

Research Article

## Radon Awareness Among Palestinian Population in the Southern Part of West Bank - Palestine

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**Abstract:** Between February and March 2015, a radon awareness survey was conducted to measure general awareness and factual knowledge about some characteristics and health hazards of radon among residents in the southern part of West Bank - Palestine. Radon awareness among people is important for monitoring its level in their residential houses to reduce the risk of adverse health effects. Furthermore, radon awareness among the public would support and facilitate researchers working for such surveys during the field work. Questionnaire data consisted of knowledge and risk perception items about radon. A total number of 550 participants responded to the questionnaires. The questionnaire was distributed randomly to people in the region, and completed and returned directly. The survey found that 67.5% of 157 respondents' males and 88.8% of 348 respondents females had heard of radon, but only 17.8% of males and 87.4% of females were knowledgeable as radon is harmful. With regard to radon testing, a small percentage of respondents who were aware of radon had their homes tested. The percentage of respondents who were aware or knowledgeable aware of radon increased with increasing education level. Awareness females in radon properties and its health effects in most questions is more than males. This study provides preliminary evidence that the residents in the area under investigation do not know much their risk of radon exposure or the deleterious consequences of exposure.

**Key words:** Radon awareness, health hazards, Palestinian population, Palestine.

### Introduction

Radon (<sup>222</sup>Rn) is a radioactive noble gas emitted by the decay of <sup>226</sup>Ra, an element of the <sup>238</sup>U decay series. Radon is an odorless, colorless, tasteless and chemically inert, naturally occurring radioactive noble gas that is in the air you breathe and the water you use for drinking, bathing and cooking. It formed naturally by the breakdown of uranium in soil, rock and water. As a gas, radon is slowly released from the ground, water, and some building materials that contain very small amounts of uranium, such as concrete, marble, bricks, and tiles [1, 2]. Radon gas breaks down further to form additional radioactive particles called radon daughters, or "progeny". Unlike radon, the progeny are not gases and can easily attach to dust and other particles. Those particles can be transported by air and can also be breathed. Radon gas can seep into your home from the soil beneath it through dirt crawl spaces, cracks in the foundation and walls, floor drains, pipes and sump pumps. If you get your drinking water from a well, it can also be a source of radon in your home [3].

Radon gas and radon progeny in the air can be breathed into the lungs where they break down further and emit "alpha particles". Alpha particles release small bursts of energy which are absorbed by nearby lung tissue. This results in lung cell death or damage. When lung cells are damaged, they have the potential to result in cancer

when they reproduce [4, 6]. The only known health risk associated with exposure to high levels of radon in indoor air is an increased lifetime risk of developing lung cancer. The risk from radon exposure is long term and depends on the level of radon, how long a person is exposed and their smoking habits. If you are a smoker and are exposed to elevated levels of radon your risk of developing lung cancer increases significantly.

The estimated global average annual dose of the population receiving natural radiation equals 2.4 mSv. It is well established that the inhalation of radon and mainly its radioactive decay products, contributes more than 55% of the total radiation dose to the world population from natural sources [6]. The World Health Organization (WHO) says radon causes up to 15% of lung cancers worldwide. Other than lung cancer, there is no evidence that radon exposure causes other harmful health effects such as any other form of cancer, respiratory diseases such as asthma, or symptoms such as persistent coughing or headaches. The WHO's new annual recommended reference level of radon is 100 Bqm<sup>-3</sup>, with an upper limit that should not exceed 300 Bqm<sup>-3</sup> [7]. Many organizations set a guideline (also known as a reference level) of 200 Bqm<sup>-3</sup> for annual

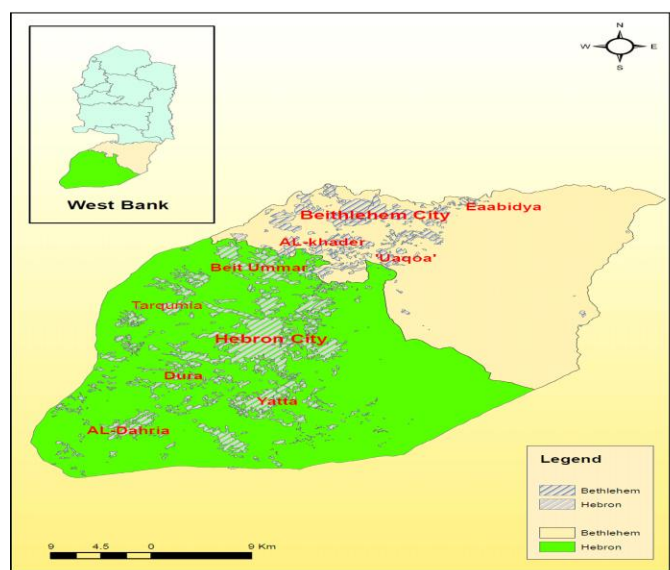
radon concentrations. The risk from radon exposure for a smoker (including those exposed to second hand smoke) is much greater than for a non-smoker. For example, if you are a lifelong smoker, but are not exposed to radon, your risk of getting lung cancer is one in ten. If you add exposure to a high level of radon, your risk becomes one in three. On the other hand, radon is the number one cause of lung cancer among non-smokers, according to EPA estimates [3]. Thus, if you are a non-smoker, your lifetime lung cancer risk at the same high radon level is only one in twenty. In September 2009, the United Nation's World Health Organization (WHO) says that radon is a worldwide health risk in homes. Dr. Maria Neira of WHO said that "Most radon-induced lung cancers occur from low and medium dose exposures in people's homes. Overall, Radon is the second most important cause of lung cancer after smoking in many countries [8, 9].

In Palestine, information about radon concentration, some surveys have been carried out [10-22]; in particular no data on the radon awareness among the Palestinian population were available. It is expected that this study will play an important role to educate the Palestinian population about radon and get them interested in assessing the radon level in their houses. Furthermore, when Palestinian population is aware of radon, they will not object the installation of radon dosimeters in their houses and their workplaces.

## Materials and Methods

### Study Area:

The study areas are Hebron and Bethlehem Governorates (Figure 1), which are located in the south of the West Bank, extended about 70 km south of Jerusalem. It is the largest area in the West Bank in terms of size and population. Its area is about 1650 km<sup>2</sup>, corresponding to about 29% of the total area of the West Bank. According to the estimates of the Palestinian Central Bureau of Statistics (PCBS) [23], the population of study area is around 750,000, reaching up to 30 % of the total population of the West Bank, 85.3% of total population live in urban areas, 12% in rural areas, and 2.7% in refugee camps. The study area lies between 400 m to 1027 m above sea level, thus the difference in altitudes leads to a difference in the wind movement and in the air pressure. The climate is Mediterranean with long hot and dry summers, and short cool and rainy winters. Accordingly, the climate of Palestine is classified as an eastern Mediterranean one [24, 25].



**Fig-1:** West Bank geographical map contain the studied regions.

## Methods

The study was conducted according to the human research ethics principles and code of conduct. The population in the area under investigation was randomly selected for the survey which was conducted in the winter semester of 2015. A total number of 550 participants responded to the questionnaires. The questionnaire was distributed randomly to people in the region, and completed and returned directly.

The first section of the instrument included personal characteristics (gender, educational level, profession or specialty, place of residence, smoker or non-smoker and age); the second section related to the extent of knowledge of the people in the southern part of West Bank about radon and its some properties. This section consisted of 16 questions:

- 1- Have you heard about radon before? [Yes, No]
- 2- According to your knowledge, radon is: [Electronic device, Natural material, Artificial material, I don't know].
- 3- Is radon [Etch, compound, element, I don't know]?
- 4- Radon is: [Gaseous material, Solid material, Liquid, I don't know].
- 5- Is radon harmful [Yes, No, I don't know]?
- 6- Is radon useful [Yes, No, I don't know]?
- 7- If radon was harmful, the most affected by it would be: [smoker, non-smoker, I don't know].
- 8- If radon was harmful, the most affected parts of the body would be: [The head, the abdomen, the lungs, I don't know].
- 9- If radon was harmful, the most harmful diseases would be: [Skin, cancer, heart, I don't know].
- 10- Radon is: [Inert material, active material, non-active material, I don't know].
- 11- Radon is: [Radioactive material, non-radioactive material, Stable material, I don't know].

12- Radon is the daughter of [Potassium, Uranium, Cesium, I don't know].

13- Radon is a material: [Its odor, color and taste; it's odorless, colorless, and tasteless; I don't know].

14-The main source of radon is: [Water, Soil, Air, I don't know].

15- When radon decays, it emits: [Alpha particles, Beta particles, Gamma ray, I don't know].

16- Are radon tested in your home/your workplace [Yes, No, I don't know].

**Statistical analysis**

The data were analyzed using a Statistical Package for Social Sciences SPSS (version 18). Frequency distribution of independent variables (sociodemographic characteristics, study characteristics and smoking habits) were computed for all of 505 participants.

**Results**

In this study, of the 550 individuals eligible to participate, 505 accepted to fill-in the questionnaire (response rate: 91.8%). The personal characteristics (including number and percentage) for the subjects are demonstrated in Table 1. As shown in table 1, 31.1 % of the subjects of the study are males and 68.9% are females; the majority of them are non-smokers (58.8%). The specializations of the subjects are as follows: 23.4% humanities, 25.5% medical sciences, 38.6% scientific areas and 12.5% are others. A large percentage of those surveyed have a high school degree or/and graduate qualifications. Concerning the age of the subjects, the majority of the respondents have been between 18 and 24 years old (47.7%). Finally, most of the respondents live in cities (67.5%).

**TABLE-1:** Number and percentage for the subjects in the Survey.

Personal characteristics	Options	No. of Participant	Percentage %
Gender	Male (M)	157	31.1
	Female (F)	348	68.9
Smoking	Smoker	208	41.2
	Non-smoker	297	58.8
Study specialization	Humanities	118	23.4
	Medical	129	25.5
	Scientific	195	38.6
Qualification	Other	63	12.5
	High school or less	212	42.0
	Under graduate	38	7.50
	Graduate	147	29.1
Age	Post graduate	108	21.4
	<18 years	117	23.2
	18-24 years	241	47.7
Where do you live?	>24 years	147	29.1
	City	341	67.5
	Village	65	12.9
	Refugee camp	99	19.6

The findings of the study for those who are aware of the radon include awareness characteristics and health hazards of radon are listed in tables 2 and 3. As shown in table 2, the responses to the first question, "Have you heard about radon before?" indicated that approximately 67.5%

of Palestinians males and 88.8% females did hear about radon before. As for the answer to the second question "Have you ever tested in your home/your work?", the majority of males and females responded by No. Respondents were then asked a third question: "Is radon harmful?" A weighted estimate of 17.8% Palestinians males and 87.4% females knew that radon is harmful. But the majority of the males (59.9%) and a minority of the females (12.1%) responded that radon is harmless and 22.3% of males and less than 1% of females do not know that radon is harmful. A weighted percentage of males said that radon is useful (35%), and most females said that radon is not useful (98%).

**TABLE-2:** Survey results of the participants who had heard general information about radon divided by gender.

Question	Options, number and percentage of the participant					
	Yes		No		I don't know	
	M	F	M	F	M	F
Q1- Have you heard about radon before?	106 (67.5%)	309 (88.8%)	51 (32.5%)	39 (11.2%)	0 (0%)	0 (0%)
Q2- Are radon tested in your home/ your work?	5 (3.2%)	7 (2%)	131 (83.4%)	295 (84.8%)	21 (13.4%)	46 (13.2%)
Q3- Is radon harmful?	28 (17.8%)	304 (87.4%)	94 (59.9%)	42 (12.1%)	35 (22.3%)	2 (0.6%)
Q4- Is radon useful?	55 (35%)	3 (0.9%)	50 (31.8%)	341 (98%)	52 (33.1%)	4 (1.1%)
	Smoker		Non-smoker		I don't know	
Q5- If radon is harmful, the most affected by it:	M	F	M	F	M	F
	73 (46.5%)	203 (58.3%)	19 (12.1%)	109 (31.3%)	65 (41.4%)	36 (10.4%)

Table 3, shows the distribution of the respondents who were investigated concerning the awareness of health hazards of radon according to gender. We asked participants, "If radon was harmful, what parts of the body would be affected by it?". The head was the reply of 47% of the males and 7.8% of females, 22.9% of the males and 27% of females replied the abdomen, 24.8% of the males and 54% of females answered the lungs and a small portion of the two sexes answered I don't know. For the question, " If radon was harmful, the most harmful diseases would be:", The answer of 47.8% of the males and a small portion of females was the skin disease, 29.3% of the males and 56% of females answered cancer, 22.3% of the males and 20.7% of females answered the heart disease, and a small portion of males and 18.7% of females answered I don't know.

Figure 2 shows the survey percentage results of the participants who had heard general information about radon.

**TABLE-3:** Survey results of the participants who had heard about awareness of health hazards of radon divided by gender.

Question	Options about awareness of health hazards (number and percentage of the participant)							
	The head		The abdomen		The lungs		I don't know	
	M	F	M	F	M	F	M	F
Q <sub>6</sub> -If radon is harmful, the most parts of the body affected by it:	74 (47%)	27 (7.8%)	36 (22.9%)	94 (27%)	39 (24.8%)	188 (54%)	8 (5.1%)	39 (11.2%)
Q <sub>7</sub> - If radon is harmful, the most diseases are caused is:	Skin		Cancer		Heart		I don't know	
	M	F	M	F	M	F	M	F
	75 (47.8%)	16 (4.6%)	46 (29.3%)	195 (56%)	35 (22.3%)	72 (20.7%)	1 (0.6%)	65 (18.7%)

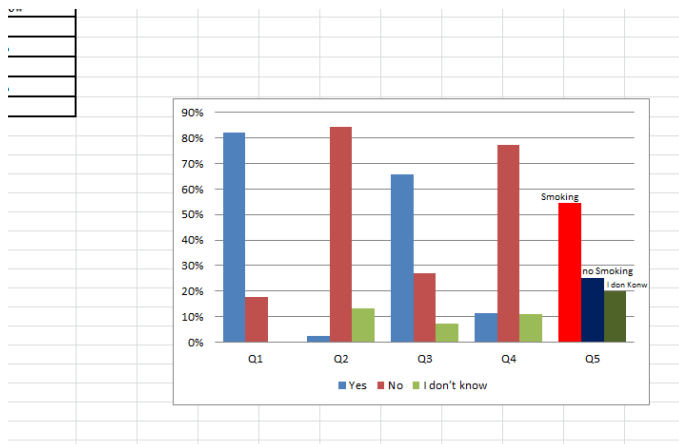


Figure 2: Survey percentage results of the participants who had heard general information about radon.

Q<sub>1</sub>- Have you heard about radon before?; Q<sub>2</sub>-Are radon tested in your home/ your work?; Q<sub>3</sub>-Is radon harmful? Q<sub>4</sub>-Is radon useful?; Q<sub>5</sub>- If radon is harmful, the most affected by it:

Table 4, shows the distribution of the respondents who were investigated concerning the awareness of general characteristics of radon according to gender. Concerning questions which deals with the characteristics of radon, the answer to the eighth question " According to your knowledge, radon is:" no one replied that the radon is an electronic device. A small proportion of the two sexes answered that radon is artificial material and 64.3% of males answered I don't know. About 33.8% participants of males and 96% participants of females from this section believed that radon was a natural material. A high percentage of male respondents (65%) said that radon is compound and high percentage of female respondents (64.1%) said that radon is an element. 26.8% for males believed that radon is a gas and 51% answered I don't know, and 96% for females answered that radon is a gaseous material. A high percentage of males (75.8%) answered that radon is a radioactive material and a high percentage of females (51.7%) answered that radon is a non-radioactive material. The majority of female participants (61.2%) state that radon is a colourless,

odourless, tasteless gas and 56% answered that radon has "an odour, colour and taste".

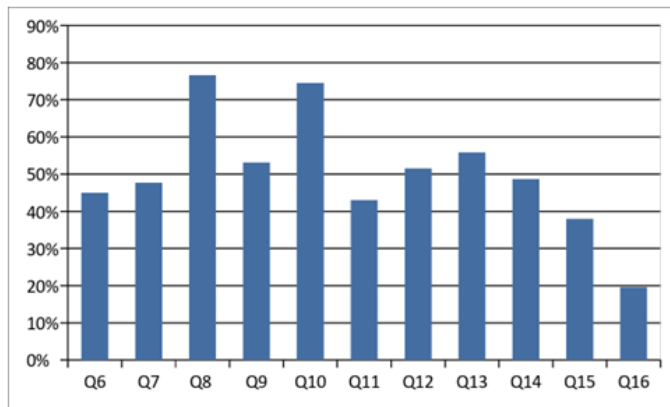
About 72% of males and 48.6% of females could correctly denote that radon is an inert gas. In addition, 65.6% of male participants recognize it as being the daughter of potassium and 58.3% of females identified radon as the daughter of uranium.

In answering question fifteenth, 78.3% of males said that the main source of radon is water and 48.3% of females responded that the main source is the soil. Finally, 53.5% of male participants responded that when radon decays, it emits alpha particles and 37.9% of females responded that it emits beta particles.

Figure 3 shows the correct answer survey results of the participants who had heard about awareness of health hazards and some characteristics of radon.

Question	Options about awareness of characteristics (number and percentage of the participant)							
	Electronic device		Natural material		Artificial material		I don't know	
Q <sub>2</sub> -According to your knowledge, radon is:	M	F	M	F	M	F	M	F
	0 (0%)	0 (0%)	53 (33.8%)	334 (96%)	3 (1.9%)	12 (3.4%)	101 (64.3%)	2 (0.6%)
Q <sub>7</sub> - Is radon?	Etch		Compound		Element		I don't know	
	M	F	M	F	M	F	M	F
	7 (4.5%)	25 (7.2%)	102 (65%)	34 (9.8%)	45 (28.7%)	223 (64.1%)	3 (1.9%)	66 (19%)
Q <sub>10</sub> - Radon is:	Gaseous material		Solid material		Liquid		I don't know	
	M	F	M	F	M	F	M	F
	42 (26.8%)	334 (96%)	8 (5.1%)	0 (0%)	27 (17.2%)	0 (0%)	80 (51%)	14 (4%)
Q <sub>11</sub> - Radon is:	Radioactive material		Non-radioactive material		Stable material		I don't know	
	M	F	M	F	M	F	M	F
	119 (75.8%)	98 (28.2%)	28 (17.8%)	180 (51.7%)	6 (3.8%)	12 (3.5%)	4 (2.5%)	58 (16.7%)
Q <sub>12</sub> - Radon is a material:	Its odor, color and taste		It's odorless, colorless, and tasteless		Its odor, colorless and taste		I don't know	
	M	F	M	F	M	F	M	F
	88 (56%)	35 (10.1%)	47 (30%)	213 (61.2%)	8 (5.1%)	15 (4.3%)	14 (8.9%)	85 (24.4%)
Q <sub>13</sub> -Radon is:	Inert material		Active material		Non-active material		I don't know	
	M	F	M	F	M	F	M	F
	113 (72%)	169 (48.6%)	8 (5.1%)	67 (19.3%)	30 (19.1%)	77 (22.1%)	6 (3.8%)	35 (10.1%)
Q <sub>14</sub> - Radon is the daughter of:	Potassium		Uranium		Cesium		I don't know	
	M	F	M	F	M	F	M	F
	103 (65.6%)	27 (7.8%)	43 (27.4%)	203 (58.3%)	3 (1.9%)	83 (23.9%)	8 (5.1%)	35 (10.1%)
Q <sub>15</sub> - The main source of radon is:	Water		Soil		Air		I don't know	
	M	F	M	F	M	F	M	F
	123 (78.3%)	31 (8.9%)	24 (15.3%)	168 (48.3%)	5 (3.2%)	103 (29.6%)	5 (3.2%)	46 (13.2%)
Q <sub>16</sub> - When radon decays, it emits:	Alpha particles		Beta particles		Gamma ray		I don't know	
	M	F	M	F	M	F	M	F
	84 (53.5%)	15 (4.3%)	15 (9.6%)	132 (37.9%)	27 (17.2%)	108 (31%)	31 (19.7%)	93 (26.7%)

TABLE-4: Survey results of the participants who had heard about awareness of some characteristics of radon divided by gender.



**Figure 3:** The correct answer survey results of the participants who had heard about awareness of health hazards and some characteristics of radon.

**Q<sub>6</sub>**-The most parts of the body affected by radon are the lung.; **Q<sub>7</sub>**-The most diseases are caused by radon is cancer; **Q<sub>8</sub>**-Radon is Natural material; **Q<sub>9</sub>**-Is radon Element?; **Q<sub>10</sub>**-Radon is Gaseous material; **Q<sub>11</sub>**-Radon is Radioactive material.; **Q<sub>12</sub>**-Radon is It's odorless, colorless, and tasteless; **Q<sub>13</sub>**-Radon is Inert material.; **Q<sub>14</sub>**-Radon is the daughter of Uranium; **Q<sub>15</sub>**-The main source of radon is Soil; **Q<sub>16</sub>**-When radon decays, it emits Alpha particles.

### Discussion

This study was the first to assess awareness of radon among the Palestinian population and its risk perception in Palestine. In the current study, similar to the approach of Poortinga et al., from the UK, Narjes et al., from Iran, Abdulaziz Alaamer from Saudi Arabia, Wang et al. from New York State and Rahman et al. from Pakistan [1,4, 26-28]. only people who had heard about radon were asked to answer awareness and perceived risk questions, respectively. The justification is that as long as a person has not heard about a risk factor, asking about the awareness and perceived risk might not produce valid results.

One of the strong points of the current research is that as the first study on this environmental risk factor in Palestine, From the above results it shows that in general, most of those who were surveyed are females (68.9%), awareness females in radon properties and its health effects in most questions is more than males and educated people with an increasing educational background level and with science education in particular. This study has a number of limitations. First, the sample suffers from self-selection (educated participant) bias as participants were referred by agreeing to participate. The sample may not represent all people. Second, the relatively small sample size does not allow for either more complex statistical modeling or broad generalization. Third, the questionnaire is cross-sectional, making inference related to causation problem.

About 67.5% of responder's males and 88.8% of females had heard about radon before this study and of these, 87.4 % of females recognized it as being harmful and 56 % of females and 29.3 % of males identified lung cancer as the main health outcome of exposure to radon.

The radon awareness level among the general public in the many countries is relatively higher than those educated people in Palestine. The internet and other information media may be used to enhance radon awareness level. However, this survey showed that the radon awareness of the educated public is less. This suggests that to improve radon awareness level via the press, media and lectures.

### Conclusion

In order to assess the degree of radon awareness in the southern part of West Bank - Palestine, a survey was conducted in several municipal towns of Hebron and Bethlehem Governorates. Also, radon as the second most important risk factor of lung cancer and it was a neglected issue even among health care providers. Having knowledge about health hazards like radon and perceiving them as a risk has a positive relationship with taking health related behaviors. Furthermore, risk perception contributes to spending more money when health is a concern.

The survey found that 67.5% of 157 respondents' males and 88.8% of 348 respondents females had heard of radon, but only 17.8% of males and 87.4% of females were knowledgeable as radon is harmful. With regard to radon testing, a small percentage of respondents who were aware of radon had their homes tested. The percentage of respondents who were aware or knowledgeable aware of radon increased with increasing education level. Awareness females in radon properties and its health effects in most questions is more than males. Efforts should be made by the concern authorities to enhance radon awareness level with the general public using tools of the press, media and lectures.

The relatively low percentage of respondents who were knowledgeable aware of radon characteristics and health hazards and the low percentage who had tested their homes strongly suggest that renewed efforts by the public health community are needed to increase knowledge about radon and its health effects and to encourage radon testing and remediation.

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