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COMMUNICATION AND RISK PERCEPTION: A CASE STUDY ON RADON GAS

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ABSTRACT

Introduction: This research is situated within the study of risk communication in the fourth wave of digital communication. Radon is a carcinogen; over the past decades, it has been recognized as the primary cause of lung cancer among non-smokers. The primary objective is to understand and define citizens' perceptions of radon gas and its risks. **Methods:** We performed a case study of a highly affected community. The methodology used encompasses literature review and survey (n=185). **Results:** Although the main characteristics as a chemical element are known, almost a quarter of the respondents have incorrect perceptions about gas. In terms of knowledge of political and legislative action, the results point to gaps in respondents' knowledge. Respondents are mainly informed through digital media; however, slightly more than half responded that they had not received information about radon from any source. **Discussion:** The findings refine results obtained in other regions and indicate that the public is scarcely aware about radon, the media hardly cover it, and despite the perception of a health risk, it is seen as a distant societal risk, a factor that potentially prevents people from taking preventative action. **Conclusion:** Radon is little known by the public and has a scant presence in traditional and digital media, although news and communication are needed to raise awareness.

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Keywords:

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1. INTRODUCTION

This research represents a preliminary exploration into the perception of a specific risk in Spain, that is, radon gas, and examines the public's understanding and risk perception of this issue.

Radon is a carcinogenic gas acknowledged by the World Health Organization's International Agency for Research on Cancer since 1988. Over the past decades, it has been recognized as the primary cause of lung cancer among non-smokers (Neri et al., 2018). In many countries, radon is the second-leading cause of lung cancer after tobacco. Its significance lies in the fact that it is a risk that persists over time with serious consequences. It is estimated that the proportion of lung cancer cases associated with radon varies between 3% and 14% depending on the average radon concentration in a country and the calculation method employed. The primary source of public exposure to ionizing radiation is natural radon and its decay products. Buildings built in areas of bedrock or uranium-rich soils can develop high concentrations of indoor radon, posing a significant health threat (Ryan & Muller, 2015).

However, despite the risk's relevance and severity, its presence in the media is scant and the public is generally unaware of it. The scientific literature underscores the necessity of promoting risk communication initiatives preliminarily analyzing the perception and understanding of the target population. Accordingly, this study aims to analyze how different groups of people perceive this risk in a case study in one of Spain's most affected autonomous communities, Galicia. This article is situated within this context, aiming to understand and explain the knowledge of the community involved in a building affected by radon gas years ago.

1.1. Risk communication and perception

Risk communication is a key factor in prevention and guiding individual behavior in response to risks. Interest in risk communication has been consistent in recent years, showing steady growth since 2013 (and earlier with a peak in 2009), but saw a marked increase with the COVID-19 pandemic. This trend is reflected in the Web of Science database, where 46.7% of the research on the subject has been published between 2019 and the present. The literature emphasizes the need for prior analysis of citizens' knowledge and perceptions to achieve effective communication actions that modify attitudes and behaviors. In order to provide the necessary information for people to make well-informed decisions, risk communication must adapt to the perceptions and needs of the message's receivers (de Vries et al., 2021). The importance of understanding what people already know and believe about risks, how people feel about these risks, what information people want to know, and which knowledge, beliefs, and feelings most influence decisions, is highlighted. More than three decades ago, an empirical study investigated the functional relationships between five sets of variables involved in the amplification process: physical consequences, the amount of press coverage, laypeople's individual perceptions, public responses, and socioeconomic and political repercussions.

Research discovered that perceptions and social responses are more strongly linked to risk exposure than to its magnitude (Renn et al., 1992).

Risk is understood as the possibility that human actions or events may have consequences that harm aspects valued by people (Rasmussen & Ihlen, 2017), and it is described in terms of the probability of loss occurrence (Stern et al., 1996). However, the concept of risk must include psychological, social, institutional, and cultural factors, thereby opening the door to the social amplification or concealment of risk depending on the actions taken by certain actors. Risk perception can be defined as people's beliefs, attitudes, judgments, and feelings, as well as broader social or cultural values and dispositions people adopt towards hazards and their benefits (Hevey, 2017). These attitudes are not objective but are influenced by communication and social interaction.

This approach explicitly highlights the inherent multidimensional (cognitive and emotional responses) and context-specific (for example, community values, cultural norms, and behaviors) aspects of risk perception, which is why the analysis of a case study involving all the affected individuals was deemed of particular value.

1.2. Research on radon gas

In recent years, research on radon gas has focused on mapping the distribution of radon and establishing its public health significance, which is of utmost importance for this study.

Scientific studies in recent years have focused on substantial efforts to map radon potential and investigate the most effective methods for reducing radon levels in different buildings. The creation of radon maps in Spain, which provide a solid foundation for research, offer information about the possible link between chronic indoor radon exposure and increased mortality from lung, stomach, and brain cancers (López-Abente et al., 2018), specifically when this exposure occurs indoors (Lorenzo-González et al., 2017; Suess, 1994). Nationally, the role of the Nuclear Safety Council in promoting the Radon Potential Map of Spain (Consejo de Seguridad Nuclear, 2017), which includes 12,000 measurements from across the Spanish territory and forms the basis for municipal zoning and the establishment of priority action areas, should be highlighted. In Galicia, there is also a radon map made by the Radon Laboratory of Galicia, University of Santiago de Compostela.

From a communication perspective, Perko and Turcanu (2020) recently conducted a study on websites that provide radon information, and the results underscored the need for local and national authorities to invest in more attractive web spaces and to evaluate their impact. Earlier, Lofstedt (2019) had already carried out a case study in Sweden concluding that radon pollution will continue to cause radon-induced lung cancer in about 500 Swedish citizens per year until new measures are taken, linking communication campaigns to risk reduction.

Regarding perception, the study by Neri et al. (2018) stands out, emphasizing that radon exposure is the second risk factor for lung cancer among smokers and the first among non-smokers. The authors also pointed out that radon concentrated at the lowest levels of houses and buildings can be reduced, thus decreasing the risk of lung cancer. The goal of this study was to measure radon knowledge among various populations to inform radon-related cancer control practices and activities. This work provides useful

information for cancer control activities, including that education is positively associated with home radon testing.

Similarly, Cronin et al. (2020) stress that risk communication is a critical component of radiation protection and public understanding of risks and benefits, while also emphasizing that it is the second leading cause of lung cancer in the United States. Individual and community understanding of the risks of exposure to radiation sources such as radon depends on communication that informs and stimulates conscious and responsible action. This study demonstrates the need for radon risk communication strategies specific to each population and culture.

Within the importance of communication and dissemination of information about radon, some studies have pointed to the media's central role in this endeavor by demonstrating the significance of media coverage in *The New York Times* in establishing global environmental risks (Mazur, 2006). However, research highlights superficial coverage (Friedman et al., 1987) due to three factors: (1) the event-oriented nature of articles, (2) the limited number of sources cited in scientific news, and (3) the lack of scientific training among local reporters and editors. Understanding not only the media agenda but also the perception of citizens (Barazza et al., 2017) is essential for effective radon communication, and scientists should make an effort to communicate and disseminate this information (Bennett et al., 2001). Innovative proposals have been made along this line, such as in Canada, where social media, workshops, webinars, public forums, poster contests, radon distribution maps, public consultations, fairs and conferences, and associations have been implemented between different governmental bodies and non-governmental organizations. There have also been recent innovations in apps and geological maps in the United States (Chiavacci et al., 2020; Kim et al., 2020).

However, the radon literature insists, as we have indicated in general risk communication, on communicators having prior knowledge of the public's risk perception before planning any action (Mora-Rodríguez & Melero-López, 2021).

Specifically on radon gas, Davydov et al. (2021) conducted an Internet survey in the fall of 2020 in the Russian Federation to understand the attitudes of citizens towards their health and radon as a possible health risk factor. The survey revealed that in the Russian Federation people were relatively uninformed about radon. Only 31.7% of respondents said they were more or less informed about radon, and the main source of information was health personnel. Similar results were obtained by Khan and Chreim (2019) in a study on radon gas in which only 32% of residents expressed concern, 12% tested their homes, and 3% mitigated radon levels in their homes located in a high-risk area in Canada.

In the workplace, Esan et al. (2020) also point out that the severity and long-term health effects of radon exposure are often underestimated due to inaccurate perceptions of radon risk, and they analyze the perception of radon risk and barriers to testing residential radon levels among the faculty of Obafemi Awolowo University. The study revealed that awareness of radon was low (46%), while 61% of respondents had poor knowledge. Only one-fifth (19.5%) of the respondents perceived a high radon risk, and 70% did not know what measures to take to detect radon in their homes. In general, despite their high level of education, knowledge/awareness about the health risks of radon is low among the faculty members of Obafemi Awolowo University; moreover, lack of knowledge about supplies for home testing is a significant barrier to residential testing.

With this conceptual and heuristic framework, we address the study of a specific risk: radon gas. Its importance lies in the fact that this risk has persisted over time, with serious health effects demonstrated for nearly 40 years, and little knowledge in public opinion despite the severity of the risk (Khan & Chreim, 2019). Currently, studies receive strong institutional and regulatory support. The World Health Organization and the EU indicate the importance of communicating about radon.

2. OBJECTIVES

This research aims to understand the reality of a community with a unique radon gas impact from a communication perspective. To achieve this, we formulated the following objectives:

- O1. Determine the degree of knowledge about radon gas, related events and intervening political and legislative actions.
- O2. Identify the origin of knowledge about radon gas in this population.
- O3. Identify the impact of communication on radon gas in this population.
- O4. Investigate the risk perception of radon gas in an affected community.

3. METHODS

The study is based on a survey at the Faculty of Communication Sciences, University of Santiago de Compostela, between January 24 and April 2, 2022. This time frame does not respond to any specific criteria but was intended as the survey execution period for this project. A questionnaire was provided on paper and through Microsoft Forms to the residents of this population center (N=758), including students, teaching and research staff (TR), and administrative and service personnel (ASP). After a pilot test of the questionnaire with about ten people, the final questionnaire consisted of thirty questions organized into seven blocks: (1) knowledge about radon and related events; (2) knowledge of political and legislative action; (3) origin of radon knowledge; (4) communication actions; (5) perception and measures in the face of personal and social risk. The whole universe was contacted and had the opportunity to respond, however the participation was voluntary, so we obtained a self-selection sampling with a response rate of 24.4% (n=185).

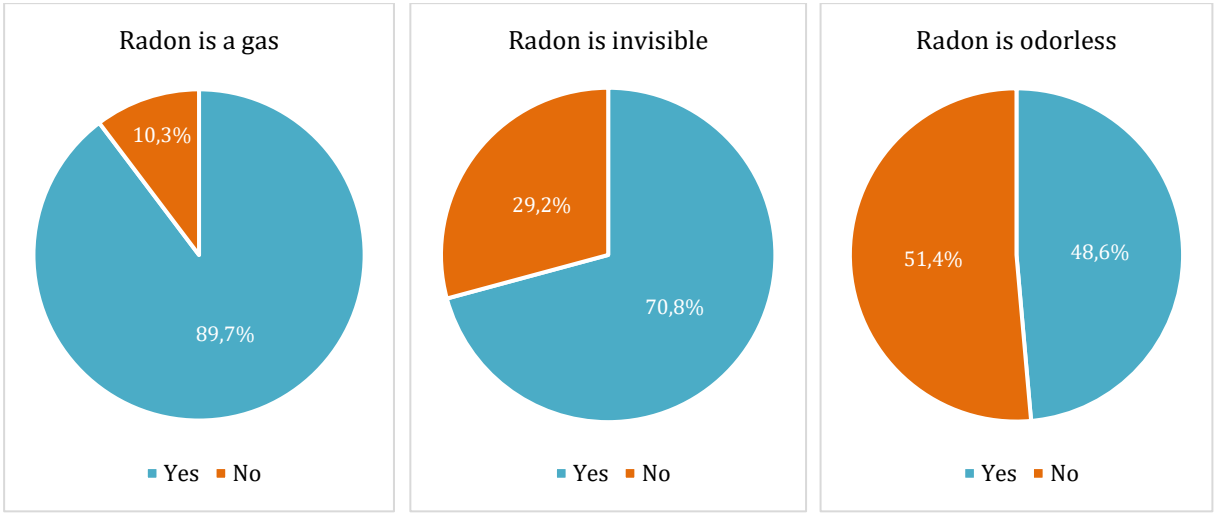
The sample consisted of 160 students, eight TR members, and 17 ASP members. 70.3% identified as female; 28.6% as male; and 1.1% as non-binary. The respondents ranged from 18 to 65 years of age, with an average age of 24.1. Given the characteristics of this population center, the vast majority of participants (82.7%) had been there for four years or less. Nonetheless, 8.1% had been there for over ten years. 91.4% are of Galician origin, so their family home is located in an area likely to be affected by radon concentration. These features make the sample a group of particular interest for analyzing their perception of radon gas.

4. RESULTS

4.1. Knowledge about radon gas, related events, and political and legislative actions

Following objective O1, the first point to analyze is knowledge about radon gas, which among the respondents was medium-high. The fundamental characteristics of this chemical element (Figure 1) are known: it is a gas, invisible to the naked eye and odorless. Nonetheless, regarding this lattermost descriptor, more than half of the respondents did not know it was odorless. Two out of three identified radon as a chemical element naturally found in soils, water and rocks as a result of the radioactive decay of other chemical elements. However, the remaining 22.4% have incorrect perceptions about the gas, e.g. that it is a pollutant resulting from industrial processes or that it is related to nuclear energy.

Figure 1. *Main characteristics of radon gas and level of knowledge.*



Source: prepared by the authors.

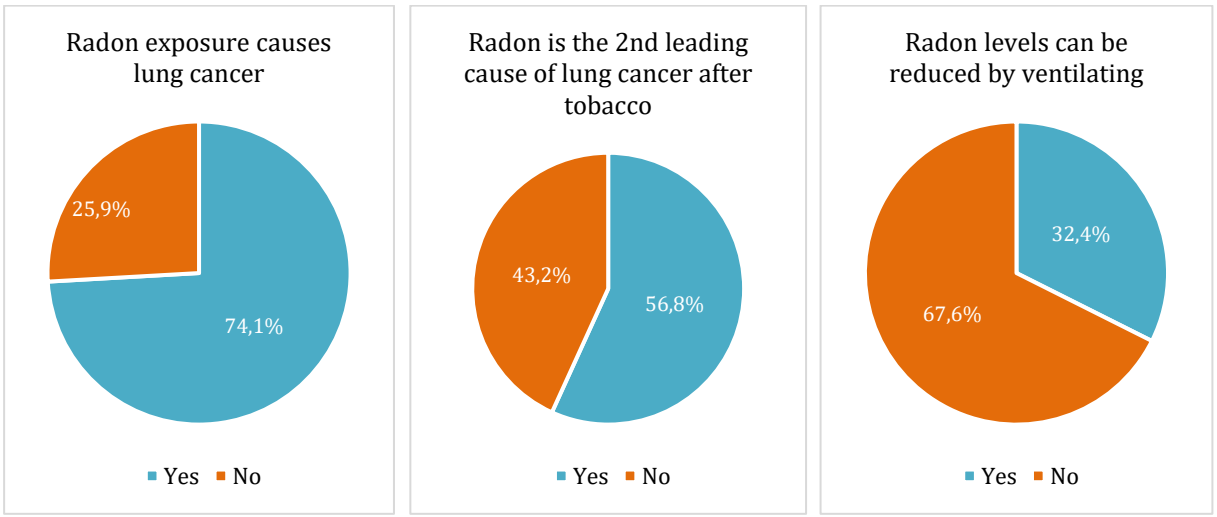
More than two thirds (69.2%) understood that radon can be found in the soil, but there are more doubts about whether it can be in the open air or in the water: a third believe that it can be found in the open air, contrary to the main mitigation measure, which is the ventilation of closed spaces, and 20.0% believe that it cannot be found in the water, despite the fact that it can be found in the groundwater of affected soils.

Regarding the sources of radon in the home or workplace, respondents identified building materials (49.2%) and uranium present in the ground (45.9%) as the main sources. However, more than a quarter (27.2%) admitted that they did not know the sources of emission of this noble gas.

The main risk associated with exposure to radon gas (Figure 2) is lung cancer, and this is recognized by the respondents (74.1%). Almost six out of ten stated they knew that it is the second leading cause of this cancer behind smoking. On the other hand, there are doubts about the use of radon in medicine, as one in four mistakenly believe that this gas is essential for performing X-rays and medical treatments.

To remedy high concentrations of radon gas, it is essential to know the measures that anyone can take. Only 32.4% know that radon levels can be reduced by ventilating.

Figure 2. *Main risk and solution of radon gas and level of knowledge.*



Source: prepared by the authors.

Secondly, significant ignorance of radon-related events is evident. 55.1% knew that a study discovered high concentrations of radon in Galician high schools, but barely a third knew that the European Union filed a case against Spain for not approving radon regulations or that in 2019 high concentrations were detected in the Sierra of Madrid. In this case, proximity to the first event led to greater levels of awareness. Lastly, only 3.2% indicated that they had heard of European Radon Day, with only four people correctly pinning it to November 7th.

As for knowledge about political and legislative action (O1), the results point to gaps in the respondents' knowledge. 16.2% stated that there are regulations or guidelines on radon in homes at the state or regional level, while 75.1% admitted they did not know and 8.6% incorrectly responded that they do not exist. Regarding the obligation to measure radon in newly built homes, 87.6% did not know or answered incorrectly that there is no such regulation. Regarding the existence of norms or guidelines for the mitigation and prevention of radon in Spain, 71.4% admitted they did not know and 24.3% stated they exist.

4.2. Source of knowledge about radon

According to objective O2, the respondents primarily source their information through digital media outlets, including Twitter, Instagram, television, instant messaging apps, and YouTube (Table 1). They indicated having received information about radon predominantly through digital media, television and print media. Specifically, *La Voz de Galicia* and *El País* stood out among a list of 19 news media recalled by a quarter of the participants.

Table 1. *Channels from which respondents had received information in the past week and from which they had received information about radon at some point in time.*

Channel		**Source of info during last week (%)**	**Info about radon at some point in time(%)**
Digital media		70.3	31.4
Instant messaging		42.7	3.8
None		23.2	53.0
NS/NC		0.5	0.0
Podcast		1.1	0.5
Written press		28.1	16.2
Radio		21.6	4.9
Social media	Facebook	7.6	1.6
	Instagram	48.1	4.3
	TikTok	23.8	0.5
	Twitter	52.4	9.7
Television		47.6	17.3
Twitch		10.3	0.0
YouTube		30.8	1.1
Others (family and friends, email, RSS)		2.7	5.9

Source: prepared by the authors.

Nevertheless, the most striking data point is that 53.0% responded that they had received no information about radon from any source. Only 14.1% remembered the source of the information: the government (6 responses), university (5), an NGO (4), scientific studies and institutions (4), media outlets (2), a political party (2), and unions, an expert or the public administration (1). 7.0% of those surveyed claimed to be aware of studies about radon, and among the answers, reports and projects from the Galician Radon Laboratory stand out.

Regarding the university itself, respondents showed widespread ignorance of its radon levels, and 76.7% indicated they have not received information about it (scoring 1 or 2 on a scale from 1–7; M=1.94).

4.3. Communication actions on radon

Responding to objective O3, one in four participants recognized that there have been specific risk communication activities about radon in Spain (23.2%). However, they also indicated that they have received scant information about radon. Nearly half (47.0%) stated they were informed by the media; 34.6% by friends and family; university, the workplace, schools and the government round out the bottom of the list with much lower figures (Table 2).

Table 2. *Institutions that provide information about radon*.

Institution	%
News media	47.0
Friends and family	34.6
University	16.8
Place of work	8.1
School	7.0
Government	6.5

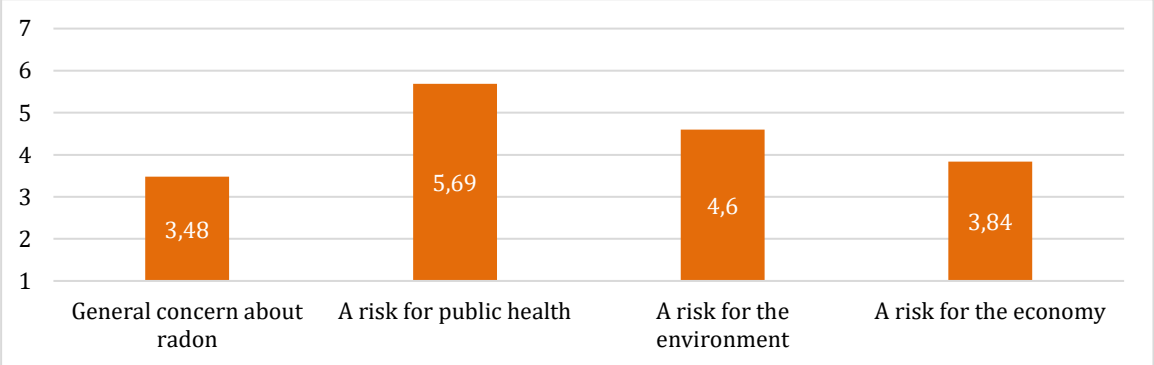
Source: prepared by the authors.

The survey results on materials used to communicate radon risks are similar: only informational talks and news from media outlets received 10 responses, while informative brochures, posters, social networks, university communications and videos were each mentioned between two and four times. As such, respondents considered the best channels, places and materials for this type of communication to be media outlets (91.8%), social networks (87.4%), informational talks (46.7%), videos (33.0%), posters (28.0%), a website (24.2%), and brochures (17.0%).

4.4 Personal and social risk perception and protection

Regarding objective O4, about the perception of personal and social risk (Figure 3), respondents are moderately concerned about radon, with 9.2% expressing strong concern (responding to 6 or 7 in a scale 1-7), although more than four out of five (83.8%) have at least some awareness of the risk. It is primarily perceived as a risk to public health, but also to the environment and, to a lesser extent, to the economy.

Figure 3. *Risk perception on radon gas (scale 1-7).*



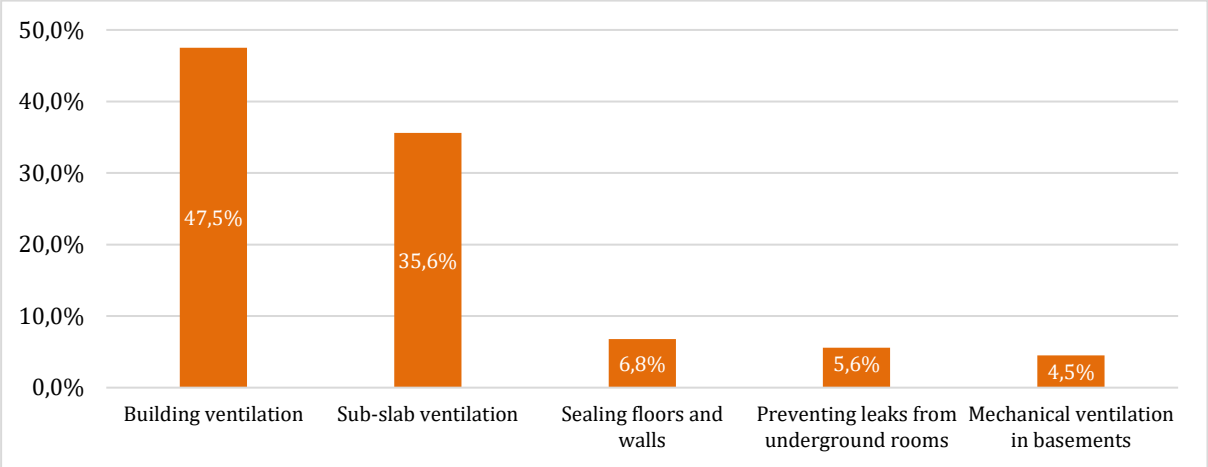
Source: prepared by the authors.

13.5% had some experience related to exposure to radon gas or know someone who has. However, this community sees it as unlikely that their friends or family could be affected by radon in the near future (M=2.91), and only 4.3% indicated that the chances are high or very high.

In general terms, the surveyed population indicated that the incidence of radon in Galicia is at an intermediate level, with 26.5% classifying it as high or very high. More than half of the participants do not have a clear idea about the impact on people and housing at the Galician and Spanish level, and only 28.1% knew that Galicia is the autonomous community with the most municipalities affected by high concentrations of radon.

As for personal actions to address radon problems (Figure 4), respondents mentioned building ventilation, sub-slab ventilation, mechanical evacuation systems in basements, preventing leaks from underground rooms to the living quarters, and sealing floors and walls. Nevertheless, nearly eighty percent (77.3%) of participants believed that a radon problem would be expensive to solve. They stated that they do not know how to perform the radon detection test (94.6%), nor where to buy the test kit (94.6%), but that they considered the tests reliable (85.4%). Almost one third (30.8%) mentioned not having enough time to perform the test. Moreover, 87.0% stated that if they conducted the test, they wouldn't know how to find an experienced professional to deal with the problem (87.0%).

Figure 4. *Actions implemented against radon concentration.*



Source: prepared by the authors.

5. DISCUSSION AND CONCLUSIONS

The study was based on a community that is assumed to be more concerned than the general population, since it is a place where occupational exposure to radon has been identified. Based on this condition, which gives a special significance to the study, since it is a phenomenon that has hardly been analyzed from the perspective of communication and risk perception, we find a community that is relatively well informed about radon gas and its risks, with less knowledge about political and legislative actions (O1). The level of knowledge about radon gas and its health risks detected by our survey is slightly higher than those detected by previous studies by Davydov et al. (2021) and Khan and Chreim (2019). We can describe this as expert knowledge, that is, aspects of radon that typically coincide with the narratives and sources mostly used in the media.

Through this awareness, the perception of a health risk arises, but it is predominantly a social risk that implies knowledge of the risk and its consequences, a high level in the autonomous community (specifically with greater awareness of radon in the workplace), and a low perception of the possibility of being affected by the risk in the short or medium term.

As we said, this is an affected community, so it is particularly interesting to know the source of this knowledge (O2). We find that, in general, they identify having received little information through the different channels, with 53.0% saying that they have never received information on radon. When asked about the case that affects them, this population shows a considerable lack of knowledge about the detection of radon concentrations in the building. This analysis shows that it is essential to generate internal communication actions within the framework of occupational health.

Inquiring about communication actions on radon (O3), we again identified a weakness. The main channels in which they identify specific actions are the media and the family environment, with only 6.5% identifying the government as an institution providing information on radon. However, our searches made it possible to locate available materials on this problem, but they may not be sufficient and may require more intense activities in priority action areas, such as the region in which this entity is located.

Finally, risk perception (O4) is key to achieving a behavioral change with regard to radon. This population shows moderate concern about radon (around 3.5 out of 7), although the risk to health is more clearly identified. The other key factor in getting action to be taken is knowledge about possible solutions and, in this regard, three out of four believe that the measures are costly and only 5.4% say they know how to perform a radon test.

Also noteworthy among the results obtained was the predominance of the Internet for receiving information, and no significant differences were detected in any of the items based on respondents' personal or work characteristics. Therefore, this case study allows for the following inferences:

- Radon is little known by the public in general —although this community has a medium-high level of knowledge— and has a scant presence in traditional and digital media. Therefore, the public is largely unaware of up-to-date information on prevention and impact.

- The public perceives the risk posed by radon as social and distant, therefore lowering the likelihood that people will take action to prevent radon.

- The perception of risk is linked to health more than to labor or regulatory issues or to expert or scientific knowledge.

- News and communication are required to increase awareness.

This study maps initial trends in the perception of the risk posed by radon, which is essential for good protection (Cronin, 2020; de Vries et al., 2021). This case study aimed to analyze the perception of risk among different sectors of an affected community, specifically at the workplace, which previous literature has scarcely analyzed. It also highlights the need to carry out studies on communication and risk perception of occupational radon exposure, since we spend a lot of time in work and study centers, which makes exposure to this gas a serious health issue. The limitations of this study are those of the survey as a research method and self-selecting sampling. Although the study of a specific place allows for a deeper understanding, the research conditions limit extrapolation of the results.

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