

## PERCEPTION OF RADIATION RELATED RISKS AMONG THREE POPULATION GROUPS

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*Abstract.* A questionnaire survey was conducted among three groups that mainly differ in socioeconomic status and professional exposure to ionizing radiations. Seventy-seven (26.3%) of the respondents were professionally exposed to radiation, 35 (11.9%) were medical doctors without professional exposure and 177 (68.4%) belonged to the general population group.

The level of *anxiety* toward radiation, expressed as a concernedness index, is significantly lower in people who are professionally exposed to radiation compared to medical doctors and general population ( $0.81\pm 0.94$ ,  $1.42\pm 1.21$  and  $1.72\pm 1.34$  respectively,  $p < 0.001$ ). In a similar manner, concernedness index values varied with the education status, with lowest values among medical university graduates and highest among public school graduates ( $p < 0.001$ ). Both university-graduated groups significantly differ from the non-university groups ( $p < 0.05$ ). *Knowledge* about radiation and knowledge about emergency plans in nuclear accident/incident were also checked in relation with concernedness, the results confirming the hypothesis that better knowledge associates lower concernedness. The extent to which people accept the civil utilization of nuclear power is also related to concernedness and knowledge, significant associations having been found.

The results suggest that a political decision in radiation matter requires a valid analysis of the public's understanding and acceptance. For that reason, it is important that radiological protection authorities develop new plans and materials for communicating with people, in order to improve knowledge upon ionizing radiation, irradiation risks and safety of nuclear energy employment for civil purposes.

*Key words:* ionizing radiation, understanding, acceptance, questionnaire.

### INTRODUCTION

Since 1895, when X-rays were discovered, ionizing radiation has been part of our life and consciousness. From the very beginning, radiation has been shrouded in myth – of exaggerated expectations as well as excessive fear [8].

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Due to the huge emotional reaction that the radiation theme presumes, the public understanding and perception of radiation risk is a major factor to consider in order to take a political, strategic or business decision.

Even before the accident of the Chernobyl power plant, in 1986, it was recognized that the overall response to accidents involving potential public radiation exposure is dependent on social and psychological factors [3, 4]. It is quite difficult for those involved in radiological protection to evaluate the extent to which these factors should be taken into account when justifying and optimizing the radiation protection aspects of the response and how to take account of them.

For any authority involved in this field it is very important to estimate the level of understanding and to what extent the population would agree to expose themselves to a threat that the lay people cannot measure or feel. On the other hand, it is the same authority's responsibility to offer the population the most accurate, reliable and understandable information available at the moment for at least three reasons:

- Pragmatic – people should be capable to protect themselves from harmful effects of radiation as well as to avoid excessive fear.
- Democratic – people should be capable of informed judgements in political matters involving radiation phenomena like nuclear energy, waste disposal, exposure limits, etc.
- Educational – the individual derives pleasure and fulfillment from knowing something about the world around [1].

The present survey was conducted to investigate the understanding and acceptance of radiation phenomena and the related risk among three Romanian groups of population: professionals involved in radiation business, medical doctors and general population.

## **METHODS**

### **RESPONDENTS**

The survey was administered in two campaigns, in spring and fall of 2002, in the form of a questionnaire to 400 people from whom 293 have responded (73.25%). The three target groups were chosen for different reasons: the professionals are supposed to be the most aware in the field, the medical doctors have high education, including some general physics, and the general population includes all educational categories, from primary to academic.

The questionnaire was administered in the national radiation protection network for the professionals, in the Bucharest Physicians College Web Page and some hospitals for medical doctors and in some public institutions and among general hospital's patients for general public.

The three groups can in no way be said that are representative for the entire population, nor even the general public group was randomized in any way; nonetheless it can be assumed that the results are indicative of conceptions and attitudes found among the three categories. It cannot be excluded that the 26.75% who did not respond differed from the respondents in relevant respects, but we think that the principal aim of the study, to identify some commonly held conceptions of radiation phenomena among population, does not render the results irrelevant by the possible bias from nonrespondents.

#### THE QUESTIONNAIRE, CODING AND ANALYSIS

The questionnaire (see Addenda) consists of 22 items. Six refer to demographic and general data such as age, gender, smoking status, presence of a chronic illness, highest education level and residency. One item identifies in which of the 3 groups the respondent is included and another the professional ionizing radiation exposure duration. Six items (8–11, 15, 18) are designed to give information about radiation fear; the answers to these items (yes = 1; no = 0) were aggregated in the statistical analysis in a “concernedness index”, on a scale from 0 to 6, and an “aggregate concernedness index” was also computed, considering 0 = 0 and any value  $\geq 1$  equal to 1. Three items (14, 19 and 20) evaluate knowledge and understanding of radioactivity and radiation. These items were also aggregated in a “knowledge index” on a scale from 0 to 3, where correct answers were coded 1 and incorrect answers were coded 0. Item 12 asks about the Balkan Syndrome, a hematological disorder in Balkan conflict veterans considered by some physicians as an effect of using a special type of ammunition (with Radon alloy) by American Army. Two items (11 and 13) reflect the attitude of the subjects towards nuclear energy. Two items (16 and 17) estimated the knowledge about any reaction measures in case of nuclear or natural catastrophe. Item 21 intended to give a perspective in the perception of the radiation risk compared with other health hazards; respondents had to range in a 10 to 1 scale, where 10 is the maximum health hazard, ten different factors including nuclear energy, smoking, alcohol, diagnostic X-ray, car accidents, fire, pesticides, earthquakes, air traveling and swimming.

Some questions include open-ended answers. For these answers three values were associated: 1, if at least one element of a correct answer was given, or if there was a rational/causal relation between question and answer; 2, if there was a wrong answer, or there was not any rational relation between question and answer; and 0, if there was not an answer at all. The answers were compared with the definitions and the statements from 2000 and 2001 *Report of the United Nations Scientific Committee on the Effects of Atomic Radiation*, seen as the best available source of sound scientific information recognized worldwide [5].

In order to picture up the studied reality, several statistical tools have been employed. First of all we have constructed the two main indexes, regarding concernedness and knowledge about radiation, following the previously described steps. Then we studied their variation according to the socio-economic status of the respondents, such as education, age, gender, residency and professional exposure to radiation. Relations with the presence of chronic illness and smoking habits were also analyzed. According to the type of measurement, ANOVA, respectively, contingency analysis was performed using the software SPSS 11.0.

## RESULTS

Of the 293 respondents, 106 were males, 181 were females and 6 did not specify their gender. Mean age was 40.51 (SD 12.35) and values ranged from 16 to 76 years. Thirty-one percent of the subjects were smokers and 19.1% declared to have a chronic illness. Seventy-seven (26.3%) were professionally exposed to radiation, 35 (11.9%) were medical doctors without professional exposure and 177 (68.4%) belonged to the general population group. Eighty-six (29%) of the questionnaire responders affirmatively hold a non-medical university degree, 69 (23%) are medical school graduates and 132 (45%) do not have any university degree.

### CONCERNEDNESS ABOUT RADIATION DANGERS OR HAZARDS

Ten respondents (3%) declared having suffered of illness caused by radiation. Sixty-seven (23%) consider the Chernobyl nuclear accident significantly harmed their health status. Fifty-three (18%) consider their health is endangered when medical radiographs are performed. One hundred fifteen (39%) would favor the closing down of nuclear plants, 133 (45%) are afraid of being exposed to radiation in their daily life and 48 (16%) consider irradiation for sterilization of foods, spices and medical devices as hazardous for their health. The mean concernedness index was 1.45 (range 0–5 on a 0–6 scale) with a standard deviation of 1.29.

People who are professionally exposed to radiation tend to have significantly lower concernedness values ( $0.81 \pm 0.94$ )<sup>1</sup> when compared to medical doctors and general population ( $1.42 \pm 1.21$  and  $1.72 \pm 1.34$  respectively,  $p < 0.001$ ). In a similar manner, concernedness index values varied with the education status, with lowest values among medical university graduates and highest among public school graduates ( $p < 0.001$ , Fig. 1). Both university-graduated groups significantly differ from the non-university groups ( $p < 0.05$ ).

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<sup>1</sup> In some cases, here and below, due to the lack of homogeneity of the variable, standard deviation can be bigger than the median. Although it seems like a mathematical nonsense, statistical analysis shows the same conclusions, even after the elimination of the outlying values.

We have also checked if there is any significant relation between the concernedness index and gender, smoking habit and presence of chronic illness, but the only significant one is that with the gender. Even when controlling for the education women prove to be more concerned with radiation than men ( $p < 0.005$ ). Duration of work in environments with high risk of radiation does not influence the concernedness with the issue.

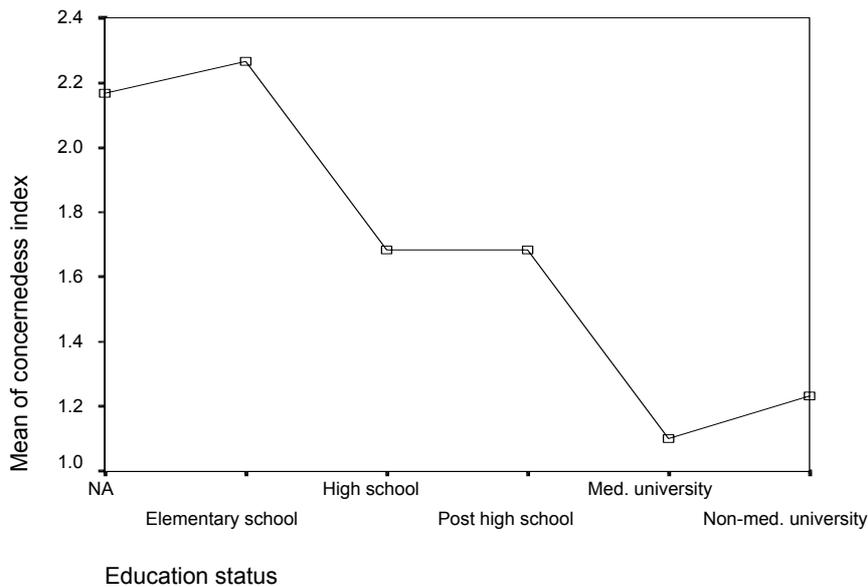


Fig. 1. – Mean of concernedness index (on a 0–6 scale) among the five education status subgroups. NA = no answer to the question ( $n = 6$ ), elementary school graduates ( $n = 16$ ), high school graduates ( $n = 60$ ), post high school graduates ( $n = 57$ ), medical university graduates ( $n = 69$ ), non-medical university graduates ( $n = 86$ ); the last two groups significantly differ from the first ones ( $p < 0.01$ , ANOVA analysis, LSD post-hoc test).

#### KNOWLEDGE ABOUT RADIATION

Three items tapped for the subjects knowledge and understanding of the radiation issues: 58% of the respondents answered correctly to only one over three items, while the rest, 42%, answered correctly two or all three items. As expected, the answers show better knowledge among radiation professionals ( $2.38 \pm 0.79$ ), compared to regular population ( $0.80 \pm 0.88$ ) and the non-exposed medical doctors ( $1.37 \pm 0.84$ ), the differences among each two of the three groups being statistically significant at a 0.001 level. No significant variation in knowledge was found with duration of professional radiation exposure. There was also no relation between knowledge and gender, residency smoking habits or presence of chronic illness.

Knowledge varied with education status (Fig. 2), medical university graduates having significantly higher mean scores than all the other socioeconomic groups ( $p < 0.001$ ).

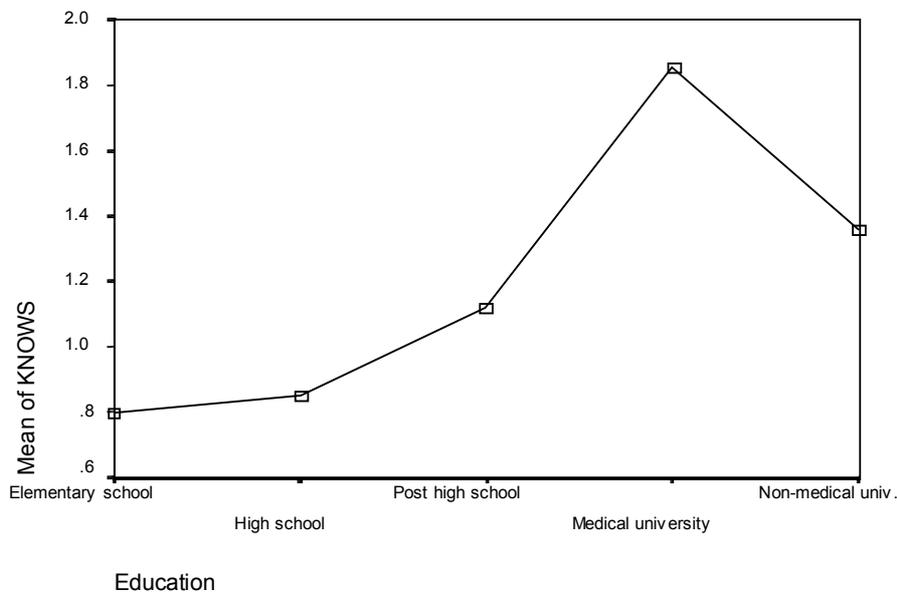


Fig. 2. – Mean of knowledge index (on a 0–3 scale) among the 5 education status subgroups. KNOWS = knowledge index; NA = no answer to the question ( $n = 6$ ), elementary school graduates ( $n = 16$ ), high school graduates ( $n = 60$ ), post high school graduates ( $n = 57$ ), medical university graduates ( $n = 69$ ), non-medical university graduates ( $n = 86$ ); medical university graduates significantly differ from all other groups ( $p < 0.001$ , ANOVA analysis, LSD post-hoc test), while non-medical university graduates also differ significantly from non-university graduates, except for the post high school graduate group ( $p < 0.05$ , ANOVA analysis, LSD post-hoc test).

#### RELATION BETWEEN KNOWLEDGE AND CONCERNEDNESS

There was a clear relation between knowledge and concernedness, people with higher knowledge scores being less concerned about radiation dangers, as a chi-square test between the knowledge and respectively aggregate concernedness index shown ( $\chi^2 = 16.25$ ,  $p < 0.001$ ). ANOVA analysis also showed significant differences of mean concernedness index among people having different knowledge scores (Fig. 3).

People affirmatively knowing about emergency plans in case of nuclear accidents had significantly lower concernedness index means ( $1.23 \pm 1.21$  vs.  $1.63 \pm 1.33$ ,  $p < 0.05$  by ANOVA). There was a highly significant association between knowledge of emergency measures in case of nuclear accident and knowledge of emergency measures in natural catastrophes ( $\chi^2 = 144.6$ ,  $p < 0.001$ ).

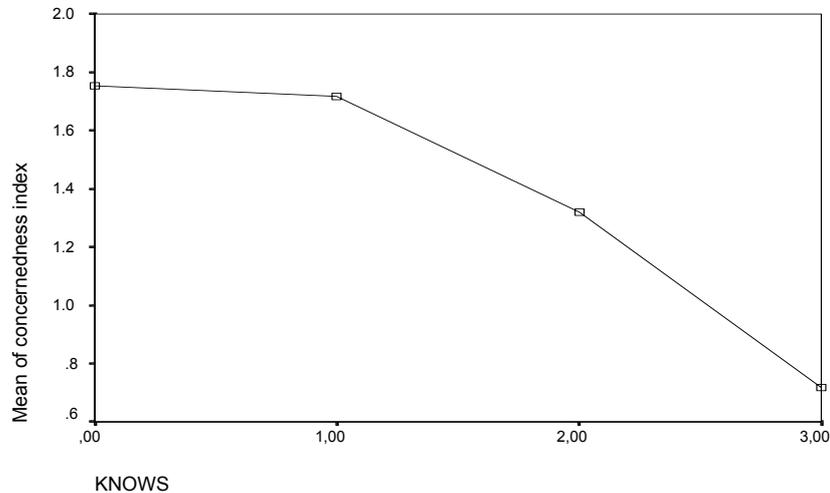


Fig. 3. – Variation of the mean concernedness index with the knowledge score (0–3). KNOWS = knowledge index; Number of individuals in each group: KNOWS = 0 (n = 93), KNOWS = 1 (n = 78), KNOWS = 2 (n = 69), KNOWS = 3 (n = 53). The group with knowledge score 3 significantly differs from all the other groups ( $p < 0,001$ ), group KNOWS = 2 differs from group KNOWS = 0 ( $p < 0,05$ ) and no significant difference exists between groups KNOWS = 0 and KNOWS = 1 (ANOVA analysis, LSD post-hoc test).

#### KNOWLEDGE ABOUT NUCLEAR ACCIDENT EMERGENCY PLANS

One hundred and nineteen respondents (40.6%) declared being acquainted to emergency plans in case of nuclear accident, while 169 (57.7%) do not have such knowledge, and 5 (1.7%) did not answer the question. Of the 119 people affirmatively knowing about emergency plans, 94 (79%) gave correct examples of emergency measures. These people had lower concernedness index means ( $1.09 \pm 1.21$ ) when compared to all the others ( $1.62 \pm 1.30$ ,  $p = 0.001$  by independent sample t-test). Knowledge of emergency plans was significantly better among radiation professionals (75%) when compared to the other professional groups (26% among non-exposed medical doctors and 15% among general public) ( $\chi^2 = 92.6$ ,  $p < 0.001$ ). University degree holders, regardless of study type, also had a significantly better knowledge of emergency measures when compared to non-university graduates ( $\chi^2 = 19.8$ ,  $p = 0.001$ ).

#### BALKAN SYNDROME

Eight subjects (2.7%) did not respond to this item, 171 (58.4%) never heard about it and 114 (38.9%) considered to know what it is. When it was to define the syndrome, there were 227 (77.5%) who did not answer, 48 (16.4%) knew

something about the subject and 18 (6.1%) gave wrong answers. The highest percentage of correct answers was obtained in the professionally exposed group (27%), while non-exposed medical doctors and general public gave less correct answers (23% and 11% respectively,  $p < 0.01$  by chi-square).

#### ACCEPTABILITY OF NUCLEAR POWER PLANTS

Table 1 illustrates the responders' acceptability of nuclear power plant (NPP) functioning and towards opening new NPPs on the Romanian territory. People agreeing with the opening of new NPPs have a significantly lower mean concernedness index when compared with those against the issue ( $0.92 \pm 1.00$  vs.  $1.77 \pm 1.33$ ,  $p < 0.001$  by ANOVA, LSD post-hoc test). Similarly, people definitely or rather wishing closing down or restricting NPP activity had higher means of the concernedness index, compared with those who would not favor this issue ( $p < 0.001$  by ANOVA, LSD post-hoc test).

Table 1

Opinions about nuclear power plants

Closing down / restricting NPP activity		Opening new NPPs	
NA	16 (5.5%)	NA	11 (3.8%)
Definitely yes	43 (14.7%)	No	179 (61.1%)
Rather yes	72 (24.6%)		
Rather no	97 (33.1%)	Yes	103 (35.2%)
Definitely no	65 (22.2%)		

There was a significant association between thinking the 1986 Chernobyl nuclear accident had unfavorable consequences upon one's health (item 9) and disagreeing with the opening of new NPPs (item 13) (Pearson  $\chi^2 = 12.1$ ,  $p < 0.05$ ).

#### PERCEPTION OF RADIATION RISK COMPARED WITH OTHER POTENTIAL HEALTH HAZARDS

Nuclear energy was placed on the third place among the most dangerous factors, with a mean score of 6.4, after smoking (mean score 6.8) and car accidents (mean score 6.6). On the contrary, diagnostic X-ray occupied the seventh position (mean score 5.5), before air traveling (mean score 4.6) and swimming (mean score 2.4), as illustrated by figure 4.

Significant scoring differences among professionally exposed, non-exposed doctors and general public were found with regard to smoking, alcohol and nuclear energy ( $p < 0.01$ ,  $p < 0.05$  and  $p = 0.001$  respectively by ANOVA); while the first two were perceived as less dangerous, nuclear energy is more feared by general public than by the responders from the other two groups. There was no correlation between smoking habits and risk perception.

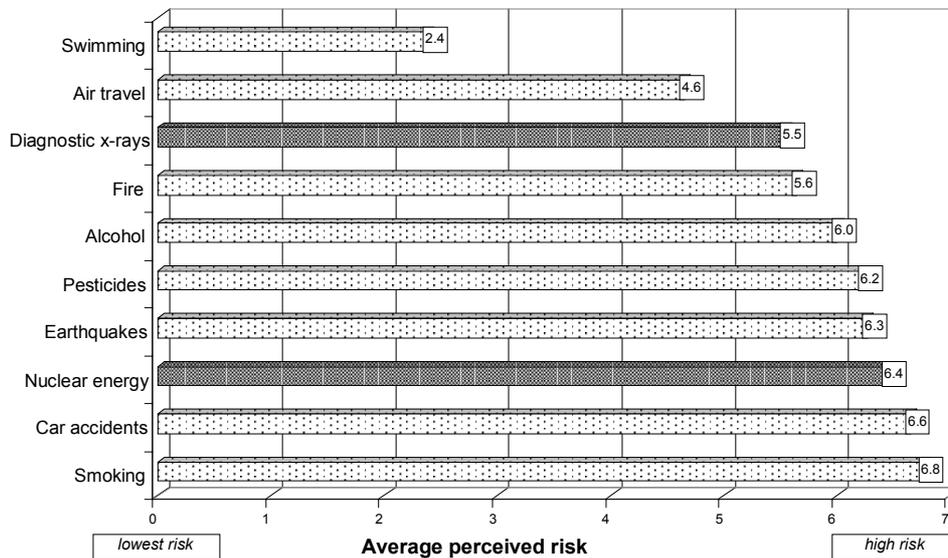


Fig. 4. – Perception of radiation risk compared with other potential health hazards. The ten above illustrated factors had to be ranged on a 1–10 scale, where 10 defines the most dangerous factor and 1 the most harmless.

## DISCUSSION

A major aim of the survey was to evaluate the understanding and the attitude people in Romania have toward radiation phenomena and civil nuclear power utilization, with their inherent risks.

As we expected, the way ionizing radiation is seen differs dramatically with education and professional exposure, which means with the information people have about the topic [6]. The most non-concerned people about radiation risks are those who work every day in radiation environment, they having both the knowledge and the routine. Medical school graduates, having enough information in radiobiology and being familiar to X-ray investigation, were also not very afraid of radiation.

It is important to stress here that only 29 (9.9%) of those who considered that Chernobyl NPP accident did harm their health had a valid medical explanation for their opinion (not necessarily true, but theoretically acceptable). This fact shows just how great the population's concern is about the theme, the fear been nourished by media and, sometimes, by physicians who are trying to explain an allegedly increase in the incidence of some diseases. The geographical proximity to Ukraine, and more important, the post communist transition in Romania, including a specific attitude toward authorities and the information they supply can explain to some extent the level of concernedness in the overall population.

The more the people think they have control over a hazardous event, the less they fear about it. Keeping abreast the population with the existence of an official reaction plan for nuclear accidents/incidents and the measures to take immediately for protecting themselves is maybe the most important thing the authorities can do for improving the acceptance of using nuclear power. This is true not only for effectiveness of those measures (that is in doubt, at least for some of them, as was demonstrated after the Chernobyl disaster), but also for psychological comfort of the people, in order to avoid panic [7].

The acceptance of NPP, far greater than in other European countries, shows that social-economic issues (that means jobs, the price of electricity) are more important at this moment for Romanians than ecological risks. On the other hand, the higher acceptance is correlated with lower concernedness and greater means of knowledge, nuclear industry being, statistically speaking, one of the safest.

The answers to item 12, about Balkan Syndrome, was considered significant for the way the people is coping with an information from media that exceed the ordinary level of complexity. Although in the days we administered the questionnaire the national media claims that a Romanian participant to United Nations Peace Force in ex-Yugoslavia suffered from that disease, the most of the respondents did not remember what was all about (77.5% did not answer).

## CONCLUSIONS

The perception of risk is different from one group to another, as shown other surveys [7], but there is no general pattern of perception, different sources of radiation are perceived in different ways. Nuclear energy was considered among the most dangerous factors. Probably because the benefit from medical procedures is more clear, diagnostic X-ray was seen as being less hazardous, although there is a certain exposure, not only possible, after a nuclear accident/incident.

The present study, even if it can not be assumed as representative for the Romanian population, shows that, although differences between perceptions and concernedness of laypersons and those of the professionals cannot be attributed only to knowledge, it is clear that better information and education about radiation is needed. A further representative survey will bring more accurate information. It is particularly needed to develop plans and materials for communicating with the public in the event of a radiological disaster, as the difficulties observed in Europe after Chernobyl have shown [2].

## ADDENDUM

### QUESTIONNAIRE

1. Your age: ....
2. Gender: 1.M; 2. F.

3. Your highest education level: 1. Elementary; 2. High school; 3. Post high school; 4. Medical University; 5. Non medical University.
4. Average population in your residency town: 1. Under 20,000; 2. 20–100,000; 3. 100–200,000; 4. Over 200,000.
5. Do you suffer of any chronic illness? 1. No; 2. Yes. If yes, what is it?.....
6. Are you professionally exposed to ionizing radiation? 1. No; 2. For less than 5 Yes; 3. For 5 to 10 Yes; 4. For more than 10 Yes.
7. Do you smoke? 1. No; 2. Yes
8. Do you have or have you ever had a disease that you consider a direct consequence of radiation exposure? 1. No; 2. Yes. If yes, what is it?...
9. Do you consider the Chernobyl Nuclear Power Plant accident in 1986 seriously harmed your health? 1. No; 2. Yes. If yes, please motivate.....
10. Do you consider harmful an X-ray medical investigation? 1. Very harmful; 2. Harmful; 3. Slightly harmful; 4. Harmless.
11. Do you think that nuclear power plant functioning should be restricted or stopped? 1. Definitely yes; 2. Rather yes; 3. Rather no; 4. Definitely no.
12. Have you ever heard about the Balkan Syndrome? 1. No; 2. Yes. If yes, could you describe it?
13. Would you agree with the opening of new NPP in Romania? 1. No; 2. Yes. Please motivate your option.....
14. At home or in the office, do you think you are exposed to ionizing radiation? 1. No; 2. Yes. If yes, what are the sources of radiation?.....
15. You consider that the ionizing radiation is 1. Very dangerous; 2. Dangerous; 3. Harmless; 4. It represents an acceptable health hazard.
16. Do you know anything about the emergency plan for nuclear accidents in your town/organization? 1. No; 2. Yes. If yes, could you give some examples of measures to be taken.....
17. How about the plans for natural catastrophes? 1. No; 2. Yes. Some examples?.....
18. Certain products (foodstuff, spices, disposable surgical devices, etc.) are sterilized by gamma radiation. Do you consider this could be hazardous for your health? 1. No; 2. Yes. If yes, why? ...
19. Please give a definition of the half life of a chemical element.....
20. Please give some examples of ionizing radiation effects in the human body.....
21. Please range in a 10 to 1 scale, where 10 is the maximum health hazard for the following activities: ...traffic accidents; ...travel by plane; ...medical X-ray investigation; ...pesticides; ...smoking; ...fire; ...alcohol; ...earthquake; ...nuclear industry; ...swimming.
22. Please, identify yourself with one of the following categories: 1. Professionally exposed to ionizing radiation; 2. MD (without professional exposure); 3. General public.

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