Abstract. The SCK•CEN, assisted by Research International, has organised in November 2002 an enquiry on the perception of risk and safety with a representative sample of the Belgian population. A Computer Assisted Personal Interview tackled several issues: general concerns related to safety and risks (societal – environmental – man-made vs. natural, etc.); role of experts; nuclear energy policy; countermeasures in nuclear emergency situations. A major finding is that the population has a very different perception of radiation such as medical X-rays (the good), radiation originating from nuclear facilities or radioactive waste (the bad) and radon (the ugly). At the occasion of the 40th anniversary of the Belgian Association for Radiation Protection, a selection of these questions has been presented also to the participants to an academic session dealing with risk perception. These participants were to a large extent professionals in radiation protection, with the addition of a group of students. Several differences in their perception as regards ionizing radiation or the catastrophic potential of facilities are apparent.

1. Introduction

The Belgian Nuclear Research Centre (SCK•CEN) has been performing nuclear research since its creation more than 50 years ago; five years ago, it was decided to broaden the scope of research to non-technological related issues as well. This has given rise to "PISA", the Programme for the Integration of Social Aspects into nuclear research (http://www.sckcen.be/pisa/). One of the projects of this program deals with risk perception, and one of the initiatives in this framework has lead to a collaboration with the IRSN (Institut de Radioprotection et de Sûreté Nucléaire) in France. IRSN has developed already in the late 1980's a 'Barometer' on risk perception, and has performed many risk perception studies as is explained in [1], [2]. In 2002, SCK•CEN decided to perform a similar study in Belgium simultaneously with the French one. The study deals with the main concerns of people, the perception of risks (technological and natural ones), the role of experts in decision making, the willingness to participate in decision making processes, the opinions on nuclear activities and nuclear emergency preparedness, and the acceptability of countermeasures. This paper only gives a synthesis of some aspects covered by the study; more information is available on the website mentioned above and in [3] and [4].

In 2003, the Belgian Association for Radiation Protection celebrated its 40th birthday by organizing an academic session in the Academy of Sciences in October 2003. The topic of the symposium was "Radioactivity: safe or dangerous, Perception of radiation risks", and the organisers decided to include an enquiry with the participants upon a selection of the questions used to interview the population. Over 80% of the participants completed the questionnaire, totalling up to over 200 persons, most of them qualifying as a professional or student in domains related to radiation protection.

2. Methodology

The methodology was kept identical in France and Belgium. A very similar list of questions was elaborated jointly by IRSN and SCK•CEN. In each country, more than 1000 individuals representative for the general public (sex, age distribution, social classes, distribution over the country, urban or rural living area, etc.) were consulted in face-to-face interviews via a CAPI (Computer Assisted Personal Interview) of about 30 minutes on selected topics. CAPI has the advantage of allowing a daily follow-up of the survey, of randomizing easily the items within one question, and of a good quality check. Furthermore, data treatment is efficient, as all data are available in digital formats immediately. In Belgium, the field work was performed by "Research International", a company specialized in opinion polls using professionals for the interviews. The survey was performed simultaneously in both countries during the second half of November 2002. No particular events that might have had a large influence upon the answers of the people occurred during this period, neither in the few months before. In the remainder of this paper, we will focus on the Belgian data.
The participants to the symposium answered 5 questions on paper, so these answers might be more influenced by the ordering of alternatives as in the enquiry of the population, when a computer supported and randomised ordering was used. However, some of the conclusions are very remarkable and beyond methodological uncertainty, as will be shown later.

3. Limitations

All results presented further in this paper reflect the opinions of the general public and are based upon averages for the entire population. The aim indeed was to have a snapshot of the public opinion. A derived aim was to adjust research priorities or some policy issues e.g. on nuclear emergency preparedness. It was not our purpose to find explanations why risks are perceived high, or to identify the main factors which do influence the public perception. Therefore, statistical analyses are not presented here, and the main factors (psychometric approach, e.g. Fischhoff [5]; social amplification of risk, e.g. Kasperson [6]) contributing to explanations are not discussed within this paper. They are described and discussed largely elsewhere in literature (see e.g. Brenot and al.[7], Sjöberg [8], Af Wåhlberg [9], and Sjöberg [10]). Some authors seek also better explanations of the responses to questionnaires by complementing them with results from other methods such as Focus Groups as used recently in Germany [11].

Secondly, the paper is limited in scope: perception of the various aspects of radiation put into perspective of a few other technological risks. Issues on future energy, the nuclear emergency organization or the role of experts are not dealt with in this paper.

3. Results

3.1. Nuclear risks in a broader context

When asked about their main concern to be selected from a list of predefined possibilities, the population apparently shows more concern for the societal problems such as insecurity, terrorism, drugs etc. than for technological risks such as nuclear or chemical risks as can be seen from Fig. 1, although also terrorism and many environmental problems are linked to technological choices as well. But it is obvious as well that, within the technological risks mentioned in the list, the nuclear one is the most often mentioned. It's maybe surprising that food risks are not mentioned very much, despite of the various food crises which occurred in Belgium and the amounts of media attention related to them in the past few years. However, it might be useful to check in future work whether the choice of
terminology would show a huge influence (e.g. mentioning 'mad cow disease' or 'dioxins' in stead of 'risk to the food chain').

3.2. Average dose of the Belgian population as compared to the perception of the exposure to various kinds of ionizing radiation

3.2.1. Average dose of exposure in Belgium

In daily life, the general population is exposed to various kinds of radiation. First of all, there is the exposure to radon and thoron, two radioactive noble gases that may concentrate in dwellings. Their decay products may give rise to considerable inhalation doses. These doses depend on soil composition and are on the average higher in Southern Belgium as compared to the North (more sandy or loamy-sandy soils in the North), but they also depend strongly on the way dwellings are constructed, ventilated, etc. Another kind of radiation of natural origin is cosmic radiation, via direct irradiation or via creation of radio nuclides such as $^7$Be in the atmosphere. A third group consists of natural radio nuclides in the soil, building materials etc. contributing to external exposure of the population. A fourth source of exposure is related to the natural radioactivity in the body, e.g. $^{40}$K. Although some variation exists depending e.g. on height or concentration of radio nuclides in the soil, these values remain rather similar for any individual within Belgium.

FIG. 2. Relative contribution of the various sources of ionizing radiation to the average dose to the Belgian population; based upon data from [12]

Techniques using ionizing radiation are part of daily medical practice, and in general bring a lot of benefit to society. As such, many people are exposed frequently to ionizing radiation; there may be a large variability between individuals as their use is coupled to the health status and age. Therefore, the average contribution to the exposure as mentioned in Fig. 2 shows a large variability from person to person, but for the general risk of radiation to society as a whole, the average annual dose remains an interesting indicator. Finally, the exposure to sources attributable to the nuclear industry is worth
considering: routine releases from facilities; the consequences of accidents such as Chernobyl on Belgium; the transportation, storage or treatment of radioactive wastes etc.

As can be seen from Fig. 2, the natural (radon, thoron, cosmic, body,...) and medical sources of exposure are predominant for the Belgian population. The contribution by the nuclear industry and fall-out (indicated in black) is minor. For further information, we refer to Vanmarcke and Brouwers in [12].

3.2.2. Perception of the risk of ionizing radiation

During the enquiry with the population, the question was asked whether the interviewees considered for a number of cases the risk for the Belgian population to be Negligible, Low, Medium, High or Very High. The same question was asked to the participants to the Symposium of the Belgian Association for Radiation Protection, from here on called 'participants'. Fig. 3 presents a selection of these data, restricted to the issues related to ionizing radiation; for each item, the upper line presents the answers by the 'participants', the lower one being the view of the general population.

When looking at Fig. 3, a number of things are apparent. First of all, the risk of radon is not well known by the public; the number of don't knows is very large, also for other questions related to radon but not published here. Among the 'participants', a more or less constant fraction does not express an opinion. In general, many people consider the risk related to radon to be from negligible to medium; the group perceiving it high or very high is relatively small, despite of the large contribution to the dose. Apparently, radon is not a major concern, and referring to the title of this paper, could be considered to be the "ugly" radiation, not really worth looking at, despite of its rather large contribution to the average dose to the population.

When we compare the results from 'participants' as compared to the general population, we see that the risk perception of nuclear installations and of nuclear waste is much different. While the population
sees nuclear installations and waste as dangerous, the opposite is thought by the professional group. The same is true for the radioactive fall-out of Chernobyl, which was relatively small for Belgium (between 1 and about 5 kBq/m²). Radiation due to facilities, and especially with negative connotations (such as waste or a catastrophe), gets a very high perception, and as such could be considered to be the "bad" radiation. For the medical radiography we see a completely different picture: the 'participants' estimate the risks of medical radiography slightly higher than the population in general. Indeed, the population and most of the 'participants' do not consider the risk of the medical exposures to be very cumbersome, despite of its high contribution to the dose of the population. Of course, the risk of medical exposures has to be balanced to the benefits the applications bring to society and individuals, and as such, medical radiation is considered to be the "good" guy. In general, there is little correlation between the average dose to the population as an indicator of the risk, and the perception by the population. Indeed, the high perception of dose attributable to facilities, wastes and Chernobyl in Belgium is not at all correlated to the facts. The perception of the 'participants' is better in line with the dose distribution.

It is not the purpose of this text to give full explanations, and the enquiry was not aimed to this either. Let's just mention that 'tampering with nature' may play an important role [13]. 'Tampering with nature' means that people are more reluctant to human intrusion into nature (e.g. by storing wastes or by genetically modifying organisms), and seem to better accept risks from a natural origin as compared to risks caused by human actions. Personal benefit seems to support the acceptance of a risk. Furthermore, trust in the actors (e.g. medical doctors) is an important factor, as well as the traditionally known factors such as voluntariness, feeling of being in control, familiarity with risk etc.

3.3 Risk of ionizing radiation in a broader context.

*FIG. 4. Fractions of the people responding to "In each of the following domains, do you consider the risks for the Belgian population to be high, medium or weak?". Top line: Participants Symposium Perception of radiation, October 2003, Bottom line: Belgian population: November 2002.*
It is worthwhile to frame radiation related risk within a broader context of other risks. Some further data of our study are illustrated in Fig. 4. It is obvious that in general the 'participants' perceive risks less high as compared to the general population (much less yellow and orange in the upper lines as compared to the bottom lines). It's worth mentioning that within the general population, in general, men perceive risks less high than women, and people with a technical-scientific background also perceive risks lower. These two factors, present in the general population as well, may contribute considerably to the explanation of the difference here considering the profile of the 'participants'. However, the height of risk perception depends strongly on the issue. An analogy between general population and 'participants' is that they show a higher risk perception for waste than for installations. It is noteworthy that the 'participants' consider the risk of nuclear wastes to be low, much lower than the perception of the general population; but for chemical wastes, they yield very analogous figures. Familiarity with the subject, knowing people and authorities involved etc. clearly helps in reducing the risk perception. Outside their own field of competence, the 'participants' can be considered to be general population, yielding a similar risk perception as well.

3.4. Trust in the protective measures by the authorities

We also included 'trust in the protective measures' by the authorities to protect the population against a number of risks. The outcome for a selection of these data is presented in Fig. 5. The upper lines present the answers by the 'participants'; the bottom lines the answers by the general population.

![Fig. 5: Fractions of the people responding to "Do you trust the authorities for the actions they take for the protection of the population in each of the listed domains?"
Bottom line: Belgian population: November 2002.](image-url)
For the first topic, Radon in dwellings, once again, there is a large group of the population not formulating an opinion. For the 'participants', we get almost a uniform distribution ranging from no trust at all to complete trust. Just for comparison, we also present the data for genetically modified foods. The more extreme position of complete lack of trust is more pronounced with the general population, a conclusion that can also be drawn for plenty of other risks.

The general population shows similar responses to the questions related to installations or wastes: the large group not showing trust in the protective actions (orange – yellow) is much larger than the one showing trust (green); in the case of the 'participants', the trust is generally speaking larger, but this is much more pronounced for the installations than for the waste issue. This may be due to the fact that other actors are involved, but maybe to the composition of the group of 'participants' too (a part of these 'participants' work in nuclear medicine etc. and are dealing daily with waste issues, while they have little to do with the control or protection related to large nuclear facilities). The results for chemical waste are similar than for nuclear waste in the case of the population, but the 'participants' consider the protective actions in the chemical fields less trustworthy than in the field of radioactivity.

The trust in the policy related to radiography is much larger as compared to the installations or waste issues. However, for the 'participants', it is apparent that the trust in the protective actions in the medical field is less pronounced than for the protective actions as regards facilities. The measures after the accident of Chernobyl are perceived very differently by the population and by the 'participants'; but also here, quite a large group of 'participants' is not very confident in the protective actions at that time. It would be interesting to study more in detail the reasons why. The lower set of data shows that for more general issues beyond the expertise of the 'participants', such as atmospheric pollution in this case, the opinion of the 'participants' gets very close to the population's opinion.

To summarise, looking more closely to the results from the radiation protection professional group, we notice they have more trust in the authorities than the public in general, however the difference is most outspoken for the nuclear waste and installations, less for the Chernobyl fall-out, the chemical waste or the atmospheric pollution in general, and non-existing for the medical radiography. Over 30% of the professional group has not really or not at all trust in the authorities for the protection measures against the Chernobyl fall out, much less than the over 50% of the general population, but still a relatively high number.

3.5. Catastrophic potential of installations

We asked the population which facilities to be selected from a list show the highest risk of provoking a serious accident or catastrophe. At this stage, the nuclear installations are into the spotlight. When grouping the first three possible choices, as illustrated in Fig. 6. The nuclear installations are mentioned most often by the population, but much less by the 'participants'. The facilities for radioactive waste are mentioned very often too by the population; this is contrary to what most experts in this field would claim, and this latter vision corresponds much better to the answers given by the 'participants'. Also mentioned often by the population: transport of dangerous goods, and here there is a good agreement with the opinion formulated by the 'participants'. These three topics are much more mentioned by the population than chemical factories and factories of fireworks, despite of the accidents of Toulouse (France, chemistry) or Enschede (the Netherlands, fire works) only a few years ago. Very obvious is the fact that the 'participants' mention the chemical plants much more, they even come in the first place. In order to remain correct, we must clarify that the 'participants' answered on paper (as explained before), and that in this case the chemical plants were listed first. This may have given rise to a non-negligible bias, but still the difference in perception between the sector one is more or less familiar with (the nuclear) and the one observed from a distance with no inside information (the chemical) is impressive. Also for transport, including airborne and by road, the difference in perception between 'participants' and population is very high, as can be seen from the figure. Worth mentioning also: dams apparently are considered safe by most of the people. It is maybe not really surprising for Belgium which has but a few small dams and few artificial lakes. We noticed however that even for France the risk for catastrophes with dams is not really considered. In reality, many dam
failures have occurred throughout the world, leading to a lot of casualties and allowing virtually no time for an adequate response. 900 (Nine hundred!!) cases have been categorised in [14].

FIG. 6. "Choosing from this list of industrial or technological activities, in your opinion which ones bear the bigger risk to cause a serious accident or disaster?", (3 choices possible, cumulative result) Participants Symposium Perception of radiation, October 2003, Belgian population: November 2002.

We also asked about the possibility of an accident like Chernobyl to occur in Belgium (see Fig. 7).

FIG. 7. Fractions of the people responding to "Do you think a nuclear accident as serious as Chernobyl could happen in Belgium", Participants Symposium Perception of radiation, October 2003, Belgian population: November 2002.
Half of the Belgian population believes that an accident like Chernobyl can occur in Belgium as well, and the same idea holds for the 'participants' to the academic session of the Belgian Association for Radiological Protection. The origin of this high number is consistent with the perception of a high risk for nuclear facilities, and maybe too with the signs of distrust regarding the authorities and several actors such as operators, trade unions, media, etc. also appearing in the complete enquiry ([3], [4]).

4. Conclusions

Several conclusions can be drawn from the information gathered above.

- Risks of technology represented by e.g. nuclear or chemical facilities don't seem to be the most important source of daily concern of the population. Issues such as terrorism, insecurity, unemployment etc. are more important in the perception of the population. It's worth noticing that of course, in this post September 11-era, there is a link between terrorism and technology as well: use of airplanes, selection of potential target installations etc.
- The risks related to nuclear facilities, but also the impact of Chernobyl on Belgium and the risk caused by radioactive waste are estimated high by large groups of the population, while the perception of the people with a radiation protection background is much different. Nuclear and chemical risks are considered by the population in a similar way, both for installations and for waste, and are preceded by the risk of terrorism and of general environmental pollution, but radiation protection people consider the chemical risk to be much higher.
- When asked about the catastrophic potential of technologies or industries, the nuclear installations take the lead, but also radioactive waste is believed to show a catastrophic potential for many Belgians. Oil refineries, gas distribution facilities and dams are not considered to show a high potential for catastrophes. Also here, there are net differences in the perception of people having a radiation protection background.
- When we compare the risks related to radiation, we find a contradiction between the average dose to the population and the perception of risk by this population. Indeed, the radon risk is not well known by the population, and always gets the highest numbers of 'no answer' or 'don't know' throughout the entire study, despite of the relatively high fraction of the average dose to the population related to it. Similarly, the use of radiation for medical applications is not perceived to be cumbersome. The general population shows a lot of trust in the protective actions of the authorities in this field, while the doses for radiology in Belgium are high and of growing concern. On the other hand, the sources of radiation causing only marginal doses in Belgium, such as releases of facilities, or radioactive waste or the impact of Chernobyl upon Belgium are believed to cause a lot of risk. It's worth mentioning that most of the Belgian population considers the information received so far related to nuclear risks to be as of "low quality".

Coming to more over-all conclusions, it is clear that several reflections could be useful, not only at the level of research, but also for the nuclear industry or other users of radioactivity, and at the level of authorities:

- Should a good policy take into account perception of a risk or only the risk as quantified and characterised by experts?
- Is there sufficient trust in all actors to come to a sustainable use of technology making use of nuclear processes or radiation? Is there sufficient knowledge within the population about these processes and the main actors?
- What can/should be done to avoid excessive exposure to radon or in the medical field, and to give adequate information on the impact of installations, waste, accidents etc. for the 'average' person living in Belgium?

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6. References


