Indoor air quality assessment and the risk establishment for the health of the people engaged in the process of preparing food

*Catalina CROITORU[1, 3], Elena CIOBANU[1], Angela CAZACU-STRATU[2]

[1]General Hygiene Department, [2]Hygiene Department
Nicolae Testemitsanu State University of Medicine and Pharmacy
[3]National Centre of Public Health, Chisinau, the Republic of Moldova

*Corresponding author: catalina.croitoru@usmf.md. Received October 05, 2016; accepted December 05, 2016

Abstract

Background: The health state assessment of the inhabitants of the Republic of Moldova in relation to the pollution of the indoor air during the process of preparing food.

Material and methods: The study was conducted in three areas of the Republic of Moldova (North, Center and South). The research was based on the inhabitants' inquiry and some measurements of physical parameters (the temperature, the relative humidity of the air) and some chemical compounds from the air (the carbon dioxide and the carbon monoxide) from the air. The measurements were carried out during summertime, with Air Quality Monitor 500 in 4 stages: before cooking meals, one hour after the beginning of cooking, at the end of the cooking and one hour after the end of preparing dishes. During the research a questionnaire has been completed, which included a number of questions referring the conditions present in the process of cooking meals, the time needed for cooking, the illnesses supported, the type of the cooking appliances, the type of the fuel used.

Results: The analysis of the questionnaires emphasized that half of the respondents have suffered frequently from bronchitis, 28% have been sick with pneumonia, 12% of the people suffered from obstructive bronchitis, 7% – from bronchial asthma and one person – from lung cancer. From the number of the respondents inquired 20% presented a diagnosis of ischemic heart disease and 7% – a stroke. The type of the room in which the people surveyed cooked the meals represents a certain risk in the development of the diseases. There is a huge risk to prepare the dishes in the living room ($2.6 \leq RR \leq 2.9$) for different nosologic forms ($p<0.01$). The relative risk of the appearance of the diseases rose depending of the fuel used: biomass ($3.3 \leq RR \leq 4.5$, $p<0.05$), agricultural waste ($3.5 \leq RR \leq 3.6$, $p<0.01$), hard coal ($3.4 \leq RR \leq 3.5$, $p<0.01$), in comparison to other types of fuel. In cases when the interviewees smoke in the house, the risk is very high ($3.4 \leq RR \leq 5.2$, $p<0.001$).

Conclusions: It is necessary to focus our efforts on the communication strategies in order to motivate the awareness of the need of educational programs intended to inform people about the sources of pollution of the rooms and the health risks.

Key words: indoor pollution, air, cooking, risk, health.

Introduction

According to a study of OMS [6, 7], 3.7 million people died because of the outdoor pollution effects and 4.3 million – as a result of air pollution in the households, that is: smoke and emissions associated with cooking appliances, the fuel used (wood or coal), or because of heating appliances. The most frequent diseases caused by air pollution are the lung diseases, heart diseases and cancer. The study from 2012 also showed that there is a stronger connection, much stronger than it was believed, between air pollution and heart diseases, as well as between lung cancer and air pollution.

Therefore, air pollution is one of the most important global risks of mortality and is to blame for the rise of the risk of suffering from chronic diseases [2, 5]. An important role in air pollution in cooking spaces is played by the type of fuel used. The greatest potential of indoor air pollution is attributed to peasant stoves, which function on such fuel as: wood, brushwood, biomass, agricultural waste, etc.

In rural areas biomass is frequently burnt in traditional stoves with an open fire, in poorly ventilated rooms with smoke emissions. The smoke emitted contains large quantities of pollutants, which lead to severe consequences for the people exposed to it. The study made in India showed that 4-6% of the national burden of the diseases are attributed to the use of solid fuel. The researches made about the use of the fuel in Indian households and the epidemiologic studies of the risks of the indoor air pollution in a series of developing countries indicate that annually approximately 440.000 of premature deaths of children under 5 and 34.000 of female deaths resulted from chronic respiratory diseases, as well as 800 cases of lung cancer can be attributed to the use of solid fuel. The recent study carried out by the World Health Organization established the burden of the diseases slightly smaller in India for the year 2000 [1, 3].

The perceived level of air pollution and the risks associated with health, as the study of the community states, have been reduced among the inhabitants, thus indicating the necessity to grow the awareness of the sources of air pollution and the risks for health associated with them [2].

Material and methods

The study was conducted in three areas of the Republic of Moldova (north, center and south). The research was grounded on the questioning of the inhabitants and the measurements of some physical parameters (the temperature, the relative humidity of the air) and chemical compounds (the carbon dioxide and the carbon monoxide) from the air. The measurements have been made in all types of rooms where the population prepares meals: kitchens, living rooms, summer kitchens, etc.

The measurements were carried out during summertime, with Air Quality Monitor 500. 150 households were included in the study (50 from each geographical area). The stages of data collection were the following: before cooking meals (the I-st stage of measurements), in an hour after the beginning (the II-nd stage of measurements), at the end (the III-rd stage of measurements) of the cooking and an hour after the end of preparing dishes (the IV-th stage of measurements) during summertime. The questionnaire has been composed of 11 items and filled with the help of the method of direct interview. To evaluate the conditions of cooking meals, there have been asked questions about the place of cooking, the type of fuel used, in order to evaluate the influence of the cooking conditions on health, the respondents have been also asked about the diseases from which they suffered. To analyze the risk of the appearance of some diseases related to the type of room used for cooking, the type of fuel used, the presence/absence/functioning of the ventilation, the relative risk (RR), attributable (RA), and the attributable fraction (FA) have been calculated.

The relative risk shows how many times larger is the proportion of the people with certain modifications amongst the ones exposed to the risk factors in relation to the proportion of the people unexposed to the risk factors (tab. 1). The risk evaluation of the factors predisposing to cause the unwanted effects upon the state of health has been done on the basis of the "Table of contingency 2x2". The interpretation of the results for the relative risk in made in relation to 1.

Table 1

The interpretation of the results of the relative risk [4]

RR	Conclusions	RR	Conclusions
RR<1	Protection factor	0.0 – 0.3	Strong protection factor
		0.4 – 0.5	Moderate protection factor
		0.6 – 0.9	Reduced protection factor
RR=1	Indifferent factor	1.0 – 1.1	Indifferent factor
RR>1	Risk factor	1.2 – 1.6	Reduced risk
		1.7 – 2.5	Moderate risk
		>2.5	High risk

The *attributable risk* shows how much higher is the frequency of the unwanted effect upon the ones exposed, in relation to 0. The *attributable fraction* shows the percentage of how much the unwanted effect present at the people exposed is due to the risk factor. In order to establish whether there is a significant difference from the statistical point of view between the groups surveyed, the value of the calculated $\chi 2$ has been compared to the one in the table. The $\chi 2$ table test (with liberty degree=1, for the "Table of contingency 2x2", which has been used in evaluating the risk) presumes a probability of 0.05 at the value of 3.8; 0.01 probability at the value of 6.6 and 0.001 probability at the value of 10.8. If the probability (p) is smaller than the critical value with 0.05, then there is a significant difference between the cases observed and the ones expected, thus the null hypothesis is discarded. Any statistical analysis always includes in a bigger or smaller proportion a series of errors resulted from the sampling (the so-called effects of random sampling), therefore the value RR calculated from the data of the study will not probably be identical to the "real" value of RR. The statistical analysis gives us the possibility to determine the "real" value of RR with the help of the interval of confidence (CI) of 95%, which presumes that in 95% of the cases this interval includes the "real" value of RR. In order to interpret the results of the statistical analysis in a pertinent scientific context, both extremities of the interval of confidence should be analyzed [4].

Results and discussions

The research that has been fulfilled has shown that the indoor air is more polluted in the case of cooking food in the inhabited areas, that is, in the living rooms, thus influencing the state of health of the inhabitants. There has been concluded that even in the cases when the population had rooms used as kitchens, the cooking conditions were not favorable, not corresponding fully to the requirements. When preparing meals in summer kitchens, the chemical and physical parameters of the air were relatively closer to normal values because the respective rooms communicate directly with the outside air. The values of the parameters studied also depend on the type of cooking installations used by the population and the fuel used. The research has shown that the air was more polluted in the case of the usage of peasant stoves. The bottled gas used for the cooker polluted the air even more than the natural gas. Among the types of fuel used in peasant stoves more pollutant were: agricultural waste, biomass, hard coal.

For the purpose of estimating the risk of contracting certain diseases that depend on the type of space used for preparing dishes, the type of cooking appliances, the type of fuel used, the presence/ absence/ functioning of the ventilation, the possibility to open the windows for airing, the duration and frequency of cooking, the smoking, the values of physical and chemical factors present in the spaces used for cooking, there have been calculated: the relative risk, the attributable risk and the attributable fraction. The evaluation of the role of the cooking conditions, the environmental factors in these rooms, through the calculation of the relative and attributable risk, has the purpose to emphasize their prevalence, their hierarchical place and degree of influence, in order to guide us toward the elaboration of a set of measures to reduce their negative impact.

The type of room, where people prepare food presents a certain risk in the disease development. Due to cooking in the living room, there is a high risk ($2.6 \leq RR \leq 2.9$) to contract different nosologic forms ($p<0.01$). 28.3 times ($p<0.01$) are more likely to risk people preparing food in the living room than in kitchens and 21.7 times ($p<0.01$) more than in summer kitchens. In the case of preparing food in kitchens, the risk is moderate (1.8≤RR≤1.9, p<0.01) and the population risks 12.4 times more than those who cook in the open air. The part of the individual risk (RA) that can be attributed to the exclusive connection to the type of room constitutes 0.51 for bronchial asthma, 0.47 for bronchitis and pneumonias, 0.46 for strokes, 0.42 for ischemic heart disease and 0.40 for obstructive bronchitis.

People, who cooked the meals on peasant stoves, present a relatively moderate risk (RR) and risk 42.3 times more in comparison to people who prepared food on cookers. If we select the cases when the peasant stove was placed in the living room, the level of the relative risk rises 2.2≤RR≤2.4, p<0.001 and is 29.4 times higher than when preparing food on cookers. The relative risk of the contraction of diseases increases in relation to the quality of the fuel used: biomass (3.3≤RR≤4.5, p<0.05), agricultural waste (3.5≤RR≤3.6, p<0.01), hard coal (3.4≤RR≤3.5, p<0.01), in contrast to other types of fuel. In cases when people were smoking in the house, the risk rose (3.4≤RR≤5.2, p<0.001).

The absolute risk of suffering from all nosologic forms is much higher in the case of preparing food on peasant stoves (for bronchial asthma – 0.68, for strokes and obstructive bronchitis – 0.64, for the ischemic heart disease – 0.56, for pneumonias – 0.55, for bronchitis – 0.48).

The respondents who prepared dishes on peasant stoves and used agricultural waste present a lower risk (RR=1.3, p<0.001) and can develop bronchitis 18.3 times more often than those who use other types of fuel, those who use biomass (RR=1.2) risk 24.4 times more (p<0.01), when using brushwood (RR=1.4, p<0.05), individuals risk 10.7 times more (p<0.01), when using wood (RR=1.2, p<0.001), they risk 7.5 times more (p<0.001), when using hard coal (RR=1.3, p<0.05) – 18.5 times more (p<0.01), when using processed coal (RR=1.2, p<0.001) they risk 12.3 times more (p<0.01), in comparison to other types of fuel.

Moreover, the respondents who used agricultural waste in the process of cooking, presented a moderate risk (RR=2.2, p<0.001) and risk 25.5 times more to develop obstructive bronchitis, people who use biomass (RR=1.5, p<0.01) risk 27.8 times more (p<0.01), and those who use brushwood (RR=1.4, p<0.01) risk 9.4 times more (p<0.05), when using wood (RR=1.5, p<0.001), they risk 8.5 times more (p<0.01), when using hard coal (RR=1.7, p<0.01) they risk 15.1 times more (p<0.01), when using processed coal (RR=1.5, p<0.01) they risk 14.2 times more (p<0.01), in comparison to other types of fuel.

Thus, people who used agricultural waste are subjected to moderate risk (RR=1.9, p<0.01) to develop pneumonias, 21.3 times more often (p<0.001) than those who use other types of fuel, if biomass is used (RR=1.7, p<0.001), people are subjected to a risk 24.4 times higher (p<0.01), if using brushwood (RR=1.4, p<0.001) people are subjected to a risk 10.7 times higher (p<0.01), if using wood (RR=1.5, p<0.001), people risk 7.5 times more (p<0.001), hard coal – (RR=1.9, p<0.05) people risk 18,5 times more (p<0.01), when using processed coal - (RR=1.8, p<0.01) people risk 12.3 times more (p<0.01), in comparison to other types of fuel.

In the case when people used agricultural waste in the process of cooking on the peasant stove, they are subjected to very high risk (RR=2.3, p<0.001), thus risking to develop bronchial asthma 36.6 times more often than (p<0.001), people who use biomass (RR=2.1, p<0.01) risk 28.7 times more (p<0.01), and those who use brushwood (RR=1.9, p<0.01) risk 22.3 times more (p<0.01), when using wood (RR=1.6, p<0.001), they risk 16.4 times more (p<0.001), when using hard coal (RR=2.4, p<0.001) they risk 26.3 times more (p<0.01), when using processed coal (RR=1.9, p<0.05) they risk 21.6 times more (p<0.01), in comparison to other types of fuel.

A relatively moderate risk (RR=2.1, p<0.001) has been detected for the development of strokes and people who used agricultural waste may have a stroke 33.1 times more often (p<0.001), if biomass is used (RR=2.1 p<0.05) people are subjected to a risk 20.7 times higher (p<0.01), if using brushwood (RR=1.7, p<0.001) people are subjected to a risk 8.3 times higher (p<0.01), if using wood (RR=1.8, p<0.001) people risk 8.1 times more (p<0.001), hard coal - (RR=2.2, p<0.001) people risk 14.6 times more (p<0.01), when using processed coal (RR=1.9, p<0.001 people risk 11.8 times more (p<0.01), in comparison to other types of fuel. The attributable risk varies between 0.50 and 0.68 for different kinds of fuel used in the case when people who suffer from obstructive bronchitis and strokes: 0.46-0.54 – in the case of people with bronchial asthma, pneumonias and ischemic heart diseases and 0.44 at people with bronchitis. The usage of less harmful fuel could prevent from 54.3% (bronchitis) to 82.5% (asthma) of illnesses.

The lack of ventilation in the kitchens constitutes a lower risk (1.4≤RR≤1.6, p<0.01), in the living room – a very high risk (2.9≤RR≤3.7, p<0.001), in the summer kitchens – a reduced risk (1.3≤RR≤1.5, p<0.05), and if applying ventilation measures, there can be prevented from 32.3% to 41% of specific diseases. The presence and the functioning of the ventilation systems in the kitchens, the presence and the possibility to open the windows, the presence of the ventilation duct in the living room and summer kitchens represent a major factor of protection; in the kitchens – constitute a major factor of protection (R=0.2, p<0.05), the living room (R=0.3, p<0.01), and in the summer kitchens (R=0.5, p<0.001) – factor of moderate protection.

The part of the absolute risk which is directly connected to the lack of an adequate ventilation system constitutes 0.88 for bronchial asthma, 0.64 for the ischemic heart diseases, 0.61 for obstructive bronchitis, 0.54 for strokes and pneumonias, 0.50 for bronchitis. In many spaces where food is prepared the conditions are unfavorable due to the lack of windows or their not being functional. This situation presents an absolute risk of 0.55 for obstructive bronchitis, 0.53 for strokes, 0.46 for the ischemic heart diseases, 0.41 for bronchial asthma, 0.40 for pneumonias, and 0.37 for bronchitis.

Calculating the risk in relation to nosology, it has been established that people who prepared food in the living room on the peasant stove, using biomass, agricultural waste and brushwood as fuel, the ventilation being insufficient and the respondents being smokers, all of this presents a very high risk of developing bronchial asthma (R=7.9, $p<0.001$), obstructive bronchitis (R=6.5, $p<0.01$), pneumonias (R=7.1, $p<0.001$), strokes (R=6.6, $p<0.001$), the ischemic heart diseases (R=6.4, $p<0.05$) and moderate risk present to develop bronchitis (R=1.9, $p<0.05$).

People who cook dishes in conditions with high temperature and air humidity are put at risk to develop pneumonias (R=4.2, $p<0.01$), strokes (R=3.7, $p<0.001$), ischemic heart diseases (R=3.5, $p<0.001$), risk moderately to develop obstructive bronchitis (R=1.8, $p<0.001$), bronchial asthma (R=1.8, $p<0.001$) and present very high risk to develop bronchitis (R=1.4 $p<0.001$). These people risk 38.6-67.4 times more than people who cook at lower values of physical factors. The absolute risk based on the modification (surpassing the norms) of the physical factors from the cooking spaces constitutes 0.53 for obstructive bronchitis, 0.51 for bronchial asthma, 0.48 for pneumonias, 0.47 for bronchitis, 0.46 for ischemic heart diseases and 0.40 for strokes.

The concentration which exceeds the norm of carbon dioxide presents a very high risk in developing bronchial asthma (R=8.5, $p<0.05$), ischemic heart diseases (R=6.8, $p<0.01$), obstructive bronchitis (R=5.5, $p<0.001$) and reduced risk to develop bronchitis (R=1.4, $p<0.01$), pneumonias (R=1.4, $p<0.001$), strokes (R=1.2, $p<0.001$). People subjected to excess carbon dioxide risk 46.8-63.4 times more than the ones who cook in conditions with normal concentrations of carbon dioxide. The undesirable effect (RA) upon the population exposed to the higher concentration of carbon dioxide is 0.47 for bronchial asthma and obstructive bronchitis, 0.43 for the ischemic heart diseases, 0.41 for pneumonias and bronchitis and 0.36 for strokes.

In cases when carbon monoxide exceeds the norm, the population risks very much to develop bronchial asthma (R=7.1, $p<0.001$) and obstructive bronchitis (R=6.3, $p<0.01$), risks moderately to develop strokes (R=2.4, $p<0.001$), ischemic heart diseases (R=2.4, $p<0.01$) and present a low risk to develop bronchitis (R=1.5, $p<0.01$) and pneumonias (R=1.2, $p<0.05$).

People who prepare food in conditions with increased concentrations of carbon monoxide risk 67.4-72.1, four times more than those who cook in conditions with normal carbon monoxide concentrations. The absolute risk of the appearance of nosologic forms specified by the respondents who cook in rooms with carbon monoxide concentration that exceeds the norm is also different and constitutes 0.67 for the ischemic heart diseases, 0.55 for bronchial asthma, 0.53 for strokes, 0.50 for obstructive bronchitis, 0.46 for pneumonias and 0.45 for bronchitis.

Reducing the duration and the frequency of food preparing, excluding the effect of the physical and chemical factors in the rooms attributed to cooking meals, there can be prevented 56.0% of cases of obstructive bronchitis, 54.3% of bronchial asthma, 51.3% of ischemic heart diseases, 45.8% of the cases of pneumonias, 44.6% of bronchitis, 29.4% of cases of strokes.

Conclusions

The results of this research may help the factors of decision to become aware of the need of educational programs intended to ensure the inhabitants with information about the sources of pollution of the indoor air and the risks they are subjected to. It is necessary to focus our effects upon the communication strategy to motivate the direct personal perception or to become aware of the environmental problems, such as air pollution. Such an approach enhances the understanding of the importance of the measures taken by the environmental policies, which make these measures easier to be received by the inhabitants, as well as to improve the personal feedback in reducing the impact of pollutants.

Without a substantial change in the policies, the total number of people who depend on solid fuel will mostly remain unchanged. The use of the pollutant fuel represents a major burden for steady development. There is also acute need of additional research in the public perception area, in order to help to understand the factor which shapes human perception. The project was done during summertime. It would be necessary to carry out a similar project with measurements during winter.

References

1. Balakrishnan K., Mehta S., Kumar P., Ramaswamy P., Sambandam S., Kumar K. S. and Smith K. R. Indoor air pollution associated with household fuel use in India: An exposure assessment and modeling exercise in rural districts of Andhra Pradesh, India. In: *Energy Sector Management Assistance Programme*, World Bank, Washington DC, USA. 2004, 114 p.
2. Egondi T., Kyobutungi C., Ng N., Muindi K., Oti S., Vijver S., Ettarh R., Rocklov J. Community perceptions of air pollution and related health risks in Nairobi Slums. *Int J Environ Res Public Health*. 2013; 10(10): 4851-4868.
3. Moshammer H, Fletcher T, Heinrich J, Hoek G, Hruba F, Pattenden S, et al. Gas cooking is associated with small reductions in lung function in children. IN: *Eur Respir J.* 2010, 36(2):249–54.
4. Mărușteni M. Noțiuni fundamentale de biostatistică: note de curs. Târgu-Mureș: University Press, 2006. 218 p.
5. Simon G. L., Bailis R., Baumgartner J., Hyman J., Laurent A. Current debates and future research needs in the clean cookstove sector. In: *Energy Sustain Dev*. 2014; 20:49 - 57.
6. WHO. Household air pollution and health. Fact sheet N°292, 2014. Available at: http://www.who.int/mediacentre/factsheets/fs292/en/ (seen 06.03.2016).
7. WHO. Ambient (outdoor) air quality and health. Fact sheet N°313, 2014. Available at: http://www.who.int/mediacentre/factsheets/fs313/en/ (seen 13.01.2016).

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