

Bulgarian public opinion survey for risk perception including radon and suggestions for communication

J.N. Djounova^{a,*}, K.G. Ivanova^b

^a Radiation Medicine & Emergency Department, National Centre of Radiobiology and Radiation Protection, Sofia, Bulgaria

^b Radon Analysis Department, National Centre of Radiobiology and Radiation Protection, Sofia, Bulgaria

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ABSTRACT

The paper reviews and analyses the results of STEAM survey of the Bulgarian population. A Survey and the preparation of a questionnaire were initiated within the framework of the IAEA Project RER9153 “Enhancing the Regional Capacity to Control Long-Term Risks to the Public due to radon in Dwellings and Workplaces”. The survey includes 1003 respondents from the Bulgarian adult population 18+. The main conclusions are:

The health of the Bulgarian people is mostly assessed as satisfactory (38.7%) and all respondent considers a person's health better than the people's health as a whole. The main risk factors that can affect the health of Bulgarians are: Stress; Unhealthy nutrition; Smoking; Polluted air/dust; Health system - difficult access, improper treatment; Economic situation - low income; Alcohol; Lack of physical activity. Risks such as Environment; Working place and Lifestyle (harmful habits) are below 10%. The general awareness of radon and associated risks with it is very low among the Bulgarian adult population: 78% know nothing or very little about the health risks of radon. Almost half of the population doesn't know if home radon testing is a priority for them. About 30% of Bulgarians think that there is no point in testing the home they live in since they always maintain good ventilation. The population does not recognize the National Radiation Protection and Public Health Authorities as a trusted source of health risk information. The internet and social media are the main sources of information regarding health risks. The most important result that should be taken into account when building a new communication strategy is the fact that nearly 40% of the respondents declare that they are informed about health risks by general practitioners (GP), and the trust in them is over 50%.

1. Introduction

Indoor radon is one of the most important indoor air pollutants, which could cause harmful health effects on the population (World Health Organization, 2009). Many authors suggest that the inhalation of radioactive radon-222 (²²²Rn) gas is the cause of lung cancer in North America and Europe among people who have never smoked (Gaskin et al., 2018; Grundy et al., 2017; Kim et al., 2016; Lorenzo-González et al., 2019; Pearson et al., 2016; Stanley et al., 2019).

The European Commission sets a limit on the Member States' reference level for the average annual radon concentration of 300 Bq/m³, taking into account the different conditions in countries (COUNCIL DIRECTIVE 2013/59/EURATOM of, 2013). Furthermore, Member States should establish and implement a radon action plan for addressing long-term risks from radon exposure. Measurements of indoor radon

concentrations are the only way to objectively assess the risk of radon exposure and a basis for policy development and taking adequate measures to protect public health. But, the effective engagement of stakeholders seems crucial for achieving the aim of health policy to protect the Bulgarian population: an emphasis on health promotion and disease prevention (Strategic Health Policy Framework to, 2020). Risk communication is an essential part of shared decision-making and evidence-based patient choice (Edwards et al., 2009). Risk communication is defined as: “The open, two-way exchange of information and opinion about risk, leading to a better understanding of the risk in question, and promoting better (clinical) decisions about management” (Ahl et al., 1993). Evidence suggests that greater levels of informed choice are associated with greater satisfaction with the process of care and, crucially, improved adherence to the chosen treatment (O'Connor et al., 2003). Waldron et al. (2011) highlight the importance of

* Corresponding author. Radiation Medicine & Emergency Department, National Centre of Radiobiology and Radiation Protection, 3 St. Georgi Sofiiski str., Sofia, Bulgaria.

E-mail address: jdjounova@ncrrp.org (J.N. Djounova).

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communication strategies that promote belief and behavior change in their review of effective methods of communicating cardiovascular risk to patients. The presentation of information for the risk and then assimilation of that information for health decision-making is the main goal of communication campaigns in public health. The mission of the radon communication strategy is to give information about the harmful factor, the ways of measuring and reducing the concentration of radon in buildings, and to improve the air quality in them (World Health Organization, 2009). Many social and psychological factors influence how people perceive risks (Sjoberg, 2003). The risk perception is strongly affected by distrust between the public and the communicators and uncertainties and knowledge gaps in the risk assessment (Chauvin et al., 2008). Radiation risk communication is also confounded by the fact that the public's perception of radiation risk differs from that of the experts (Perko, 2014).

There are no systematic studies in Bulgaria on radiation risk perception, but there is radiophobia related to previous incidents and poor communication. The communication of radon risk and prevention messages poses serious challenges because radon is not widely known and may not be perceived as a health risk by the public (Makedonska et al., 2018). A Communication Strategy – “one size fits all approach” (Bouder et al., 2021), had been a part of the first National Radon Program 2013–2017. We used STEAM survey to determine if the Strategy thus developed has yielded results also.

The survey has done a general study on risk perception and ways of communication including radon risk perception. The STEAM survey aims to determine the degree to which information on radon was assimilated by respondents and identify possible failures in risk communication, assess respondents' readiness to measure indoor radon concentration in their homes, and take protective actions, if necessary, identified the sources of information on health risk factors, including radon. A Survey and preparation of a questionnaire were initiated within the framework of the IAEA Technical Cooperation Project RER9153 “Enhancing the Regional Capacity to Control Long-Term Risks to the Public due to radon in Dwellings and Workplaces”. In this paper, we present the results of the STEAM survey for the Bulgarian population and made an analyze for further development of an effective radon risk communication strategy.

2. Material and methods

Dates are based on the results for the Bulgarian population from the National Statistical Institute (National Statistical Institut, 2020). The survey includes 1003 respondents from the Bulgarian adult population 18+. The number of responders was evaluated under the supposed random sampling error of 2.2% for a 95% confidence interval.

2.1. Distribution of the questionnaire (survey)

The questionnaire was prepared within the framework of the IAEA RER 9153 in the English language. After the translation, the questionnaire was adapted by National Centre for Radiobiology and Radiation Protection (NCRRP) in Bulgarian. In addition, we carried out a pilot study to refine the wording of the questions. Participation in the survey was voluntary. We tested the comprehensibility of different audiences. The questionnaire was divided into five parts: socio-demographic data; general health; radon; risk perception and information sources. The questions about radon include: general knowledge about radon and health risk due the radon exposure; testing the radon in the home; taking actions to reduce the radon level in the house.

The research is quantitative and nationally representative. Sampling: the model is compiled based on Statistics Bulgarian's population statistics database by sex, age, region, and type of settlement. The Data collection method - Computer-Assisted Web-based Interview (CAWI).

3. Results

3.1. Bulgarian demographic data

Demographic data, based on the results for the Bulgarian population from the National Statistical Institute (O'Connor et al., 2003), the total population of Bulgaria is 6,838,937 and consists of 3,311,311 males (48.42%) and 3,527,626 females (51.58%). The population in urban areas is larger than that in rural areas. According to NSI, 73.12% of the population lives in urban areas and 26.88% in rural areas. The adult population (18+) is 84.5% of all and 28.94% of them are over 65 years.

3.2. Socio-demographic data of survey participants

The survey includes 1003 respondents from the Bulgarian adult population 18+, 51.30% female and 48.70%, male. The age groups of the respondents in percentage are 11.80% of the age group 18–24 years old; 33.30% of the age group 25–44-year-olds; 33.20% of 45–64-year-olds and 21.70% over 65. Most of the respondents which comprise 94.10% don't work in the field of ionizing radiation. In terms of education, 48.30% completed university, and 50.80% completed secondary school. The information about the type of home, type of settlement (residence), and monthly household income is presented in Table 1.

3.3. Evaluation of the general health

The questionnaire starts with the questions “How do you think your health is in general?” and “How do you think the health of Bulgarians in general is?” There are no differences in answers to this question by age and by “Type of settlement”.

The health of the Bulgarian people is mostly assessed as satisfactory (38.7%), in addition, 18.2% assessed it as good. 37.3% consider the general health of the Bulgarian people to be bad. At all ages, the response “satisfactory” and “poor” are almost equal in value, except for the 18–24 age, where the answer “satisfactory” predominates. Comparison of the opinion about one's health and the health of Bulgarians show that all respondent considers a person's health better than the Bulgarian people health as a whole (Fig. 1).

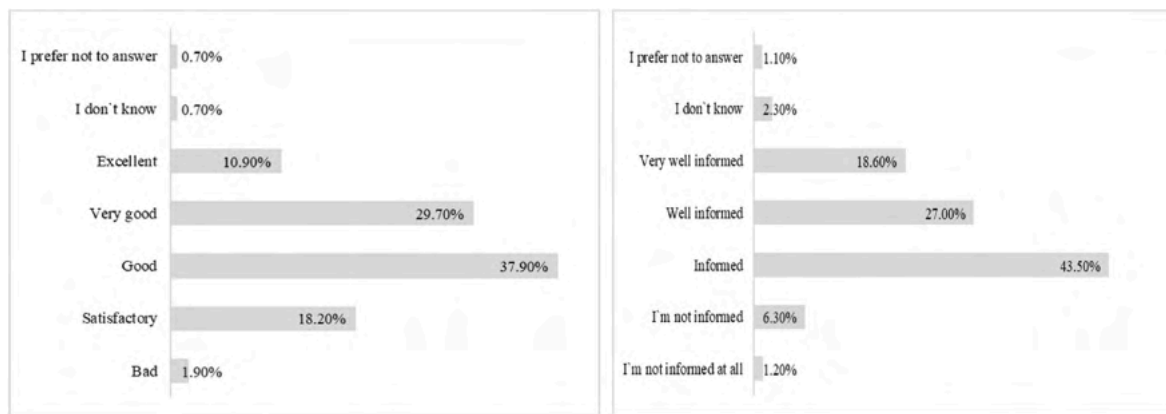
3.4. Risk factors, affecting the health

Regarding the information on the risk factors for health, most Bulgarians consider themselves to be quite aware of these potential risks (89.1%). This is the predominant answer for all age categories. In case of potential risks affecting the health of the population, the majority of

Table 1

Type of home, type of settlement (residence), and monthly household income of the respondents.

Monthly household income	Less than the minimum income	3.50%
	Above the minimum income but less than the average income	37.40%
	Above the average income but less than the maximum income	44.80%
	Above the maximum income	5.90%
	I prefer not to answer	8.40%
Type of home do you live	One family house	19.60%
	Two-story house	18.10%
	Dormitory	0.70%
	Other types of the detached house	5.10%
	Apartment or floor of a building	19.20%
	Apartment, a residential unit in a multi-story building	37.10%
	Other	0.20%
Type of settlement	Sofia	17.20%
	Other Cities	13.10%
	Towns	47.80%
	Villages	21.90%



a) Bulgarians' health evaluation

b) Self-evaluation of health

Fig. 1. Comparison of perceptions of the health.

respondents declare feel informed (79.1%). Awareness of one's health risks is normally higher than that of the general public.

The main risk factors that can affect the health of Bulgarians are: Stress, tension, mental strain; Food, unhealthy nutrition, malnutrition; Smoking; Polluted air/dust; Health system - poor, difficult access, improper treatment; Economic situation - low income, unemployment; Alcohol; Lack of physical activity (the factors are presented in descending order). Other risks such as Environment - unhealthy, polluted; Working place, working conditions; Overweight, obesity or Lifestyle - general (harmful habits, unhealthy, tense) are below 10%. The results are presented in Table 2.

Notably, significantly more women than men define stress as the most significant risk factor for their health, whereas more men define it as a general disease. For all age groups, stress, food, general disease, and polluted air are the four main problems, but more young people, than the other age groups, consider polluted air a main health risk. The difference between Sofia and the inhabitants of small villages is that dirty air is a major health risk for the capital citizens. Respondents from other places - indicate the diseases as a major problem. With low risk or no risk for the individual and national health are considered 2 h' fly plane, security checks with X-ray and diagnostic medical radiation.

More than half of Bulgarians declare that they know how to protect

Table 2
Data for Risk factors, affecting the health.

	All respondents	Gender		Age			
		Female	Male	18-24	25-44	45-64	over 65
Total	1003	514	489	118	334	333	217
Stress, tension, mental strain	42.30%	46.20%	38.30%	35.30%	42.60%	43.10%	44.50%
Food, unhealthy food, wrong/wrong/unhealthyon, malnutr	41.40%	44.30%	38.40%	40.20%	40.40%	42.20%	42.40%
Smoking/cigarettes	19.10%	17.90%	20.30%	20.40%	21.70%	16.90%	17.70%
Polluted air/dust	19.00%	20.60%	17.30%	23.70%	21.00%	17.70%	15.30%
Health system - poor, difficult access, improper treatment	16.80%	14.70%	19.10%	13.20%	16.50%	16.00%	20.70%
Economic situation - low income, unemployment, financial	16.10%	16.10%	16.20%	14.00%	13.60%	15.70%	21.70%
Alcohol	14.30%	12.20%	16.60%	13.60%	16.50%	14.20%	11.90%
Immobility, stagnation, lack of physical activity, non-exe	14.20%	12.50%	16.10%	13.30%	16.20%	14.80%	10.90%
General disease - allergy, blood, heart, flu	10.20%	8.80%	11.70%	4.80%	11.40%	9.10%	13.10%
Lifestyle - general/harmful habits, unhealthy, tense/	9.80%	9.70%	9.80%	12.40%	10.40%	9.50%	7.80%
Environment - unhealthy, polluted	9.30%	11.00%	7.50%	8.80%	7.30%	11.00%	9.90%
Overweight, obesity	8.80%	7.60%	10.00%	7.20%	9.90%	8.10%	9.00%
Covid	7.80%	6.70%	8.90%	8.70%	6.80%	7.20%	9.70%
Anti-epidemic measures - non-compliance, not wearing mask	6.80%	7.20%	6.50%	6.90%	5.20%	9.70%	4.90%
Lack of information	4.20%	4.10%	4.20%	1.90%	3.60%	4.50%	5.70%
Infection with viruses, bacteria	4.20%	4.50%	3.80%	2.70%	5.50%	3.10%	4.50%
Not good hygiene	3.70%	3.50%	4.00%	4.20%	4.80%	2.70%	3.50%
Climate/weather, cold, variable	2.60%	1.80%	3.50%	5.20%	2.80%	2.50%	1.20%
Contacts, communication with people-general	2.60%	1.50%	3.70%	2.00%	3.40%	2.30%	2.10%
Poor quality of water	1.50%	2.20%	0.70%	1.30%	1.70%	2.10%	0.30%
NA	1.40%	1.50%	1.40%	2.20%	3.00%	0.40%	0.30%
Self-medication, medication	1.40%	1.80%	1.00%	1.80%	2.40%	0.60%	1.10%
Working place, working conditions	1.30%	2.00%	0.60%	0.80%	0.30%	1.50%	2.90%
Fatigue/over fatigue, overload, physical exertion, insult	1.30%	1.00%	1.60%	0.00%	1.50%	2.10%	0.50%
Heredity, family/genetic predisposition	1.10%	0.90%	1.20%	2.20%	0.50%	1.70%	0.30%
The age	1.10%	0.60%	1.50%	5.60%	0.70%	0.30%	0.30%
Drugs/caffeine	0.90%	0.80%	0.90%	0.00%	0.70%	1.40%	0.90%
Contact/closeness with patients with Covid 19	0.70%	0.80%	0.50%	0.90%	0.40%	0.00%	2.00%
Accident, incident	0.50%	0.60%	0.30%	0.80%	0.30%	0.60%	0.30%
Insomnia	0.40%	0.70%	0.00%	0.00%	0.00%	0.80%	0.30%
None	0.20%	0.10%	0.40%	0.80%	0.20%	0.20%	0.00%
Weak/lowered immunity	0.10%	0.30%	0.00%	0.00%	0.00%	0.40%	0.00%

themselves from any risk factors that could affect their health. Generally, women feel like they have less control than men. The lowest share of those who agree with it is among people aged between 45 and 64 years old, as well as, among those living in Sofia. More than 1/3 of the population completely disagrees or disagrees that it has control over the risk factors for its health, and another 1/3 neither agrees nor disagrees. Less people, living in Sofia think they have control over the risk factors, whereas more people living in villages tend to think so.

51% of respondents agree that the decisions regarding health risks must be taken by experts. Maximum consent is demonstrated in the cities and minors in the village. The statement that home air quality is very important for health is the most agreed of respondents (90.4%). The residents in towns were more likely to agree with the statement (93.4% agreed), the height-educated people, the people with more income, and those over 64 (94%). More than 90% of the people say that regardless of the weather they try to keep their homes well-ventilated.

3.5. Awareness of radon and associated risks

The general awareness of radon and associated risks with it is very low among the Bulgarian adult population: 77% admit they know nothing or very little about radon; 78% know nothing or very little about the health risks of radon radiation. The information on the knowledge of radon and health risk are presented in Fig. 2a and b respectively. Most people think that radon is a radioactive gas, but they don't know if it is a problem in the area where they live. The highest awareness is among people aged above 65 years old.

In order to understand their attitudes towards radon, respondents were presented with various statements and asked to assess the extent to which they agreed with them:

- Most people would not test their home for radon radiation but they would take action in case of high levels of radon in their home;
- More than half of the population admit that the decision to take action to reduce the level of radon in their home does not depend entirely on them; the average assessment of women is lower than the one of men;
- Almost half of the population doesn't know if testing home for radon is a priority for them, half of the population also doesn't know if testing for radon is easy;
- About 30% of the Bulgarian adult population think, that there is no point in testing the home they live in for radon radiation, as they always maintain good ventilation; another 36% hesitate about the issue – they neither agree nor disagree with that opinion;

In the answer to another question “I would take immediate action to reduce the level of radon in my home” (Fig. 3), the vast majority (78%) of the surveyed population stated they would undertake immediate actions to reduce the level of radon in their homes in case high levels of

radon are recorded there. 60% of the people agree with the opinion that reducing the level of radon in their home is a priority over taking action on other risk factors in case of registered high levels of radon (Fig. 4).

This discrepancy is due to the very low awareness of radon and associated risks.

3.6. Communication of the health risks

One of the main aims of the communication strategy is to establish the level of public trust and credibility towards different communication channels when receiving information concerning health risks.

In the STEAM survey, we again analyze the preferred sources of information regarding health risk (Fig. 5) and the trust in them (Fig. 6).

The answer shows that the internet, followed by social media are the main sources of information regarding health risks. 43.8% indicate the Internet, 18.9% - social media, and 17.5% - television. It must be concluded that a successful campaign would be carried out in an electronic environment (including radio not indicated as a preferred medium). Distrust of public health structures ranges between 37 and 45%. The most important result that should be taken into account when building a new communication strategy is the fact that nearly 40% of the respondents declare that they are informed about health risks by general practitioners (GP), and the trust in them is over 50% (54.5%). These data are extremely important because they show a previously unexploited opportunity to provide information and send appropriate messages.

4. Discussion

The majority of Bulgarians consider their health to be satisfactory or good and there is no statistical difference between self-evaluation of health and the health of the nation. The difference is noticeable only in the younger (18–24 years). The same result was published for the STEAM survey of the Russian public (Waldron et al., 2011) and the Albanian population (Sjoberg, 2003).

The opinion of Bulgarians differs from the results published by Davidov and al. concerning the main health risks. According to the Russians, they are environmental, i.e. related to the state of the environment, bad habits, various diseases, lifestyle, stress, COVID-19, poor-quality food, and drinking water.

For all age groups, stress, food, general disease, and polluted air are the four main problems, but more young people, than the other age groups, consider polluted air a main health risk. The difference between Sofia and the inhabitants of small villages is that dirty air is a major health risk for the capital citizens. Respondents from other places - indicate the diseases as a major problem. This result is influenced by different factors including the often published in the media about the polluted air in big Bulgarian cities and started procedures in the EU concerning this issue.

Regarding the prioritization of the risks for individual and national

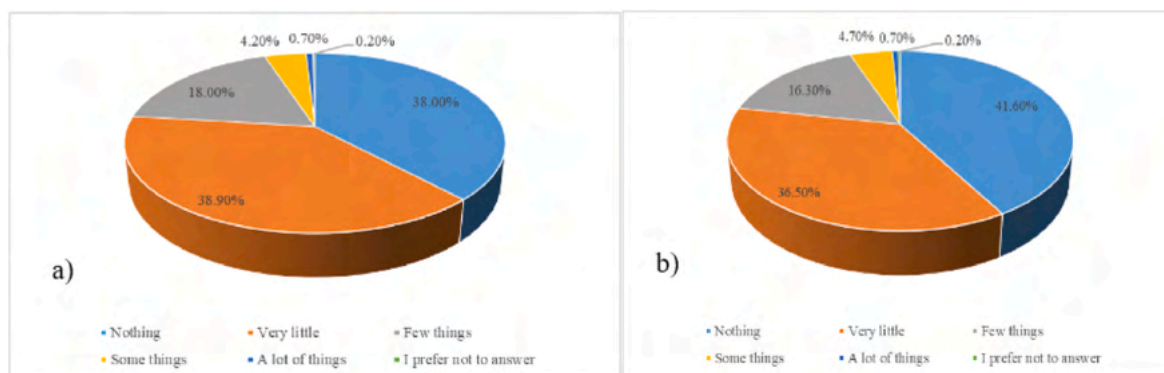


Fig. 2. a) Awareness of radon and b) Knowledge of health risks due to radon exposure.

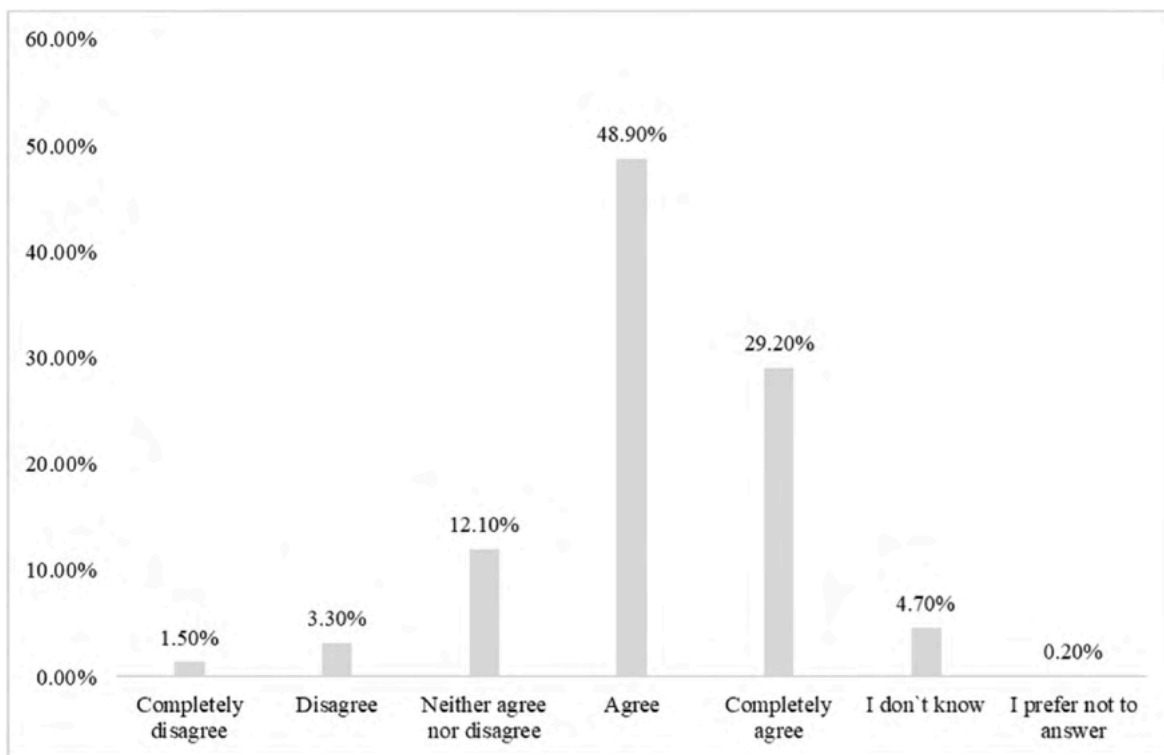


Fig. 3. I would take immediate action to reduce the level of radon in my home.

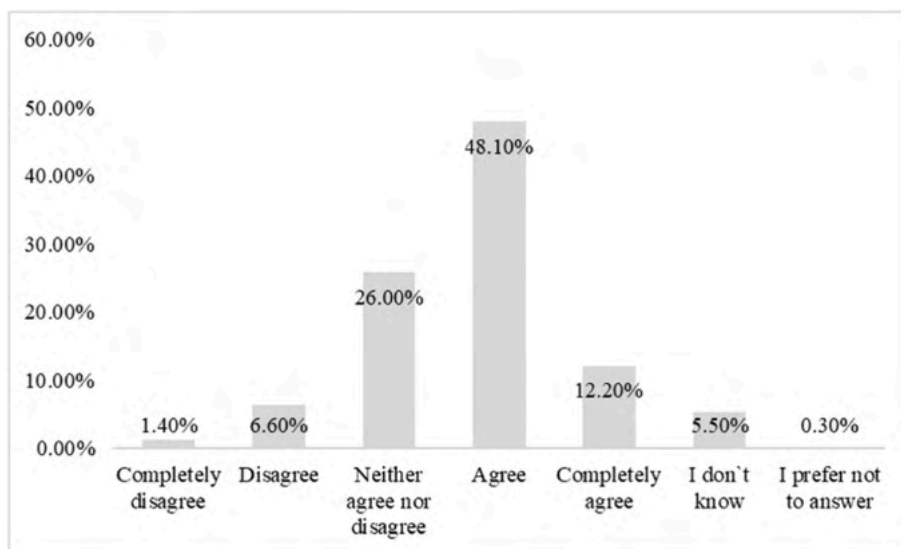


Fig. 4. Reducing the level of radon in my home is a priority over taking action on other risk factors.

health from ionizing radiation, the highest risks are considered areas with high natural radioactivity and nuclear power plant. Bulgarian citizens don't identify medical exposure as a health risk. This result is worrying in the context of the formation protective healthy culture, and the justification as a basic principle of radiation protection of the patients. Other authors also noted the discrepancy between risk perception and real risk (La Verde et al., 2020). In general, people considered natural sources less risky than artificial ones.

Regarding the awareness of radon, 77% of adult Bulgarians admit they know nothing or very little about radon. The previous study (Makedonska et al., 2018) shows that 80% of respondents have heard about radon. This high percentage of answers may be due to the fact that

the people who volunteered to fill the questionnaire have a high level of education. But in fact, only half of that 80% have a thorough understanding of the gas and the areas where it usually could be encountered. The percentage of people who know the underlying health effects of radon exposure is high (77%) but have no correct understanding of the health problems which are possible to be induced by radon. Only 66% of people answering the questions know the correct answer about the health effects and 56% of them have known the connection between the health effects of radon and smoking. Even surveys conducted among medical professionals show that knowledge of the health effects of radon is not high (Hazar et al., 2014). About 67% of responders had heard about radon before the study and of these, 83.5% recognized it as being

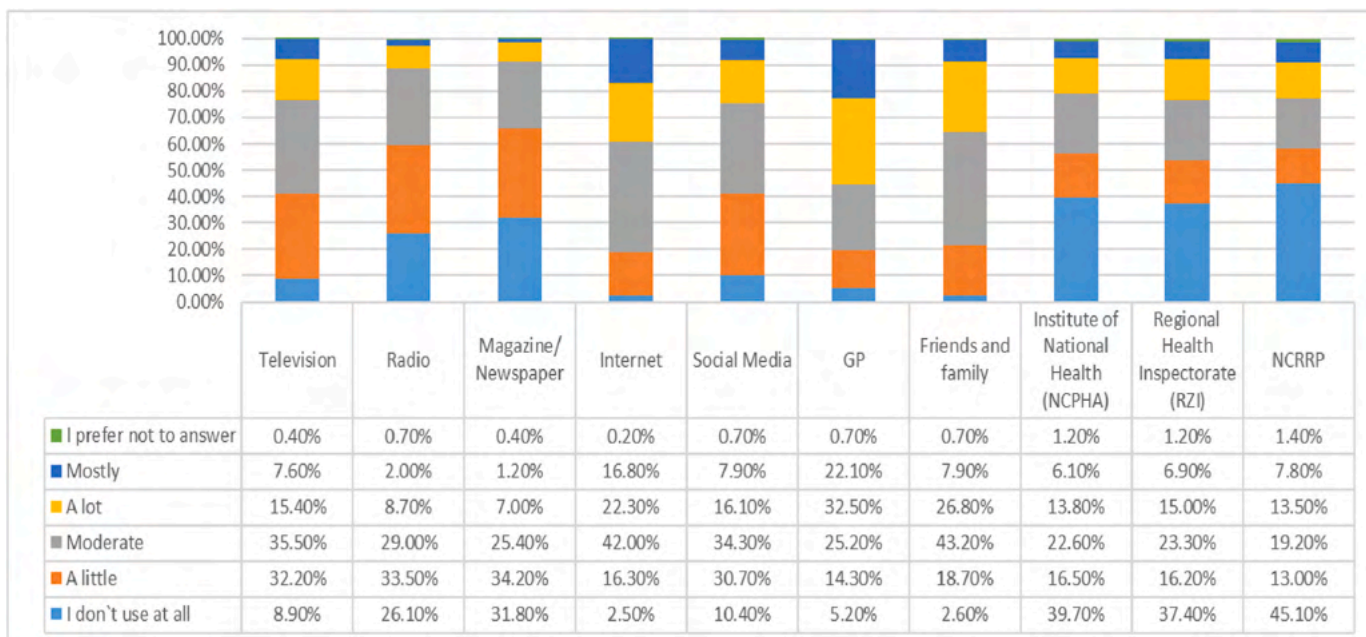


Fig. 5. Confidence in health risk information resources.

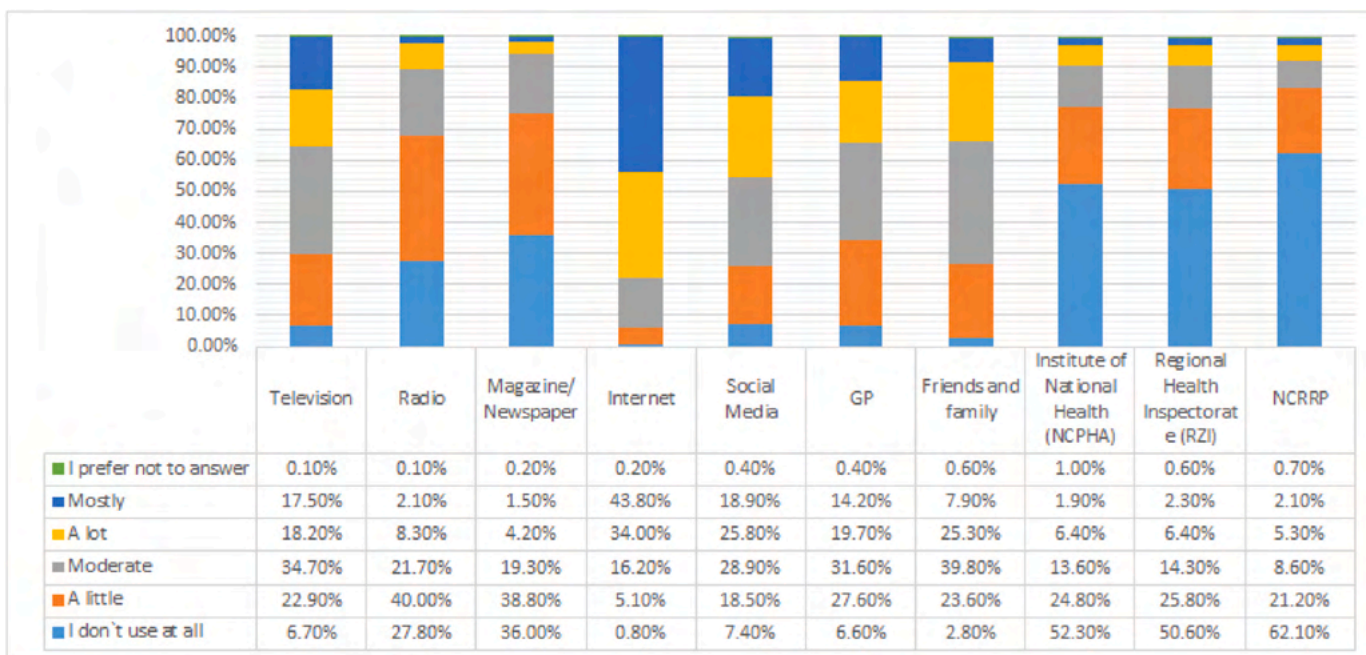


Fig. 6. The most commonly used health risk information resources.

hazardous, but only 34.5% identified lung cancer as the main health outcome of exposure to radon.

Poortinga et al. (2011), found that the participation of local authorities is important to the levels of awareness of the community – in this case they had higher levels of awareness and were more likely to have tested their home for radon. Communication messages are more effective when they are targeted at stakeholders with their specific differences with regard to individual risk, individual barriers, and needs (Cronin et al., 2020).

Studies by other Bulgarian authors (Chobanova et al., 2020) show that 70% of all survey participants know what radon is, but a relatively small percentage of people who have “heard of radon” identify it as a

cause of lung cancer. The percentage of respondents who have more knowledge about the source and potential effects increases with increasing educational level. G. La Verde et al. also highlight awareness seems to be related to the degree of knowledge on the topic and the educational background. The research done by Pugliese unequivocally shows that including radon risk information in high school students’ education significantly increases awareness.

In comparison with the answers in the STEAM survey of the Russian population (Davydov et al., 2021), Bulgarians are better informed (only 23.2% of Russian respondents had heard “something” about it, and another 8.5% said they knew “quite a bit” or “a lot” about it). The results of the Albanian survey (Tushe et al., 2022) also demonstrated very little

or no knowledge about radon (77% had no knowledge). These results are not related to dramatic differences between the information and education of the population. We think that this is due to the time of the start of the radon risk evaluation.

The first national program related to the survey of radon in dwellings in Bulgaria started in 2013. Even with the launch of the first National program to assess the risk of radon exposure in homes in 2013–2018, it was established that the Bulgarian population was not informed about this health risk. In 2014, we launched a “Survey to establish the state of awareness of the population about the risks of radon” ([National Radon Programme Report, 2018](#)). The questionnaire was prepared based on the Questionnaire of the EU Project “Radon Prevention and Remediation” ([European Commission](#)). The obtained results show that the Bulgarian population is still not familiar with this problem. The fact that only 321 people took a survey out of 10,227 page views shows that people are not interested. In the following years, we tried to increase the awareness of the population and form active behavior in the direction of taking measures to reduce the risk of radon. Through all these years, we realize the communication strategy that includes the distribution of information for radon and the associated health risks. Effective communication is part of the risk analysis process and is necessary for the management of information and opinion related to real and perceived hazards. It is essential to inform the public in ways that do not create undue apathy, complacency, or overconfidence while not creating undue stress or alarm ([U.S., 2010U.S.](#)). We employ the communication methods that begin by widely broadcasting radon exposure health effects through messaging targeting the general public. Communications about health and environmental hazards tend to focus on the cognitive (rational and information-related) aspects; however, research shows that individuals’ actions are also driven by the emotional aspects of risk. Information is the driver of behavior only if it is able to overcome the many biases that individuals have in processing risk information. The perception of radon risk is subject to unconscious, cognitive, and emotional biases that influence the way information is processed: radon risk is perceived as distant, uncertain, and easily taken for granted; these biases may act to minimize risk perception ([Cori et al., 2022](#)).

It is important to promote the construction of clear and reliable communication strategies, able to create effective messages, deliver them through the most convenient and relevant channels, and receive feedback ([Kurita et al., 2007](#)).

In 2017, a survey was conducted again with the same questions. Our goal was to objectively evaluate what has been done so far. The results showed that survey participants were approximately 52% more than in 2014. One of the positive results recorded was that approximately 10% more participants now want to test their homes for indoor radon concentration. The study performed in four US states demonstrated that the respondents were more likely to test their homes for radon if they previously heard of radon-related health issues. This study provides information that “education is positively associated with home testing for radon” ([Neri et al., 2018](#)).

The answers to the questions ‘If you have to measure radon in your home, whom do you trust to do it?’ and ‘Who do you trust most in health matters?’ are specifically of interest as they contradict each other. While on the first question 80% of the respondents trust the state institutions and scientific organizations and only 20% of independent experts and private organizations, the second question has a major variation of responses. 56% of those surveyed have stated that they trust independent experts and Non-governmental organizations (NGOs). Only 5% have confidence in government institutions and scientific organizations ([Makedonska et al., 2018](#)). In 2017, unfortunately, the number of those who do not trust anyone has increased.

When analysing the results of implemented till now communication strategy, the following trends are observed: Regardless of the invested funds (although limited in volume) and the efforts of specialists from the NCRRP, RHI, and public health structures, they are not recognizable to the audience when looking for health risk information. These data are

completely controversial to the results of the Albanians survey where the most trusted sources are the Institute of Public Health and the Office of Radiation Protection which are institutions that are directly related to public health ([Tushe et al., 2022](#)). Similar are the results from the survey of the Russian population: Medical specialists come as the most trustworthy source of information on health risks, first of all, family doctors and physicians in polyclinics; people also trust medical prevention centers, Rospotrebnadzor, regional and local public health care authorities ([Davydov et al., 2021](#)).

These results need a profound analysis. The probable reason, for the lack of recognition of Bulgarian public health authorities like the trusted sources for information about health risks, could be the existing mistrust of the state in general. Another reason could be the insufficient efforts to enforce the recognition of these entities or the quality of the campaigns being conducted, for example not using all media such as Facebook and the Internet. Other authors indicate the importance of social media influencer campaigns are useful to encourage younger people and/or women to become radon aware and test their residential environments ([Cholowsky et al., 2021](#)). They recommend leveraging social media and word-of-mouth methods as strategies that better target younger people and are likely to have the greatest future impact. Finally, the effects of radon communication campaigns need to be systematically measured, improved and pitfalls and lessons learned openly shared ([Bouder et al., 2021](#)).

The results highlight the following issues, the resolution of which would improve communication with stakeholders. Objectively, the use of television is expensive and the public resource under the National Plan does not cover the preparation of such materials. There is also a subjective problem - in order to achieve recognition in the electronic environment, it is necessary to allocate human resources to maintain interactive communication (for example questions and answers); the presentation of the materials must also be specific. In practice, despite having competent specialists in the field of health risk prevention, public health authorities do not possess the specific necessary skills for this purpose. The only solution, in our opinion, is the creation of a working group of experts with different profiles.

The studies ([Fitzpatrick-Lewis et al., 2010](#)) highlight that the impact or effectiveness of risk communication strategies is affected by personal risk perception, trust in the source of information and previous personal experiences with emergencies. As well, the methods of delivering the message are important. People integrate messages more effectively when the message delivery incorporates personal interaction. No single method of message delivery is best. Risk communication strategies that incorporate the needs of the target audience with a multi-faceted delivery method are effective at reaching the largest audience.

5. Conclusion

The paper reviews and analyses the results of the STEAM survey of the Bulgarian population. Some lessons learned, and several areas for future focus could be outlined:

- The general awareness of radon and associated risks with it is very low among the Bulgarian adult population: 77% admit they know nothing or very little about radon; 78% know nothing or very little about the health risks of radon radiation.
- Almost half of the population doesn’t know if testing home for radon is a priority for them, half of the population also doesn’t know if testing for radon is easy;
- About 30% of the Bulgarian adult population think, that there is no point in testing the home they live in for radon radiation, as they always maintain good ventilation; another 36% hesitate about the issue – they neither agree nor disagree with that opinion;
- Steps to enhance the credibility of National radiation protection and Public health authorities should be taken.

- Considerable increase in active communication is needed in all channels, incl. extensive use of the internet and social networks. Understandable messages are needed, as the general perception of radionuclide exposure is incomprehensible to the general public. It's mandatory to include the GP's in the communication of the health risk of radon exposure.
- Collaboration with social sciences specialists should be sought regarding changing the behavior of Bulgarian citizens.

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References

- Ahl, A. S., Acree, J. A., Gipson, P. S., McDowell, R. M., Miller, L., & McElvaine, M. D. (1993). Standardization of nomenclature for animal health risk analysis. *Revue scientifique et technique*, 12(4), 1045–1053. <https://doi.org/10.20506/rst.12.4.744>
- Bouder, F., Perko, T., Lofstedt, R., Renn, O., Rossmann, C., Hevey, D., Siegrist, M., Ringer, W., Pözl-Viol, C., Dowdall, A., Fojtková, I., Barazza, F., Hoffmann, B., Lutz, A., Hurst, S., & Reifenhäuser, C. (2021). The Potsdam radon communication manifesto. *Journal of Risk Research*, 24(7), 909–912. <https://doi.org/10.1080/13669877.2019.1691858>
- Chauvin, B., Hermand, D., & Mullet, E. (2008). New age beliefs and societal risk perception. *Journal of Applied Social Psychology*, 38(8), 2056–2071.
- Chobanova, N., Ivanova, K., Junakova, D., & Kunovska, B. (2020). Communication of the risk of radon exposure. *General Medicine*, 22(6), 27–32.
- Cholowsky, N. L., Irvine, J. L., Simms, J. A., Pearson, D. D., Jacques, W. R., Peters, C. E., Goodarzi, A. A., & Carlson, L. E. (2021). The efficacy of public health information for encouraging radon gas awareness and testing varies by audience age, sex and profession. *Scientific Reports*, 11(1), Article 11906. <https://doi.org/10.1038/s41598-021-91479-7>. PMID: 34099826; PMCID: PMC8185097.
- Cori, L., Curzio, O., Donzelli, G., Bustaffa, E., & Bianchi, F. (2022). A systematic review of radon risk perception, awareness, and knowledge: Risk communication options. *Sustainability*, 14, Article 10505. <https://doi.org/10.3390/su141710505>
- COUNCIL DIRECTIVE 2013/59/EURATOM of. (2013). Laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom, 5 December *Official Journal of the European Union L*, 13(1).
- Cronin, C., Trush, M., Bellamy, W., Russell, J., & Locke, P. (2020). An examination of radon awareness, risk communication, and radon risk reduction in a Hispanic community. *Jun International Journal of Radiation Biology*, 96(6), 803–813. <https://doi.org/10.1080/09553002.2020.1730013>.
- Davydov, A. A., Biblin, A. M., & Kononenko, D. V. (2021). Radon risk communication issues: Results of the all-Russian public opinion survey. *Health Risk Analysis No*, 3, 29–41. <https://doi.org/10.21668/health.risk/2021.3.03.eng>. UDC 546.296: 316.654 (470).
- Edwards, A. (2009). Risk communication. In A. Edwards, & G. Elwyn (Eds.), *Shared decision-making in health care: Achieving evidence-based patient choice* (2 nd edn., pp. 135–141). Oxford, UK: Oxford University Press.
- European Commission. RADPAR project. web.jrc.ec.europa.eu/radper/.
- Fitzpatrick-Lewis, D., Yost, J., Ciliska, D., & Krishnaratne, S. (2010). Communication about environmental health risks: A systematic review. *Environmental Health*, 9, 67. <https://doi.org/10.1186/1476-069X-9-67>. PMID: 21040529; PMCID: PMC2988771.
- Gaskin, J., Coyle, D., Whyte, J., & Krewski, D. (2018). Global estimate of lung cancer mortality attributable to residential radon. *Environmental Health Perspectives*, 126(5), Article 057009. <https://doi.org/10.1289/EHP2503>. PMID: 29856911; PMCID: PMC6072010.
- Grundy, A., Brand, K., Khandwala, F., Poirier, A., Tamminen, S., Friedenreich, C. M., & Brenner, D. R. (2017). Lung cancer incidence attributable to residential radon exposure in Alberta in 2012. *CMAJ Open*, 5(2), E529–E534. <https://doi.org/10.9778/cmajo.20160053>. PMID: 28663187; PMCID: PMC5498175.
- Hazar, N., Karbakhsh, M., Yunesian, M., Nedjat, S., & Naddafi, K. (2014). Perceived risk of exposure to indoor residential radon and its relationship to willingness to test among health care providers in Tehran. *Journal of Environmental Health Science and Engineering*, 12(1), 118.
- Kim, S. H., Hwang, W. J., Cho, J. S., & Kang, D. R. (2016). Attributable risk of lung cancer deaths due to indoor radon exposure. *Ann. Occup. Environ. Med.*, 28, 8.
- Kurita, T., Arakida, M., & Colombage, S. R. N. (2007). Regional characteristics of tsunami risk perception among the tsunami affected countries in the Indian ocean. *Journal of Natural Disaster Science*, 29, 29–38.
- La Verde, G., Longobardi, C., Fronzino, T., La Commara, M., D'Avino, V., Coppola, F., & Pugliese, M. (2020). Environmental radiation and risk perception: A survey in the campania region (southern Italy). *Il Nuovo Cimento - B*, 43(C), 150. <https://doi.org/10.1393/ncc/i2020-20150-0>
- Lorenzo-González, M., Ruano-Ravina, A., Torres-Durán, M., Kelsey, K. T., Provencio, M., Parente-Lamelas, I., Leiro-Fernández, V., Vidal-García, I., Castro-Añón, O., Martínez, C., Golpe-Gómez, A., Zapata-Cachafeiro, M., Piñeiro-Lamas, M., Pérez-Ríos, M., Abal-Arca, J., Montero-Martínez, C., Fernández-Villar, A., & Barros-Dios, J. M. (2019). Lung cancer and residential radon in never-smokers: A pooling study in the northwest of Spain. *Environmental Research*, 172, 713–718. <https://doi.org/10.1016/j.envres.2019.03.011>
- Makedonska, G., Djounova, J., & Ivanova, K. (2018). Radon risk communication in Bulgaria. *Radiation Protection Dosimetry*, 181. <https://doi.org/10.1093/rpd/ncy096>
- National Radon Programme Report. (2018) (in Bulgarian) www.radon.bg.
- National Statistical Institut. (2020). www.nsi.bg.
- Neri, A., McNaughton, C., Momin, B., Puckett, M., & Gallaway, M. S. (2018). Measuring public knowledge, attitudes, and behaviors related to radon to inform cancer control activities and practices. *Indoor Air*, 28(4), 604–610. <https://doi.org/10.1111/ina.12468>
- O'Connor, A. M., Stacey, D., Entwistle, V., Llewellyn-Thomas, H., Rovner, D., Holmes-Rovner, M., Tait, V., Tetroe, J., Fiset, V., Barry, M., & Jones, J. (2003). Decision aids for people facing health treatment or screening decisions. *Cochrane Database of Systematic Reviews*, (2), Article CD001431. <https://doi.org/10.1002/14651858.CD001431>. Update in: *Cochrane Database of systematic reviews*. 2009; (3):CD001431. PMID: 12804407.
- Pearson, D. D., Anikin, A., & Goodarzi, A. A. (2016). Environmental sources of ionizing radiation and their health consequences. In *Genome stability* 712. Elsevier.
- Perko, T. (2014). Radiation risk perception: A discrepancy between the experts and the general population. *Journal of Environmental Radioactivity*, 133, 86–91.
- Poortinga, W., Bronstering, K., & Simon, L. (2011). "Awareness and perceptions of the risks of exposure to indoor radon: A population-based approach to evaluate a radon awareness and testing campaign in england and wales," risk analysis. *John Wiley & Sons*, 31(11), 1800–1812.
- Sjoberg, L. (2003). Distal factors in risk perception. *Journal of Risk Research*, 6(3), 187–211.
- Stanley, F. K. T., Irvine1, J. L., Jacques1, W. R., Salgia1, S. R., Daniel G, I., Winquist, B. D., Torr, D., Brenner, D. R., & Goodarzi, A. A. (2019). Radon exposure is rising steadily within the modern North American residential environment, and is increasingly uniform across seasons. *Scientific Reports*, 9, Article 18472. <https://doi.org/10.1038/s41598-019-54891-1>
- Strategic Health Policy Framework to improve the health of the nation in the period 2014. available: http://www.mh.government.bg/media/filer_public/2015/04/08/nacionalna-zdravnastrategia_2014-2020.pdf, (2020).
- Tushe, K., Prifti, D., Shano, J., Kaçeli, M., & Dhoqina, P. (2022). Results of Albania public opinion survey on Radon risk perception. *RAP Conference proceedings*, 7(1–4). <https://doi.org/10.37392/RAPPROC.2022.00.RAP-PROCEEDINGS.ORG>. ISSN 2737-9973 (ONLINE).
- U.S. Department of health and human services. <http://www.hhs.gov/od/documents/RiskCommunication.pdf>. July 2010.
- Waldron, C.-A., van der Weijden, T., Ludd, S., Gallacher, J., & Elwyn, G. (2011). What are effective strategies to communicate cardiovascular risk information to patients? A systematic review. *Patient Education and Counseling*, 82(2), 169–181.
- World Health Organization. (2009). *WHO handbook on indoor radon: A public health perspective*. Geneva: World Health Organization.