (-12.74;11.2)	0.07 (-11.29;11.42)
2013-2014	16.29 (4.52;28.05)	8.22 (5.18;11.26)
Change (%)	-2210.18	12102.37
Neoplasms		
2003-2005	-13.7 (-48.51;21.12)	15.84 (-19;50.67)
2013-2014	-86.25 (-127.71;-44.8)	-33.46 (-67.53;0.61)
Change (%)	529.78	-311.3
Circulatory system diseases		
2003-2005	1577.21 (1496.52;1657.9)	390.9 (311.7;470.1)
2013-2014	1302.16 (1212.43;1391.9)*	502.3 (418.79;585.81)
Change (%)	-17.44	28.5
Respiratory system diseases		
2003-2005	145.72 (128.47;162.98)	34.89 (20.46;49.32)
2013-2014	87.27 (64.76;109.78)*	20.24 (7.45;33.03)
Change (%)	-40.12	-41.98
Digestive system diseases		
2003-2005	227.27 (201.4;253.13)	115.73 (94.52;136.93)
2013-2014	145.17 (113.29;177.05)*	107.72 (87.56;127.88)
Change (%)	-36.12	-6.92
External causes		
2003-2005	65.52 (49.17;81.87)	29.85 (16.87;42.83)
2013-2014	51.58 (28.44;74.72)	29 (17.22;40.77)
Change (%)	-21.28	-2.87
Other diseases		
2003-2005	67.99 (47.08;88.89)	24.71 (9.36;40.05)
2013-2014	61.1 (36.21;85.98)	18.45 (5.03;31.87)
Change (%)	-10.14	-25.33

Reference group-a population with higher education. RD-rate difference. CI-confidence interval. SDR-standardised death rate.
RD was calculated: SDR in a study group-SDR in the reference group, per 100000 population.
Change in RD was calculated: (RD2013-2014-RD2003-2005)/RD2003-2005 x 100.
* $p<0.05$ compared to the period 2003-2005

Source: author's calculations based on NBS and NAPH data

Annexe 13. Mortality rate ratio by the level of education and cause of death in 2003-2005 and 2013-2014, Moldova, by sex

A13.1. Males aged 30 years and over, main causes of death

	RR (95% CI)		
	2003-2005	**2013-2014**	**Change (%)[1]**
All causes of death combined			
Primary or lower	1.86 (1.81-1.9)*	2.22 (2.17-2.27)*	19.6**
Secondary	1.19 (1.14-1.24)*	1.38 (1.34-1.43)*	16.5**
Higher (ref.)	1.0	1.0	
Infectious diseases			
Primary or lower	3.68 (3.3-4.05)*	7.57 (6.95-8.18)*	105.8**
Secondary	1.95 (1.6-2.31)*	5.54 (5.02-6.07)*	183.7**
Higher (ref.)	1.0	1.0	
Neoplasms			
Primary or lower	1.02 (0.91-1.14)	1.16 (1.04-1.27)	12.9
Secondary	1.01 (0.9-1.12)	1.17 (1.08-1.26)	15.6
Higher (ref.)	1.0	1.0	
Circulatory system diseases			
Primary or lower	1.79 (1.73-1.85)*	2.37 (2.31-2.44)*	32.5**
Secondary	1.06 (0.99-1.12)	1.32 (1.26-1.38)*	24.9**
Higher (ref.)	1.0	1.0	
Respiratory system diseases			
Primary or lower	3.75 (3.56-3.95)*	5.31 (5.03-5.58)*	41.4**
Secondary	1.83 (1.63-2.03)*	2.32 (2.06-2.59)*	26.7**
Higher (ref.)	1.0	1.0	
Digestive system diseases			
Primary or lower	2.44 (2.29-2.59)*	1.94 (1.76-2.12)*	-20.4**
Secondary	1.8 (1.66-1.95)*	1.46 (1.32-1.6)*	-19.2**
Higher (ref.)	1.0	1.0	
External causes			
Primary or lower	2.73 (2.58-2.88)*	2.77 (2.58-2.97)*	1.5
Secondary	1.9 (1.76-2.05)*	2.15 (2-2.31)*	13.1
Higher (ref.)	1.0	1.0	
Other diseases			
Primary or lower	1.58 (1.34-1.83)*	2.25 (1.96-2.53)*	42.1**
Secondary	1.04 (0.8-1.28)	1.28 (1.04-1.53)	23.4
Higher (ref.)	1.0	1.0	

RR-rate ratio, times. Reference group (ref.)-population with higher education. CI-confidence interval.

* p-value < 0.05 compared to the reference group.

** The difference in RR between the two periods is statistically significant (p<0.05)

[1]change in relative difference was calculated: ($RR_{2013-2014}$-$RR_{2003-2005}$) / $RR_{2003-2005}$ x 100

Source: author's calculations based on NBS and NAPH data

Annexe 13 (continued)

A13.2. Males aged 30 years and over, detailed causes of death

	RR (95% CI)		
	2003-2005	**2013-2014**	**Change (%)[1]**
Cancer of the digestive system			
Primary or lower	1.09 (0.93-1.25)	1.03 (0.86-1.2)	-5
Secondary	1.11 (0.96-1.27)	1.18 (1.05-1.31)	5.9
Higher (ref.)	1.0	1.0	
Cancer of the respiratory system			
Primary or lower	1.32 (1.09-1.54)	1.89 (1.64-2.13)*	43.1**
Secondary	1.16 (0.94-1.37)	1.88 (1.69-2.08)*	62.8**
Higher (ref.)	1.0	1.0	
Cancer of the genitourinary system			
Primary or lower	0.66 (0.33-0.99)	0.96 (0.68-1.24)	45.4
Secondary	0.74 (0.42-1.07)	0.87 (0.64-1.1)	17.1
Higher (ref.)	1.0	1.0	
Other neoplasms			
Primary or lower	0.91 (0.62-1.2)	1.01 (0.72-1.3)	10.8
Secondary	0.87 (0.59-1.15)	0.78 (0.58-0.98)	-10.4
Higher (ref.)	1.0	1.0	
Heart diseases			
Primary or lower	1.91 (1.84-1.99)*	2.53 (2.45-2.6)*	31.9**
Secondary	1.09 (1.01-1.17)	1.34 (1.26-1.41)*	22.3**
Higher (ref.)	1.0	1.0	
Cerebrovascular diseases			
Primary or lower	1.52 (1.41-1.63)*	1.99 (1.87-2.11)*	30.8**
Secondary	0.98 (0.86-1.09)	1.28 (1.16-1.39)*	30.6**
Higher (ref.)	1.0	1.0	
Liver diseases			
Primary or lower	2.39 (2.22-2.56)*	2.08 (1.88-2.29)*	-12.9
Secondary	1.78 (1.62-1.95)*	1.63 (1.47-1.79)*	-8.5
Higher (ref.)	1.0	1.0	
Other diseases of the digestive system			
Primary or lower	2.58 (2.27-2.89)*	1.65 (1.3-2)	-36.1**
Secondary	1.86 (1.57-2.16)*	1.1 (0.82-1.38)	-40.9**
Higher (ref.)	1.0	1.0	
Transport accidents			
Primary or lower	1.41 (1.1-1.73)	1.73 (1.15-2.3)	22.2
Secondary	1.19 (0.9-1.47)	1.7 (1.32-2.07)	42.9
Higher (ref.)	1.0	1.0	
Suicide, homicide, undetermined			
Primary or lower	2.74 (2.49-2.99)*	2.51 (2.15-2.86)*	-8.5
Secondary	2.17 (1.93-2.4)*	2.26 (1.98-2.53)*	4.2
Higher (ref.)	1.0	1.0	
Other external causes			
Primary or lower	3.15 (2.92-3.38)*	3.16 (2.9-3.41)*	0.1
Secondary	1.98 (1.76-2.21)*	2.19 (1.98-2.39)*	10.2
Higher (ref.)	1.0	1.0	

RR-rate ratio, times. Reference group (ref.)-population with higher education. CI-confidence interval.

* p-value < 0.05 compared to the reference group. ** The difference in RR between the two periods is statistically significant (p<0.05)

[1]change in relative difference was calculated: ($RR_{2013-2014}$-$RR_{2003-2005}$) / $RR_{2003-2005}$ x 100

Source: author's calculations based on NBS and NAPH data

Annexe 13 (continued)

A13.3. Females aged 30 years and over, main causes of death

	RR (95% CI)		
	2003-2005	**2013-2014**	**Change (%)[1]**
All causes			
Primary or lower	2.31 (2.25-2.36)*	2.11 (2.06-2.17)*	-8.5**
Secondary	1.39 (1.33-1.44)*	1.39 (1.34-1.45)*	0.5
Higher (ref.)	1.0	1.0	
Infectious diseases			
Primary or lower	0.96 (0.39-1.54)	7.86 (6.73-8.99)*	715.9**
Secondary	1 (0.47-1.54)	4.42 (3.45-5.39)*	340.2**
Higher (ref.)	1.0	1.0	
Neoplasms			
Primary or lower	0.95 (0.83-1.07)	0.8 (0.67-0.94)	-15.9
Secondary	1.05 (0.94-1.17)	0.9 (0.81-1)	-14.3
Higher (ref.)	1.0	1.0	
Circulatory system diseases			
Primary or lower	2.55 (2.48-2.62)*	2.39 (2.32-2.46)*	-6.1**
Secondary	1.38 (1.31-1.46)*	1.46 (1.39-1.52)*	5.3
Higher (ref.)	1.0	1.0	
Respiratory system diseases			
Primary or lower	4.43 (4.14-4.72)*	4.04 (3.67-4.42)*	-8.7
Secondary	1.82 (1.52-2.12)*	1.65 (1.28-2.01)	-9.7
Higher (ref.)	1.0	1.0	
Digestive system diseases			
Primary or lower	3.19 (3.01-3.37)*	2.65 (2.45-2.86)*	-16.8**
Secondary	2.12 (1.94-2.29)*	2.13 (1.95-2.31)*	0.8
Higher (ref.)	1.0	1.0	
External causes			
Primary or lower	2.34 (2.09-2.59)*	2.46 (2.11-2.81)*	5.2
Secondary	1.61 (1.37-1.85)*	1.77 (1.5-2.05)*	10
Higher (ref.)	1.0	1.0	
Other diseases			
Primary or lower	2.28 (2-2.57)*	2.49 (2.16-2.82)*	8.9
Secondary	1.47 (1.19-1.74)	1.42 (1.15-1.7)	-3
Higher (ref.)	1.0	1.0	

RR-rate ratio, times. Reference group (ref.)-population with higher education. CI-confidence interval.

* p-value < 0.05 compared to the reference group.

** The difference in RR between the two periods is statistically significant (p<0.05)

[1]change in relative difference was calculated: ($RR_{2013-2014}$-$RR_{2003-2005}$) / $RR_{2003-2005}$ x 100

Source: author's calculations based on NBS and NAPH data

Annexe 13 (continued)

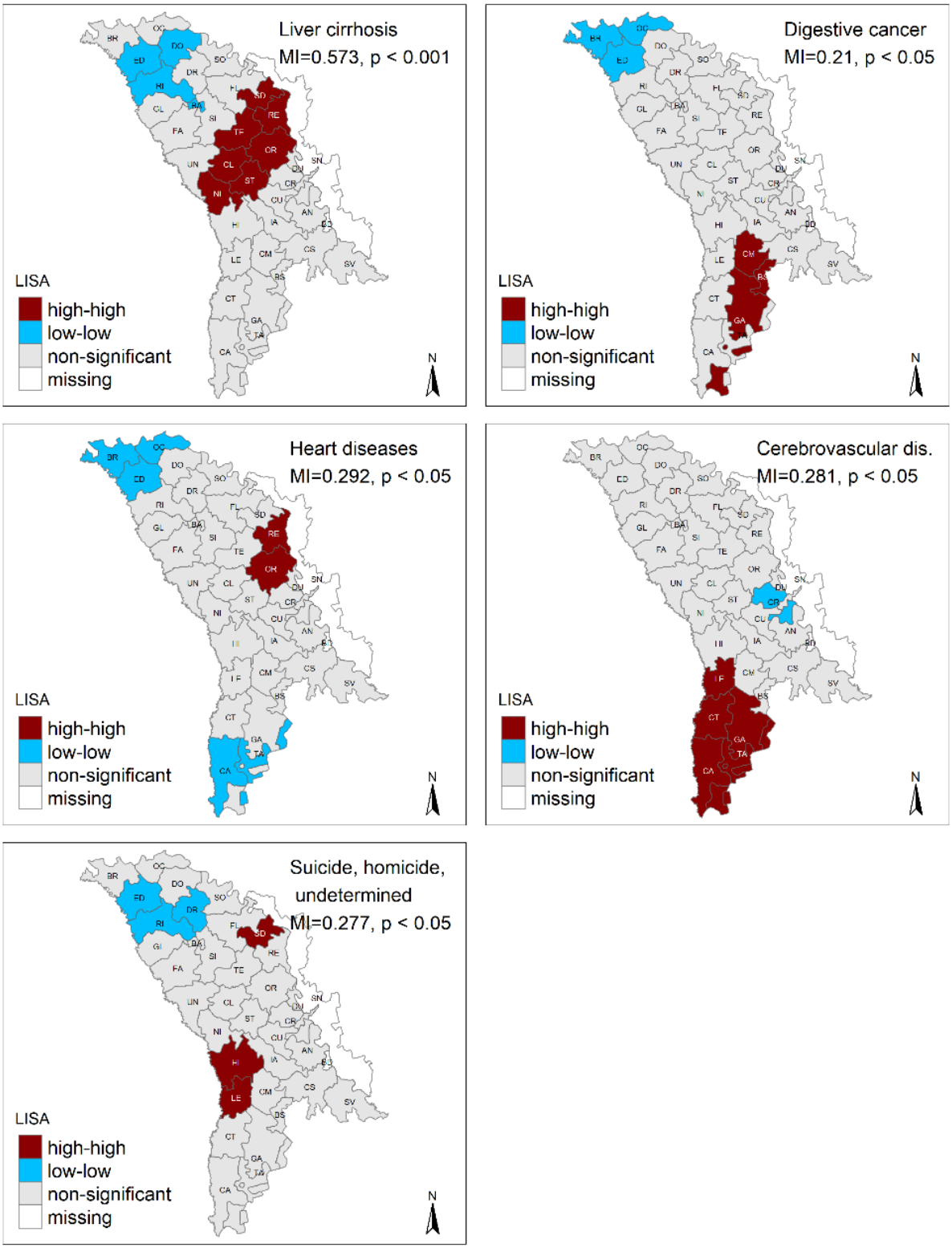
A13.4. Females aged 30 years and over, detailed causes of death

	RR (95% CI)		
	2003-2005	**2013-2014**	**Change (%)[1]**
Cancer of the digestive system			
Primary or lower	1.1 (0.9-1.3)	0.76 (0.56-0.96)	-31
Secondary	1.23 (1.03-1.43)	0.84 (0.68-1)	-32**
Higher (ref.)	1.0	1.0	
Cancer of the respiratory system			
Primary or lower	1.02 (0.64-1.41)	0.95 (0.49-1.41)	-6.6
Secondary	1.01 (0.63-1.4)	1 (0.66-1.34)	-1
Higher (ref.)	1.0	1.0	
Breast cancer			
Primary or lower	0.92 (0.64-1.2)	0.7 (0.4-1)	-23.9
Secondary	1.13 (0.87-1.39)	0.85 (0.64-1.06)	-24.7
Higher (ref.)	1.0	1.0	
Cancer of the genitourinary system			
Primary or lower	1.01 (0.71-1.31)	1.2 (0.87-1.52)	18.4
Secondary	1.06 (0.77-1.35)	1.14 (0.91-1.37)	7.2
Higher (ref.)	1.0	1.0	
Other neoplasms			
Primary or lower	0.7 (0.42-0.97)	0.63 (0.22-1.03)	-10
Secondary	0.75 (0.48-1.01)	0.89 (0.65-1.12)	18.8
Higher (ref.)	1.0	1.0	
Heart diseases			
Primary or lower	2.73 (2.64-2.81)*	2.66 (2.58-2.74)*	-2.5
Secondary	1.39 (1.29-1.48)*	1.52 (1.43-1.6)*	9.7
Higher (ref.)	1.0	1.0	
Cerebrovascular diseases			
Primary or lower	2.16 (2.04-2.28)*	1.84 (1.72-1.96)*	-14.9**
Secondary	1.38 (1.26-1.5)*	1.33 (1.21-1.45)*	-3.7
Higher (ref.)	1.0	1.0	
Liver diseases			
Primary or lower	3.58 (3.38-3.78)*	3.85 (3.61-4.09)*	7.6
Secondary	2.31 (2.11-2.51)*	2.88 (2.67-3.1)*	24.9**
Higher (ref.)	1.0	1.0	
Other diseases of the digestive system			
Primary or lower	1.83 (1.41-2.24)	1.09 (0.7-1.47)	-40.5
Secondary	1.43 (1.02-1.84)	1.13 (0.81-1.46)	-20.6
Higher (ref.)	1.0	1.0	
Transport accidents			
Primary or lower	1.1 (0.48-1.71)	3.56 (2.36-4.76)*	224.7**
Secondary	0.97 (0.4-1.55)	2.17 (1.21-3.12)NA	122.8
Higher (ref.)	1.0	1.0	
Suicide, homicide, undetermined			
Primary or lower	2.01 (1.56-2.47)	1.36 (0.69-2.02)	-32.5
Secondary	1.69 (1.27-2.12)	1.23 (0.8-1.65)	-27.6
Higher (ref.)	1.0	1.0	
Other external causes			
Primary or lower	3.08 (2.72-3.43)*	3.14 (2.69-3.59)*	2
Secondary	1.79 (1.44-2.14)	2.08 (1.69-2.47)*	16.2
Higher (ref.)	1.0	1.0	

RR-rate ratio, times. Reference group (ref.)-population with higher education. CI-confidence interval.
* p-value < 0.05 compared to the reference group. ** The difference in RR between the two periods is statistically significant (p<0.05)
[1]change in relative difference was calculated: ($RR_{2013-2014}$-$RR_{2003-2005}$) / $RR_{2003-2005}$ x 100

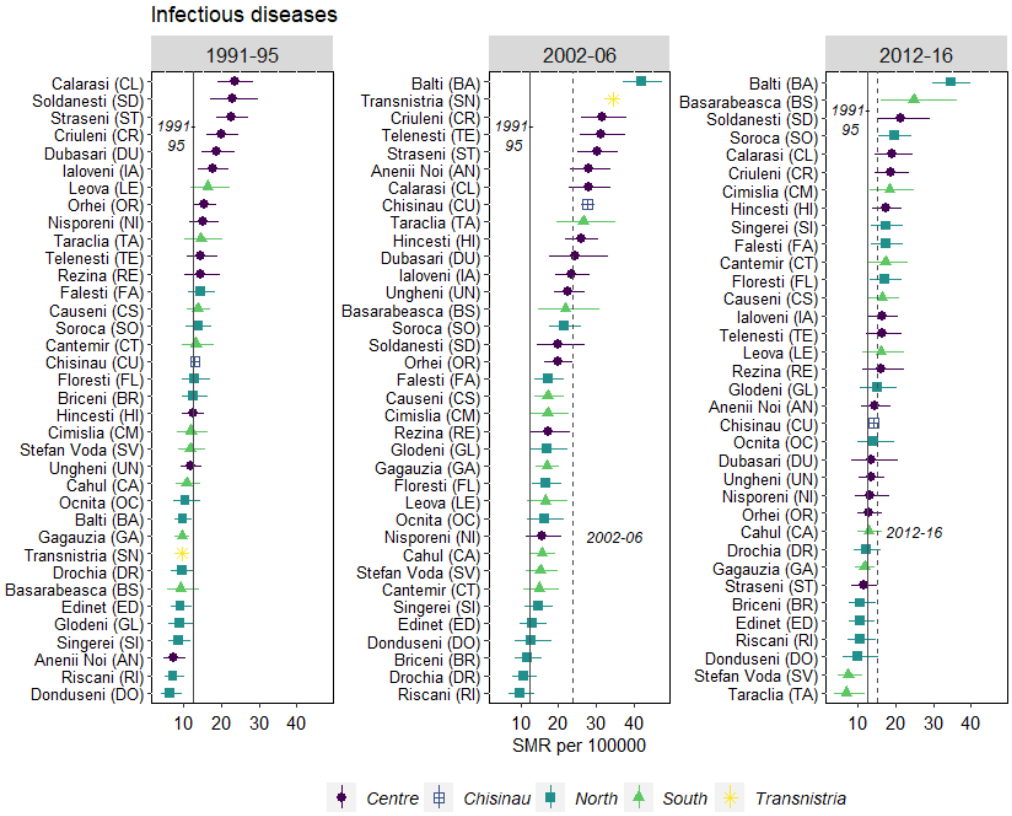
Source: author's calculations based on NBS and NAPH data

Annexe 14. LISA map for standardised mortality rates from some detailed causes of death in 2012-2016 in Moldova, both sexes

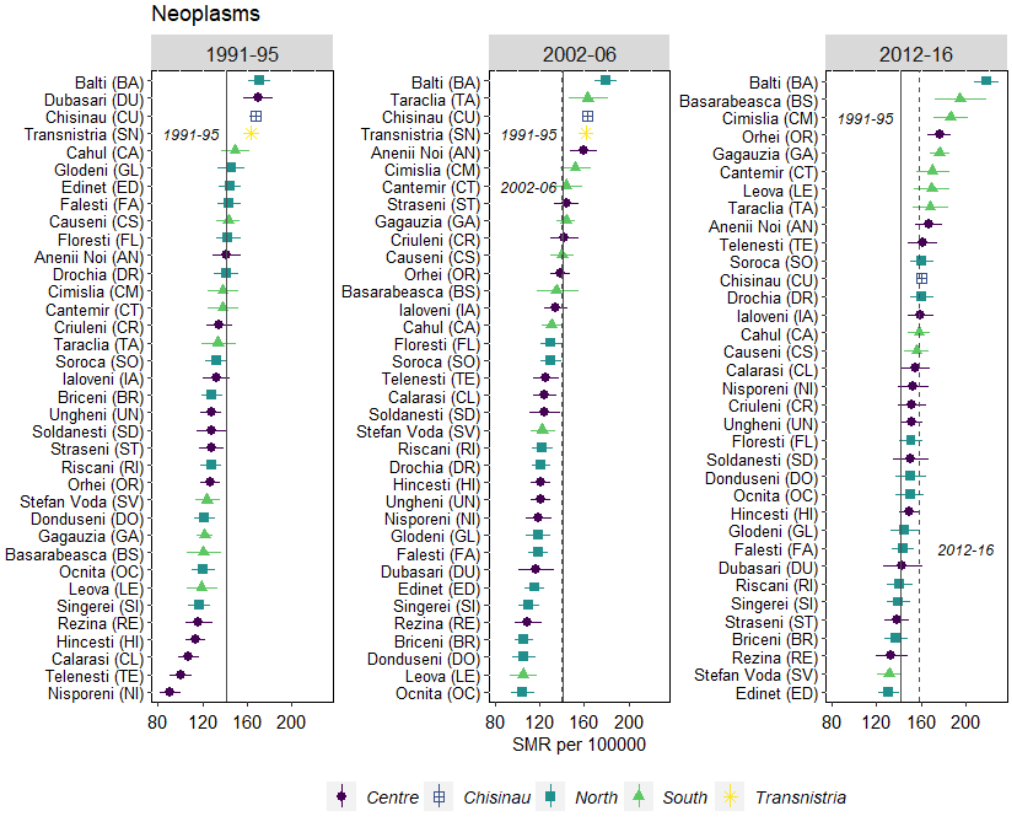


Note: number of permutations = 9.999
Source: author's calculations based on NBS and NAPH data.

Annexe 15. Standardised mortality rates from main causes of death with 95% confidence intervals by the district in Moldova in 1991-1995, 2002-2006 and 2012-2016, both sexes (per 100000)

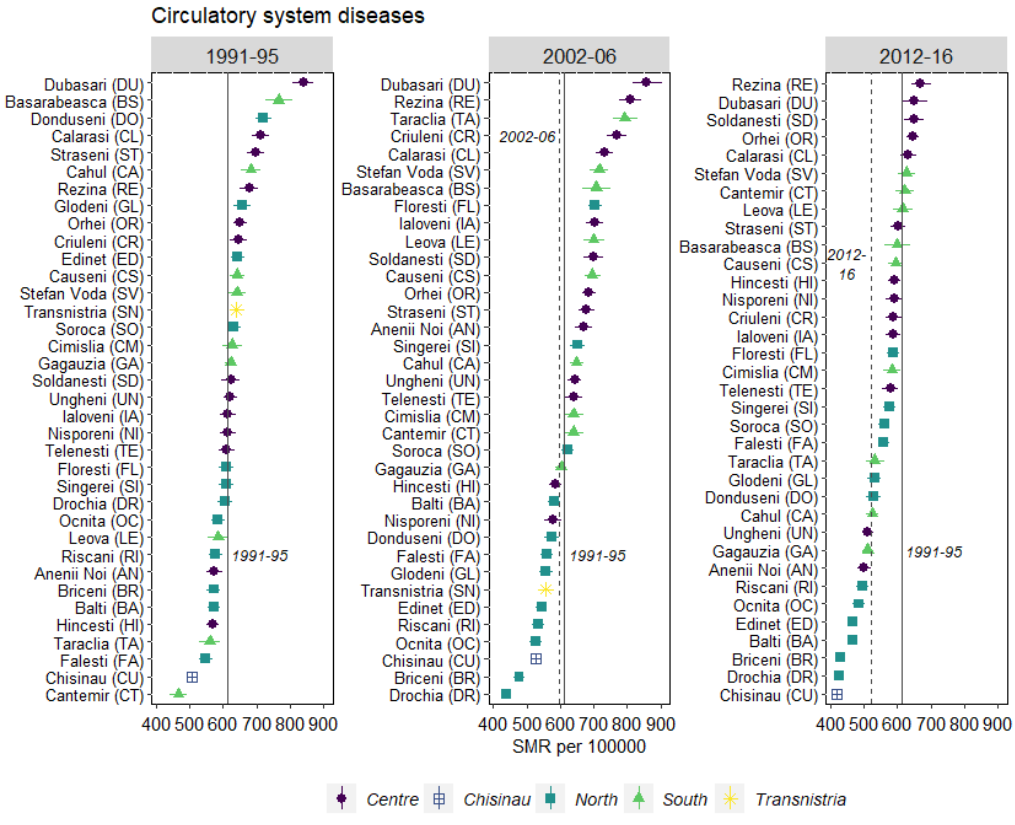


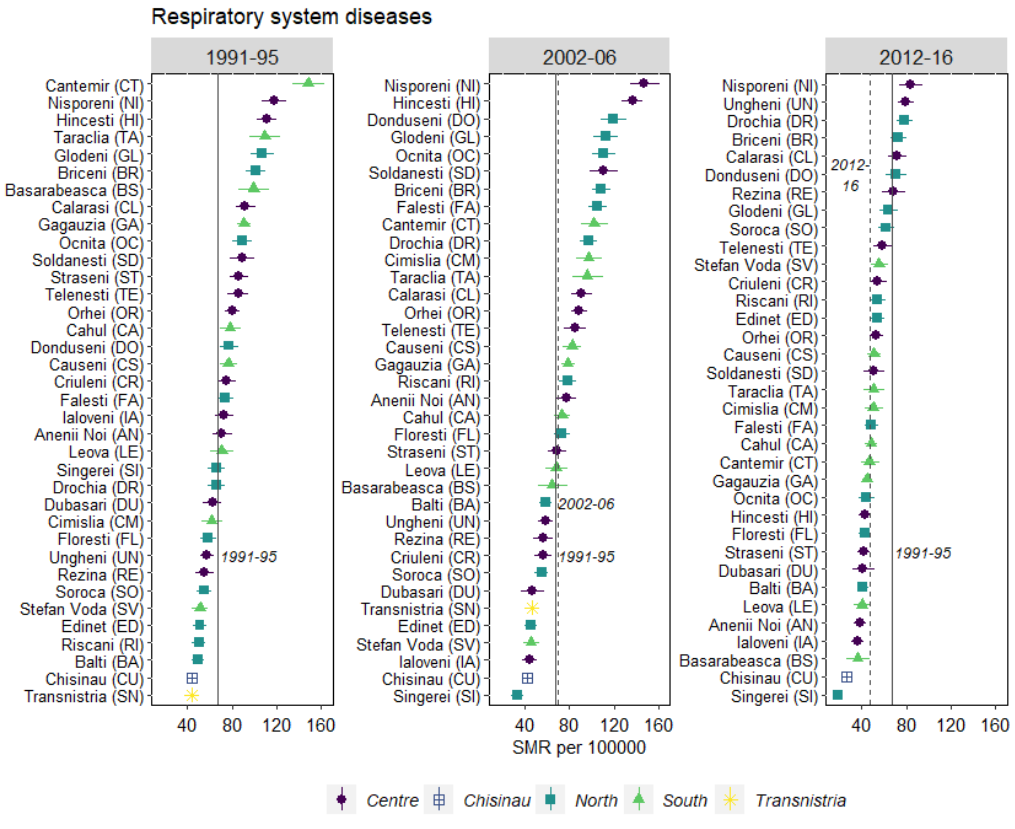
Reference rate in 1991-95 = 12.5 per 100000



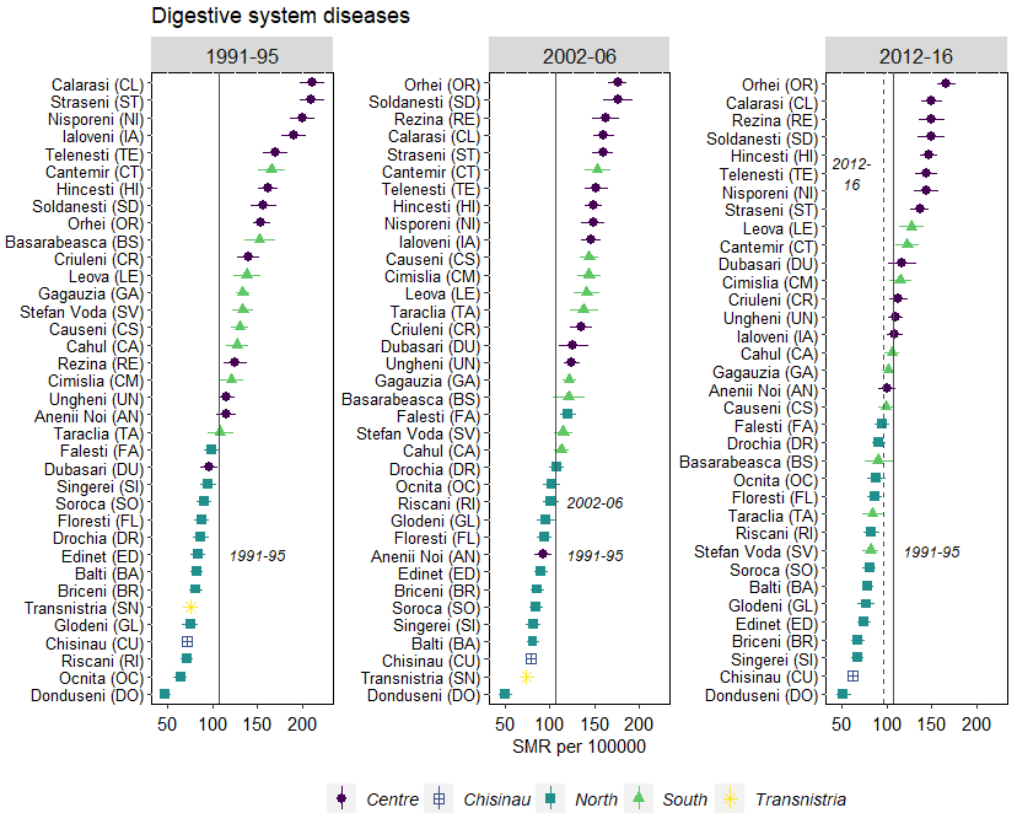
Reference rate in 1991-95 = 141.3 per 100000

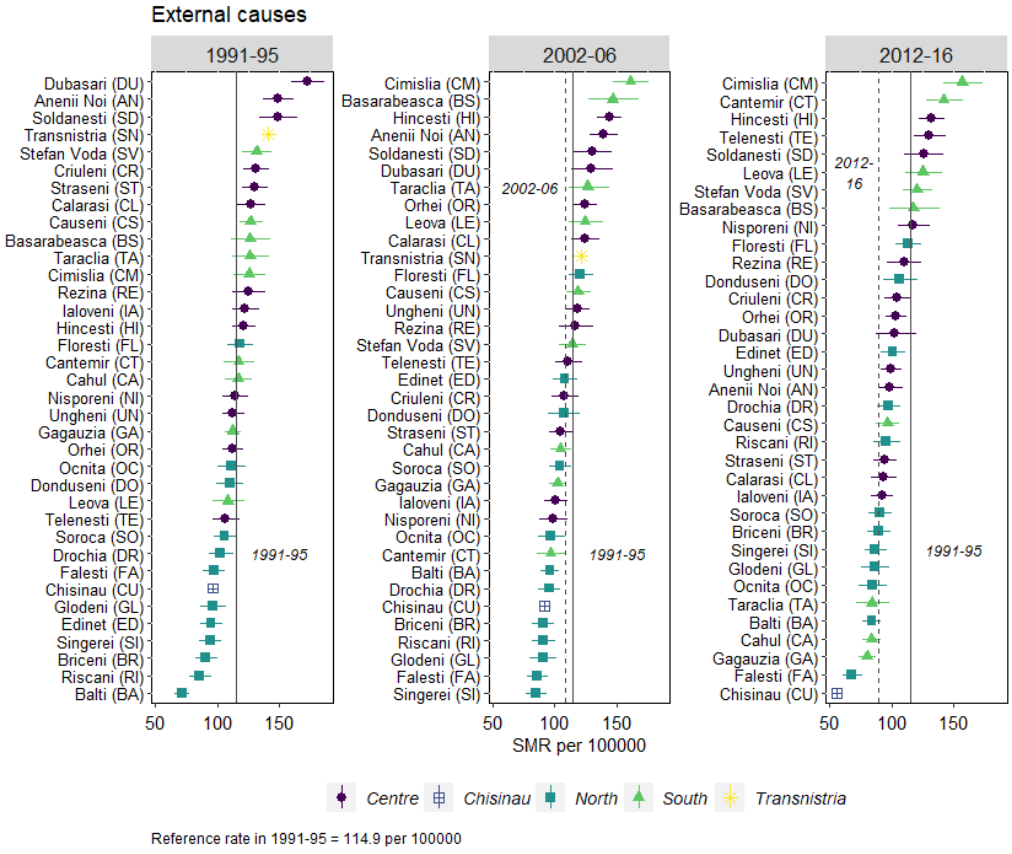
Annexe 15 (continued)



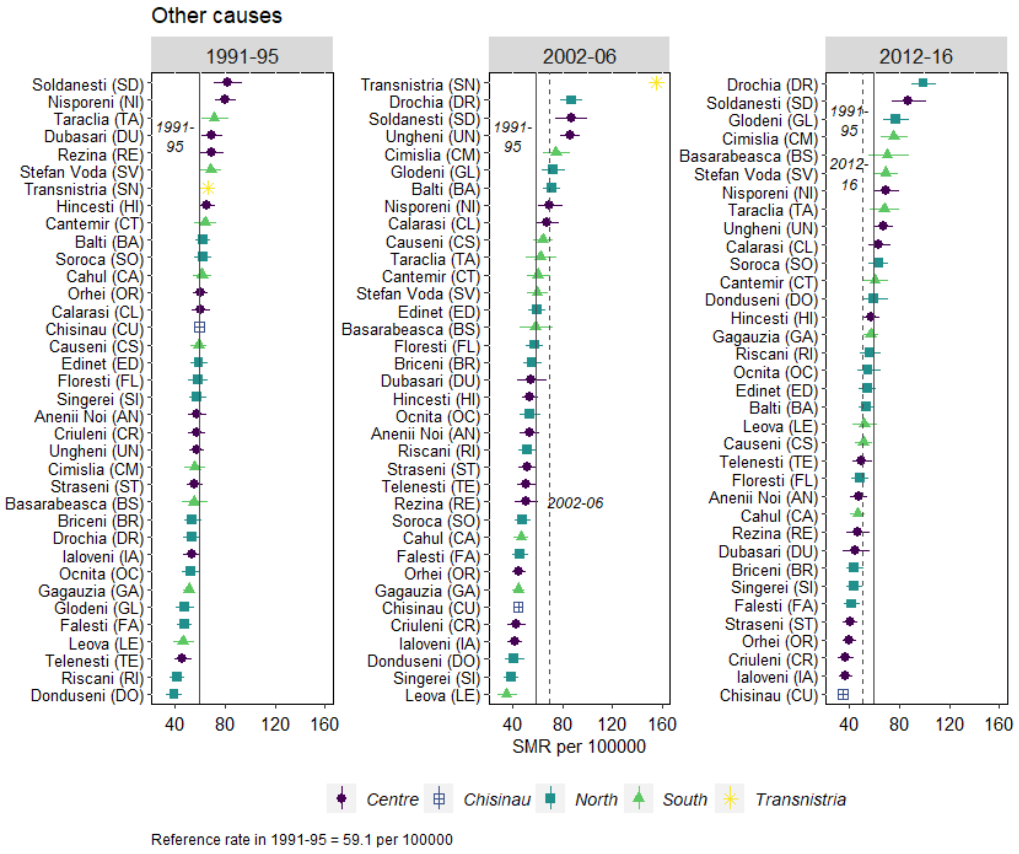


Annexe 15 (continued)





Annexe 15 (continued)



Source: author's calculations based on NAPH, NBS and Transnistrian statistical office data.

Annexe 16. Certificate and act of implementation issued by Nicolae Testemitanu SUMPh

Republica Moldova
Ministerul Sănătăţii

CERTIFICAT DE INOVATOR

Nr. **5971**

Pentru inovaţia cu titlul

Reconstituirea seriilor mortalității pe cauze de deces pentru anii 1965-2020 în Republica Moldova conform clasificării fixe a cauzelor de deces

Inovaţia a fost înregistrată pe data de
la Universitatea de Stat de Medicină şi Farmacie
"Nicolae Testemiţanu"

Se recunoaşte calitatea de autor(i)

PENINA Olga

Data eliberării **10 ianuarie 2023**

L.Ş.

(Semnătura autorizată)

APROB
Proiector pentru activitate de cercetare,
USMF „Nicolae Testemițanu" din RM
academician al AȘM,
prof. univ., dr. hab. șt. med.
Stanislav GROPPA
25 ianuarie 2023

ACTUL nr. _2_
DE IMPLEMENTARE A INOVAȚIEI
(în procesul științifico – practic și științifico-didactic)

1. **Denumirea ofertei pentru implementare**: ***„Reconstituirea seriilor mortalității pe cauze de deces pentru anii 1965-2020 în Republica Moldova conform clasificării fixe a cauzelor de deces".***
2. **Autori:** Penina Olga, conf. univ., dr. șt. med., Catedra de medicină socială și management „Nicolae Testemițanu".
3. **Numărul inovației**: *nr.5971 din 10 ianuarie 2023*
4. **Unde și când a fost implementată**: Seriile reconstituite ale mortalității pe cauze de deces conform reviziei a 10-a a Clasificării Internaționale a Maladiilor și a Cauzelor de Deces pentru Republica Moldova în anii 1965-2020 au fost implementate în cadrul bazei de date internaționale The Human Cause-of-Death Database și activităților științifico-didactice ale Catedrei de medicină socială și management „Nicolae Testemițanu" pe parcursul anilor 2020-2022.
5. **Eficacitatea implementării**: Seriile reconstituite ale mortalității asigură compatibilitatea datelor privind mortalitatea pe cauze de deces între țări și în timp.
6. **Rezultatul implementării**: Rezultatele analizei mortalității după cauza de deces în Republica Moldova pe baza seriilor reconstituite au fost reflectate într-o monografie colectivă cu cercetători de la Institutul Național de Studii Demografice din Franța, publicații în reviste naționale și internaționale și la conferințe internaționale. Au fost utilizate în elaborarea materialelor didactice la disciplinele „Medicină socială și management în sănătate" și „Biostatistica și metodologia cercetării științifice" pentru studenții de la programele de studii integrate și de licență.

Prezenta inovație este implementată conform descrierii în cerere.

Prof. univ., dr. hab. șt. med., Catedra de medicină socială și management „Nicolae Testemițanu" **GREJDEAN Fiodor**

Șef department, Departamentul Didactic și Management Academic, dr. șt. med., conf. univ. **STRATULAT Silvia**

Șef departament, Departamentul Cercetare, dr. hab. șt. med., conf. univ. **RAEVSCHI Elena**

Annexe 17. Implementing Act 1 issued by INED

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INSTITUT NATIONAL D'ÉTUDES DÉMOGRAPHIQUES

www.ined.fr

Paris, 20 June 2022

Implementing Act

I herewith confirm that in the framework of the thesis of *doctor habilitat* in medical science "Socio-demographic and regional mortality disparities in the Republic of Moldova" written by Dr. Olga Penina, Associate Professor at *Nicolae Testemitanu* State University of Medicine and Pharmacy of the Republic of Moldova, the reconstructed mortality series according a constant classification of causes of death (the 10th revision of the International Classification of Diseases and Causes of Death) were produced for the Republic of Moldova (since 1965) and Romania (since 1980) based on a special method of reconstruction.

The reconstructed mortality series according to a constant classification of causes of death for the Republic of Moldova and Romania are available within the Human Cause-of-Death Database, a joint project of the French Institute for Demographic Studies (INED) in Paris, France and the Max Planck Institute for Demographic Research (MPIDR) in Rostock, Germany, https://www.causesofdeath.org/cgi-bin/main.php.

The reconstructed mortality series according to a constant classification of causes of death warrant data comparability across time and countries and facilitate research on the comparative analysis.

Should you have any questions or concerns, please do not hesitate to contact me by email mesle@ined.fr

France Meslé

Director of the Human Cause of Death Database (INED)
Directrice de recherche (INED)

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INSTITUT NATIONAL
D'ETUDES DEMOGRAPHIQUES
9 cours des Humanités
93322 AUBERVILLIERS CEDEX

Institut national d'études démographiques - Campus Condorcet - 9, cours des Humanités - CD 50004 - 93322 Aubervilliers Cedex - France
Tél. +33 (0)1 56 06 20 00 - Fax +33 (0)1 56 06 21

Annexe 18. Implementing Act 2 issued by INED

ined
INSTITUT NATIONAL D'ÉTUDES DÉMOGRAPHIQUES

www.ined.fr

Paris, 20 June 2022

Implementing Act

I herewith confirm that in the framework of the thesis of *doctor habilitat* in medical science "Socio-demographic and regional mortality disparities in the Republic of Moldova" written by Dr. Olga Penina, Associate Professor at *Nicolae Testemitanu* State University of Medicine and Pharmacy of the Republic of Moldova, daily time series of deaths due to COVID-19 registered in the Republic of Moldova and Romania accompanied with metadata were produced according to the standard protocol of the "Demography of COVID-19 Deaths" database.

The standard spreadsheet files and methodological sheets on daily COVID-19 deaths in the Republic of Moldova (18/04/2020 – 19/04/2022) and Romania (22/03/2020 – 21/04/2022) are available on the website of the French Institute for Demographic Studies (INED), Paris https://dc-covid.site.ined.fr/en/.

Should you have any questions or concerns, please do not hesitate to contact me by email arianna.caporali@ined.fr

Arianna Caporali

Coordinator of the Demography of COVID-19 Deaths Database
French Institute for Demographic Studies (INED)

INSTITUT NATIONAL D'ETUDES DEMOGRAPHIQUES
9 cours des Humanités
93322 AUBERVILLIERS CEDEX
ined

Institut national d'études démographiques - Campus Condorcet - 9, cours des Humanités - CD 50004 - 93322 Aubervilliers Cedex - France
Tél. +33 (0)1 56 06 20 00 - Fax +33 (0)1 56 06 21

Declaration of responsibility

Declarația privind asumarea răspunderii

Subsemnatul, declar pe răspundere personală că materialele prezentate în teza de doctorat sunt rezultatul propriilor cercetări şi realizări ştiinţifice. Conştientizez că, în caz contrar, urmează să suport consecinţele în conformitate cu legislația în vigoare.

Penina Olga

Semnătura _____

Data 20/02/2023

CURRICULUM VITAE

PERSONAL INFORMATION

PENINA OLGA

str.Gh. Asachi 58, ap.20, Chisinau, MD-2028, Republic of Moldova

(+373)-22 60-58-89 (+373)-687-904-94

olga.penina@usmf.md

Skype (olga.penina)

Sex fem Date of birth 02/02/1977 Nationality Republic of Moldova

DOMAINS OF COMPETENCE

Public health, demography, epidemiology, biostatistics

WORK EXPERIENCE

2017-present	N. Testemitanu State University of Medicine and Pharmacy of the Republic of Moldova (SUMPh), Department of Social Medicine and Management, associate professor
2014-2017	N. Testemitanu SUMPh, Department of Social Medicine and Management, assistant professor
2013-2016	Academy of Sciences of Moldova, National Institute for Economic Research, Centre for Demographic Research, coordinator scientific researcher
2005-2013	Academy of Sciences of Moldova, Institute of Philosophy, Sociology and Political Sciences, Department of Demography, superior scientific researcher
2004-2005	Academy of Sciences of Moldova, Centre for Medical and Socio-Demographic Research of the Family, scientific researcher

EDUCATION AND TRAINING

01/01/2021-01/01/2023	Post-doctoral study in Social Medicine and Management, N. Testemitanu SUMPh
21/09/2022-14/10/2022	The East European Bioinformatics and Computations Genomics School
01-04/2022	Bioinformatics and Computational Medicine Course, N. Testemitanu SUMPh
14/06/2021-18/06/2021	Data Visualization – The Art / Skill Cocktail – online course, the International advanced studies in demography research training program – The International Max Planck Research School for Population, Health and Data Science
01/03/20221-11/03/2021	Health Systems Management – Leadership and Governance, online course – The International Cooperation Program of the Government of Japan
18-22/02/2019 19-28/09/2018	Clinical Epidemiology Seminar organized by the Réseau d'Epidémiologie Clinique Francophone (RECIF, France). N. Testemitanu SUMPh
05/2017	Specialization program in the field of social medicine and health management, Lucian Blaga University of Sibiu, Faculty of Medicine, Romania, Sibiu
2012	Doctor of medical sciences (doctor în științe medicale). Thesis: Cause-Specific Mortality Trends in Moldova, 1965-2010

2005-2008	Doctoral study in Social Medicine and Management, Academy of Sciences of Moldova, Institute of Philosophy, Sociology and Political Sciences
2000-2003	Clinical Residency in Internal Medicine, N. Testemitanu SUMPh
2001-2003	The State University of Moldova, Institute of Continuing Education, Faculty of Foreign Languages (speciality: English translator)
1994-2000	N. Testemitanu SUMPh, Faculty of General Medicine

PERSONAL SKILLS

Mother tongue Russian

Other language(s)	**UNDERSTANDING**		**SPEAKING**		**WRITING**
	Listening	**Reading**	**Spoken interaction**	**Spoken production**	
Romanian	C1	C1	C1	C1	C1
English	C1	C1	C1	C1	C1
French	A2	A2	A2	A2	A2

Computer skills Microsoft Office, R, VBA, SQL, SPSS

ADDITIONAL INFORMATION

Publications	Over 50 publications, including four collective monographs, one monograph, four didactic materials
ORCiD	https://orcid.org/0000-0002-3884-2751
GitHub	https://github.com/PeninaOlga
Projects	- Post-doctoral research project "Socio-demographic and regional disparities of mortality in the Republic of Moldova" financed by the Government of Moldova; - AXA Project "Mortality Divergence and Causes of Death", participant (2013-2016); - International Project DIMOCHA "From Disparities in Mortality Trends to Future Health Challenges", participant (2013-2017).
Scientific activity abroad	- Invited scientific researcher at French Institute for Demographic Studies (INED, France): 06/2022, 05/2019, 06/2016; 06/2015; 10/2014; 06/2013; 06/2011; 06/2010; 03/2008; 05-06/2007; 10-11/2006. - Invited scientific researcher at Max Planck Institute for Demographic Research (Germany): 01/2016; 01/2017; 04/2013)
Activity in scientific journals	One Health & Risk Management Journal, statistical editor Peer-review: Population Studies, Economy & Sociology, One Health & Risk Management
Memberships	IUSSP, International Union for the Scientific Study of Population since 2013; European Association for Population Studies since 2009

Date 06/02/2022 Olga Penina