Studiegebied Handelswetenschappen en Bedrijfskunde

Opleiding Master of Science in het milieu- en preventiemanagement

Intern aangestuurde masterproef

The differences in perception of radiological risks

lay people versus new and experienced employees in the nuclear sector

Masterproef aangeboden door

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tot het behalen van de graad van

Master of Science in het milieu-

en preventiemanagement

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Academiejaar: 2012 – 2013

Verdedigd in: januari 2013

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Master Thesis

The differences in perception of radiological risks: lay people versus new and experienced employees in the nuclear sector

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Abstract

This paper studies the differences in perception of radiological risks between four different groups: the general population without (a) and with experience related to radiological risks (b), new employees (c), and professionally exposed people (d) in the nuclear sector. More precisely, the research goal is to determine whether there is a significant difference in risk perception between these four groups for two radiological risks - an accident at a nuclear installation and medical X-rays - and if this difference can be explained by confidence in authorities, the knowledge level about radiological risks and/or the risk perception of other risks or other variables that are included. The data are gathered using computer assisted personal interviews based on the SCK-CEN Barometer of the Belgian Study Center for Nuclear Energy or another questionnaire based on the SCK-CEN Barometer. The relations between risk perception and the independent factors are tested with linear regression analysis. The differences in risk perception are for both risks significant different between the groups. The professionally exposed people and the new employees in the nuclear sector have a significant higher risk perception for medical X-rays compared to the risk for an accident at a nuclear installation. For the general population without experience it was just the opposite. The general population with experience does not have a significant difference in risk perception between the two radiological risks. Confidence in authorities is determined as an important variable. People have a lower perception of radiological risks when they have more trust in the authorities.

Introduction

The society of today is faced with several major technical and environmental risks such as nuclear energy, dangerous waste, climate change, food safety, etc. (Sjöberg, 1999; 2005). In order to manage and communicate these types of complex risks properly and to be able to develop the best available policies, Renn (2005) introduced the concept Risk Governance. Risk Governance is defined as, "applying the principles of good governance to the identification, assessment, management and communication of risks in a broad sense." The inclusion of all available (scientific) knowledge about the physical attributes of the risks as well as detailed knowledge of stakeholders' concerns is considered as a feature of Risk Governance. After all, in scientific literature, a difference in risk perception between experts and the lay public is elaborated. The risk assessment of the experts, mostly defined in terms of likelihood or probability and severity of the expected consequences, are often seen as the 'objective truth', while the opinion of the lay public are seen as an expression of concern about the unknown effects or the well-known but unlikely, negative consequences (Fishhoff, Slovic & Lichtenstein (1983); Botterill & Mazur, 2004). The reaction of the public is also often called a 'gut' reaction (Sjöberg, 2000a). After all, the public does not have the same knowledge and experience as the experts. Some authors are even convinced that also experts are biased (Skjong & Wentworth, 2001). Nevertheless, in the case of controversial topics, like nuclear power and radiological risks, socio-economic and ethical values should be considered (Hämäläinen, 1991).

From the constructivist point of view, risk is considered as a mental construct. As a consequence, several stakeholder groups have their own perspective and conceptualization of a risk, driven by differences in interests, values, culture and experience (Renn, 2005; 2008). In other words, people tend to make their own risk constructs and images, also called perceptions. It is important that decision makers take into account stakeholders' risk perceptions because "human behavior is primarily driven by perception and not by facts or by what is understood as facts by risk analysts and scientists" (Renn, 2005). The fact that stakeholders use their own perspective makes it very difficult for the decision makers. Before the decisions were made on calculations (risk and probability) and now they have become a more complex, political matter (Hämäläinen, 1991).

In order to explain why people have different risk perceptions, it is necessary to gain insight into the factors that influence the difficult and complex process of risk perception (Sjöberg, 2000b). In general, three dominant perspectives can be distinguished: the Psychometric Paradigm (psychological perspective), the Cultural Theory (anthropology & social-culture perspective) and the Social Amplification of Risk Framework (sociological perspective).
The Psychometric Paradigm, developed by Fischhoff, Slovic, Lichtenstein, Read and Combs (1978), makes use of a cognitive perspective, to explain why risks are often perceived differently. Nine factors are examined: dread of a hazard, the fact that the risk is known/unknown, the amount of control people experience when they are exposed to the risk, the fact they are (in)voluntarily exposed, the knowledge of the people exposed to the hazard, the potential to cause chronic or catastrophic damage, the potential to cause an instant damage, the fact that the technology is new and the potential impact of the hazard (Siegrist et al., 2007). The amount of factors used in a study based on the Psychometric Paradigm can vary, but mostly these nine risk- and situation related factors are taken into account. However Fischhoff et al. (1978) concluded that 2 factors explain around 80% of the risk perception: dread and novelty of the risk. For example, one decade ago, the risk perception of nuclear power was highly determined by the dread dimension and the fact that it was seen as a new, unknown hazard (Sjöberg, 2000b).
The Cultural Theory was first published by Douglas and Wildavsky (1982). The starting point of this theory is the idea that the social and cultural context, the way that people interact and the norms and values of a societal group determine how social groups perceive and understand risks (Wildavsky & Dake, 1990). In the original theory, Douglas and Wildavsky distinguished 4 social groups in order to describe differences in risk perception and risk behavior as a consequence of cultural biases. This model is a two-dimensional grid, each measures sociality and helps to understand why different cultures have different perceptions. All groups fairing their different hazards: Egalitarians (concerned towards technology and environment), Individualists (threats to the market and the risk of war), Hierarchists (law and order), Fatalists (none of the above mentioned risks) (Wildavsky & Dake, 1990). The social context of the respondent and the way that this person interacts with his/her environment determine the risk perception. A lot of factors can be included when this theory is used, but gender, education, income and size of community are often to be found (Sjöberg, 2000b). Although, the studies based on the Cultural Theory only found weak, but systematic relationships.
The Social Amplification of Risk Framework is an analytical, sociological perspective that gives insights into the diverse aspects influencing risk perception. The model of Kasperson et al. (1988) focuses on the social amplification and attenuation of risks. The role of the media is emphasized within this perspective. Wynne (1996) also stresses the importance of the amount of trust people have in the competence and expertise of individuals or organizations that are responsible for risk management for the understanding of risk perception.
Albeit the Psychometric Paradigm and the Cultural Theory have claimed to offer a certain value of explanation, both theories have been criticized for their limited explanatory value just explaining at maximum 20% of the risk perception (Sjöberg, 2000b). Consequently, no model is comprehensive and complete as risk perception is the result of people's individuals beliefs, attitudes and norms as well as wider social and cultural aspects.

It is important to realize that risk and perceptions of risk change in time. In the study of Kanda, Tsuji and Yonehara (2011) the risk perception of the Japanese respondents rose temporal for long

term health risks like X-rays, food additives… But other risk perceptions like nuclear power remained very high during 25 years. The risk perception did vary over the years, influenced by accidents like Fukushima and Chernobyl. Overall the risks with the highest risk perception are those with a non-routine risks (e.g. nuclear power, handguns).

The Psychometric Paradigm is the most dominant perspective used to explain the differences in risk perception by experts and the public as it helps to explain why people are very reactive towards certain hazards and indifferent about other risks (Slovic & Weber, 2002). It has been used in the fields of nanotechnology (Slovic & Weber, 2002; Siegrist, Keller, Kastenholz, Frey & Armin, 2007; Sjöberg, Truedsson, Frewer & Prades, 2000; Weber, 2001) and the use of GMO in food and medical applications (Savadori, Stefania, Nicotra, Rumiati, Finucane & Slovic, 2004).
In general, the experts have significantly lower risk perceptions than lay people. These differences are explained by Siegrist et al. (2007) referring to the less familiarity of the public and the differences in knowledge about the risk. The public has also less trust in government to protect against and communicate about risks. The experts have better insight in the role and activities of the government and can better assess whether the reaction of the government is effective or not. Related to nuclear risks, Sjöberg et al. (2000), asked experts and lay people to give their own risk perception of nuclear risks and to estimate the perception of the other group. The experts were aware of the fact that they do have a lower risk perception than the public, but the public made a wrong estimate of the risk perception of the experts. The public was not aware of this difference in risk perception and rated the risk perception of experts the same as their risk perception. According to Sjöberg and Drottz-Sjöberg (1994) the reason why experts have a lower risk perception is linked with responsibility. The experts feel responsible for the safe use of radiological applications. The radioactive waste experts feel responsible for it. As such, for risks where the experts don't feel responsible, they have a similar risk perception as the public. The explanation given to the often large gap in risk perception between experts and the public relates to the mistrusted communication and the assurances about nuclear risks and nuclear safety by the public. The communication can be mistrusted by the public when the experts disagree about risks, so there is not a scientific consensus (Sjöberg, 1999). Also other authors like Otway and Winterfeldt (1992) discussed pitfalls in expert judgment. In this study, different teams of experts assessed same risk: the probability of failure in a nuclear power plant. The estimates of the different groups varied strongly (up to factor 50). Disagreement between experts is bad for the trust in experts.
Cohen (1998) tried to explain the gap in risk perception by assuming that the public is misinformed about risks or misled in favor of one's advantage. But people are not ignorant about risks, nor completely misinformed (Sjöberg, 1999). Knowledge has no effect on people's perception of a specific risk (Perko, Železnik, Turcanu, Thijssen, 2012) like e.g. nuclear power. When public's risk perception is higher for a risk than the objective risk, this will cause difficulties for the public acceptance of this risk. Another problem caused by the same reason is located at the level of the communication of risks (Kanda, Tsuji and Yonehara, 2011). It will become very difficult to communicate about these risks. Siegrist et al. (2007) believe that the experts construct their risk perceptions on actual risks and their knowledge of these risks, so they don't use the same methods like the public in their risk assessment. The public seems to use often cues like benefit/disadvantages, unfamiliar risk…

The goal of this paper is to contribute to the discussion on the differences in risk perception related to nuclear activities. In particularly, the differences in risk perception of two radiological risks - a nuclear accident and medical X-rays - of four different groups are studied: 1) the general public that never has had a job in which they could be exposed to radioactivity, 2) the people who have had a job that involved the use of radioactivity, 3) the new employees in the nuclear sector and 4) the people who are professionally exposed to radiation. The group of new employees is not strong represented in the literature. Sjöberg (1999) already compared differences in risk perception of students and found very strong co-variation between line of study (science, technology, social science of humanities) and the perceived risk: "students in the field of science and technology (…) were much less concerned about risks of nuclear technology than others, although they had not yet

acquired expert knowledge". Based on the study of Sjöberg (1999), the hypothesis of this study is that the risk perception of the new employees rather contrasts with the perception of the lay public as a result of their differences in background and studies. Nevertheless, it is expected that the risk perception of new employees is also very different from the professionally exposed people, because they are lacking experience and are less familiar with nuclear applications and the use of radioactive materials. In concrete, the present paper contributes to the following research question: Is there a significant difference in the risk perception for nuclear accidents and medical X-rays between the general public (differentiating between those who have had a job that involved the use of radioactivity and those who have not), the professionally exposed people and the new employees in the nuclear sector? And if there is a significant difference, can it be explained by the knowledge of the respondents, their confidence in authorities to protect them, and/or their risk perception of other risks.

The paper structures as follows: the next section elaborates the method used. The data collection of respondents is discussed as well as the questionnaire used. The following part presents the results of this study. First the characteristics of the different groups are described. A linear regression is done in order to investigate which factors mostly influence the risk perceptions of these four social groups. The last part links our findings with the literature, discusses the main findings and the method used and draws a conclusion.

Methods

This section depicts the method used. First, the data collection of each group of respondents is elaborated as the method to approach each group was different. Secondly, the list of questions is amplified. Thirdly, the statistical tools for data analysis are elaborated.

Participants

The participants included in the study are divided in four groups: the general Belgian public (differentiating between those who have had a job that involved the use of radioactivity and those who have not), the professionally exposed people of Belgian Study Center for Nuclear Energy (SCK-CEN) and the new employees at SCK-CEN.

The data collection of the general Belgian population is based on an opinion survey (SCK-CEN Barometer) using Computer Assisted Personal Interviews (CAPI) between 25/05/2011 and 24/06/2011 (Turcanu, Perko & Schröder, 2011). In total 1020 respondents participated and 605 refused to cooperate (participation degree of 63%).
A stratified quota sampling is used, to make sure that all dependent variables are representative for the Belgian (+18) population: age, gender, province, region, urbanization and professionally active status.
For the analysis, the general population group is split into two different samples, making a difference between those who have had a job that involved the use of radioactivity (nuclear power plant, industry or hospital using radioactive sources, natural radioactivity in ores and other materials) (5,2% or 53 respondents) and those who have not (94,8% or 967 respondents).

According to Skjong and Wentworth (2001), an expert is someone who has a background in the topic. In this paper we don't use the word expert, but prefer 'people who are professionally exposed to radiation', as the latter is a broader concept, also involving non-experts who are exposed to radiation. At SCK-CEN this group corresponds to 539 employees who can enter the controlled area and are registered as such for monitoring. They are all wearing dose-meters, measuring the amount of radiation received, and they have all received a special radiation-protection education. For the collection of the data, the professionally exposed people were invited by email to fill in a digital questionnaire, their anonymity was safeguarded. After 2 recalls, 351 respondents had filled in the questionnaire. 19 respondents were excluded as they had already participated in the Barometer study or in the new employees study. In total 332 professionally

exposed people are included in the study. The data of the professionally exposed people were gathered from 23 May 2012 until 11 June 2012.

42 newly employed people at SCK-CEN were identified and contacted. They all had a seniority of less than one year at SCK-CEN. The interviews were carried out between 13/05/2011 and 18/05/2011. Before filling in the questionnaire, the respondents received a short introduction about the research goal, obtained guaranty for anonymity, and received an explanation of the method used. This introduction is important to encourage people to respond. The questionnaire was completely the same as the questionnaire of the public and it will be elaborated in more detail in the next section.

Questionnaire

In order to be able to compare the different groups, each participant of the study received the same questions based on the SCK-CEN Barometer (Appendix A). If relevant, some additional questions were added typical for one group (e.g., years of experience). The query sheet was available in three languages: Dutch, English and French. The translation of the questionnaire was done by native speakers. The questionnaire was tested by a pilot study to make sure that the questions were clear and to verify that the questions were interpreted in the same way by different respondents.
The first part of the SCK-CEN Barometer contains questions related to the individual characteristics of the respondent like age, gender and level of education. The second part of the survey is a list of statements to find out the respondents' risk perception and confidence in the authorities for several nuclear- and industrial risks. The respondents had to answer using a five points Likert-Scale: very low, low, average, high, very high or choose for don't know / no answer. In the following part of the questionnaire, the respondents are asked to give their opinion on several statements concerning science and technology, followed by statements about nuclear energy. For example "In general I believe that the benefits/advantages of nuclear energy outweigh the disadvantages." The respondents can answer again using a five point Likert-scale: strongly disagree, disagree, more or less agree, agree, strongly agree or choose for a sixth category "don't know / no answer". In the next part, respondents can discuss several arguments pro or against nuclear energy, they can rate their public participation in the decision-making process and they are asked to give their opinion on the management of nuclear technologies and the actors operating in the nuclear field. The accident at Fukushima is broached in the succeeding part of the questionnaire and the relevance of this accident for Belgium is questioned.
Knowledge about the nuclear domain is the next theme of the SCK-CEN Barometer. The knowledge of the respondents according to nuclear radiation is measured making use of 10 questions. One example of a question posed to the respondents as an illustration: "The measurement unit for radioactivity is: Becquerel, Hertz, Metres/second or don't know/no answer." The following theme of the Barometer study deals with the iodine campaign while the last questions are related to the respondents' perception of radioactive waste.
The new employed people and the general population both filled in the complete SCK-CEN Barometer (see Appendix A). The Barometer contains many questions which were not relevant to the previously defined research questions of this master thesis. Only the questions that are relevant to this master thesis are included in the questionnaire of the professionally exposed people (see Appendix B). The most comprehensive changes relate to the background of the respondents, which is limited to ensure their anonymity, the list of industrial and nuclear risk is also limited to three nuclear risks, while the questions related to the iodine campaign and the radioactive waste perceptions are also excluded.

Data analysis

The data are analyzed using the statistical program SPSS. To determine if a value was significant, the p-value is set at 0,05 (95%) in all cases. A Chi^2 is calculated to check whether the four groups in this study have a different ratio of female and male respondents. All four groups are checked

separately. A cross tabulation gives a clear overview of the distribution of the respondents into the different age groups, split up by the four groups.
The knowledge of the respondents is measured on a ten item scale and a Games-Howell post-hoc test is executed. The Games-Howell post-hoc test does not rely on homogeneity of variance, since there is no homogeneity of variance. Other tests like Bonferroni are not performed. The correlation between the independent variables is studied with a Pearson correlation test.
A one-way ANOVA is performed to see whether the differences between the groups in confidence in authorities are significant. A Bonferroni test is performed to compare the results. A paired sample t-test checks for significant differences within the groups.
A one-way ANOVA is performed to see whether the differences in perception for each risk between the groups are significant. Significant differences between the groups results in a Bonferroni post-hoc test.

A linear regression is applied for the regression analysis of the different groups. The dependent variable in the first case is the risk perception of an accident at a nuclear installation, followed by the risk perception of medical X-rays. The independent variables are gender, age, confidence in authorities to protect against the according risk (an accident at a nuclear installation or medical x rays), knowledge, risk perception medical X-rays (for an accident at a nuclear installation), an accident at a nuclear installation (for medical X-rays) and different statements about advantages of nuclear power and the management of nuclear power.

Results

Characteristics of the different groups of respondents

In the following part, the characteristics of the different groups are presented: gender, age, confidence in authorities, knowledge about nuclear energy, the experienced benefits to nuclear energy and medical X-rays, and risk management.

The ***ratio male/female*** is not in every group representative in correspondence with the Belgian population. Belgium has slightly more women than male inhabitants: 51,1% of the Belgian population is female and 48,9% are male (Steegmans, Van Aerschot, Poot & Van Haegendoren, 2006). The general population without experience has 473 male (48,9%) and 495 female (51,1%) respondents, without a significant different ratio in gender, compared to the Belgian population (*Chi²=0,001, two tailed p=0,09795*). The gender ratios did vary significantly in the three other groups compared to the Belgian population. Within the general population with experience, 34 (65,4%) male and 18 female (34,6%) participated in the study (*Chi²=5,692; p=0,017, df=3*). In the group of new employees 27 male (64,3%) and 15 female (34,7%) respondents are included (*Chi²=4,026, p=0,0448, df=3*). The group of the professionally exposed people contains 275 male (82,9%) and 57 female (17,2%) respondents. As a consequence, the gender ratio of this group has the highest deviation (*Chi² =153,104; p=0,001, t(3)=119,8*). To summarize, there are strong significant differences between the four groups in the ratio of gender.

The respondents are subdivided over nine ***age categories*** (-25 years, 25-30, 31-35, 36-40, 41-45, 46-50, 51-55, 56-60 and older than 60 years). The distribution of the respondents into the different age groups is split up by the four groups. The differences in age between the four groups are significant. The groups of the new employees (2,4%) and the professionally (3,6%) exposed people have a very small number of respondents older than 60. This is not surprising as the official age of retiring in Belgium is 65 years. Most respondents (87,4%) in the group of new employees are between 25 and 45 years old. In the group of professionally exposed people only 2 respondents are younger than 25 years old (0,6%).

The ***knowledge*** of the respondents is measured on a ten item scale and an AVOVA with a Games-Howell post-hoc test is executed. The general population without experience has a significant lower mean score compared to the other groups (*M=6,09; SD=1,877*). The mean level of knowledge of the general population with experience (*M=7,19; SD=1,704*) is significant higher than the mean

knowledge level of the general population without experience, but significant lower compared to the professionally exposed people (*M=8,11; SD=2,153*). The new employees (*M=8,00; SD=1,343*) only have a significant higher level of mean knowledge than the general population, but not compared to the general population with experience or the professionally exposed people.

Table 1 reveals that the **confidence in authorities** to protect against an accident at a nuclear installation and medical X-rays differs a lot between the four groups. The differences between the groups are tested using a one-way ANOVA, there is a significant difference in confidence in the authorities to protect against an accident a nuclear installation (F(3,1370)=12,273; p<0,001).
A Bonferroni post-hoc test indicates that there is no significant difference between the general population without (M=3,15; SD=1,15) and with experience (M=3,25; SD=1,05; p=1,000), but the confidence of the general population without experience is significantly lower compared to the confidence of the new employees (M=3,92; SD=0,97; p<0,001) and the professionally exposed people (M=3,50; SD=1,10; p<0,001). The general population with experience has only a significantly lower level of confidence compared to the new employees (M=3,92; SD=0,97; p<0,028). The professionally exposed people (M=3,50; SD=1,10) do not have a significantly lower level of confidence in authorities to protect against an accident at a nuclear installation compared to the new employees (M=3,92; SD=0,97; p<0,148). 42,1% of the people without experience have a 'high' to 'very high' trust in the government compared to 50% of the general population without experience, 72,5% of the new employed people and 56,8% the professionally exposed people.
There is also a significant effect of the group on the confidence in authorities to protect against medical X-rays (F(3,1370)=6,129; p<0,001). A Bonferroni post-hoc test indicates that the level of confidence in the authorities to protect against medical X-rays of the general population without experience (M=3,15; SD=1,10) varies significantly from the confidence of the new employees (M=2,65; SD=1,08; p=0,019) and the professionally exposed people (M=2,94; SD=0,93; p=0,008). The general population with experience (M=3,23; SD=0,95) does not have significantly more trust compared to the general population without experience (M=3,15; SD=1,10; p=1,000), neither compared to the new employees (M=2,65; SD=1,08; p=0,052), nor the professionally exposed people (M=2,94; SD=0,93; p=0,358). The difference in confidence in authorities to protect against medical X-rays is not significant between the new employees (M=2,65; SD=1,08) and the professionally exposed people (M=2,94; SD=0,93; p=0,637).

Table 1: Confidence in authorities

Confidence in authorities to protect								
	General population without experience		General population with experience		New employees		Professionally exposed people	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
An accident at a nuclear installation	3,15	1,15	3,25	1,05	3,92	,97	3,50	1,10
Medical X-rays	3,15	1,10	3,23	,95	2,65	1,08	2,94	,93

The confidence in authorities not only differs between the four groups, but also within each group depending on the type of risk. In the following paragraph, the variations within the groups are studied. The difference in confidence in authorities to protect against an accident at a nuclear installation and medical X-rays is for the general population without experience not significant (*p= 0,878; t(949)=-0,153*). The trust in authorities of the general population with experience do not significantly (*p= 0,816; t(50)=0,234*) differ between the two risks. The new employees have significantly (*p<0,000; t(38)=6,171*) more trust in authorities to protect against an accident at a nuclear installation, compared to their trust in authorities to protect against medical X-rays. The difference in trust in authorities for the two risks are less explicit compared to the new employees,

but there is still a strong significant (*p= 0,000; t(323)=8,539*) difference in trust in authorities. The professionally exposed people have more trust in authorities to protect against an accident at a nuclear installation compared to medical X-rays.

The experienced ***benefits*** related to nuclear power are measured by the following statements: 'In general I believe that the benefits/advantages of nuclear energy outweigh the disadvantages' (*p<0,001; F(3)=120,02*), 'The reduction of the number of nuclear power plants in Europe is a good cause' (*p<0,001; F(3)=181,510*) and 'Are you in favor or not against nuclear energy?' (*p<0,001; F(3)=183,513*). The differences between the four groups, tested with ANOVA, are for all three questions strongly significant. The overall conclusion drawn from the results is that the new employees and the professionally exposed people are in favor for nuclear energy. They perceive the benefits superior to the disadvantages. As a consequence, they regret the policy decision to reduce the number of nuclear power plants. The general population without experience is the most skeptical about nuclear power and is in favor of the reduction of nuclear power plants.

The perception of the respondents regarding ***risk management*** of nuclear energy is questioned with seven statements: 'Nuclear reactors in Belgium are operated in a safe manner', 'There is insufficient control by authorities on the safety in nuclear installations in Belgium', 'I believe that in Belgium radioactive waste is stored in a safe manner', 'The transport of radioactive materials is not safe', 'The production of fuel for NPP's causes environmental damage', 'I feel well protected against risks from nuclear installations', 'Nuclear power endangers the future of our children'. The differences between the groups for all statements are strongly significant (*p<0,001, t(12)=485,07*). The general population is more convinced that there is insufficient control to many risks involved with nuclear energy and that it endangers the future of our children. In order to illustrate the differences between the four groups, the results regarding the statement 'Nuclear power endangers the future of our children' are presented. The majority of the general population without experience considers nuclear power as a danger for the future generation (51% agree or strongly agree). A fourth of this group (25,5%) responds neutral and almost as much respondents disagree (23,5%). The general population with experience is slightly less worried: 40,4% (strongly) agree against 36,5% (strongly) disagree. The new employees and the professionally exposed people are much less worried about the dangers of nuclear power for future generations (92,6% and 88% disagree or strongly disagree, respectively).

The correlation between the independent variables is measured with a Pearson correlation. The correlations are described in Appendix C, the levels of significance are displayed with * (0,001<p≤0,05) or ** (p<0,001).

Risk perception

Table 2 presents the mean values and standard deviations for the perceived risk of each risk individually, for the four different groups. A one way ANOVA between the four groups is performed for the risk perception of an accident at a nuclear installation, there is a significant difference between the groups (*F(3,1368)=61,808; p>0,001*). The differences in risk perception between the groups are tested post-hoc with a Bonferroni test, the differences between the general population without (M=2,99; SD=1,19; p=0,91) and with experience (M=2,90; SD=1,27) are not significant (*p=0,8*), but the general population without experience has a significantly higher risk perception compared to the new employees (*M=1,92; SD=1,04; p<0,001*) and the professionally exposed people (*M=2,02; SD=1,13; p<0,001*). The same post–hoc test indicates a significantly higher risk perception of the public with experience compared to the new employees (*M=1,92; SD=1,04; p=0,001*) and the professionally exposed people (*M=2,02; SD=1,13; p<0,001*). The difference in risk perception for an accident at a nuclear installation is not significantly different between the new employees and the professionally exposed people.

A one-way ANOVA is also performed for medical X-rays, the difference in risk perception between the groups are significant (*F(3,1376), p=0,011*). A Bonferroni post-hoc test is performed because of this significant difference between the groups. The risk perception of medical X-rays of the general population without experience (*M=2,62; SD=1,04*) varies not significantly from the general population with experience (*M=2,71; SD=0,96; p=1,000*) and the new employees (*M=2,65; SD=0,95; p=0,790*), but the general population without experience has a significant lower risk perception compared to the professionally exposed people (M=2,84; SD=0,97; p=0,005). The risk perception of medical X-rays of the general population with experience (*M=2,71; SD=0,96*) is not significantly different from the new employees (M=2,65; SD=0,95; p=0,897) nor from the professionally exposed people (*M=2,84; SD=0,97; p=0,724*). The new employees (*M=2,65; SD=0,95*) do not have a significantly lower risk perception for medical X-rays than the professionally exposed people (*M=2,84; SD=0,97; p=1;000*).

Table 2: Risk perception

	General population without experience		General population with experience		New employees		Professionally exposed people	
Risk perception	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Accident at a nuclear installation	2,99	1,19	2,90	1,27	1,92	1,04	2,02	1,13
Medical X-rays	2,62	1,04	2,71	0,96	2,65	0,95	2,84	0,97

The risk perception also differs within each group depending on the type of risk. The general population without experience has a significant higher risk perception for an accident at a nuclear installation (*p<0,001; t(951)=8,32*) compared to medical X-rays. The difference in risk perception for an accident at a nuclear installation and medical X-rays is for the general population with experience not significantly different (*p=0,350; t(51)=0,944*). Also the differences in risk perception between the two risks are significant within the group of new employees (*p=0,001; t(38)=-3,73*) and within the group of professionally exposed people (*p<0,001; t(324)=-0,667*). These results prove that the two radiological risks are often perceived differently.

Identifying predictors for risk perception for each group

In this section the predictors for the risk perception of the two radiological risks are analyzed. Only the significant *(p<0,05)* and almost significant (0,09>*p* <0,05) results are reported.

The linear regression is executed for every group and for the two risks separately. The linear regression for the general population without experience indicates a significant relation between

the risk perception of the general population without experience for an accident at a nuclear installation and the risk perception for medical X-rays (*p< 0,001; β = 0,265; t(15)=7;84*). This result suggests that the risk perception of the general population about an accident at a nuclear installation will be higher when their risk perception of medical X-rays is higher. The second significant relation is between an accident at a nuclear installation (dependent variable) and the statement 'The transport of radioactive materials is not safe' (*p*< 0,001; *β* = 0,148; *t*(15)=3,75). The more they are of the opinion that the transport of radioactive materials is dangerous, the higher their risk perception for an accident at a nuclear installation will be.
There are four significant relations found for medical X-rays in the general population without experience. The general population without experience will have a lower risk perception for medical X-rays, the more they trust the authorities to protect against medical X-rays (*p=0,007; β=096; t(15)=-2,74*). The older the respondent of the general population without experience, the lower the risk perception of this person (*p=0,049; β=-0,066; t(15)=-1,97*).
The third significant relation is between medical X-rays and an accident at a nuclear installation (*p< 0,001; β= 0,279; t(15)=7,88*). The last relation is found with the statement 'I believe that in Belgium radioactive waste is stored in a safe manner' (*p=0,031, β=0,107; t(-2,29*). When the people believe that radioactive waste is stored in a safe manner, their risk perception for medical X-rays will be lower.

The only significant relationship between the risk perception of the general population with experience is the confidence in authorities to protect them against the risks of an accident at a nuclear installation (*p=0,021; β=0,42; t(15)=-2,43*). The more confidence these people have in the authorities, the lower their risk perception.
There is one significant relation found for the medical X-rays. The risk perception for medical X-rays for the general population with experience has a significant relation with the statement 'In general I believe that the advantages of nuclear energy outweigh the disadvantages' (*p=0,017; β=-0,480; t(15)=-2,54*). This finding shows that this group has a lower risk perception for medical X-rays, when they believe that the advantages outweigh the disadvantages.

There is a significant relationship for the new employees between the risk perception for an accident at a nuclear installation and the statement 'The reduction of the number of nuclear power plants in Europe is a good cause' (*p=0,008; β=0,891; t(15)=4,20*). The more they agree with this statement, the higher their risk perception for an accident at a nuclear installation.
The risk perception of medical X-rays of new employees is significant lower when they have more trust in the authorities to protect against medical X-rays (*p=0,039; β=-0,795; t(15)=-3,52*). This is the only significant relation found for the risk perception of medical X-rays for the new employees. An interesting, but not significant relation is found for gender (*p=0,087; β=1,12; t(15)=2,44*). This result indicates that female respondents have a higher risk perception for medical X-rays, although this result is not significant.

The professionally exposed people have a higher risk perception for an accident at a nuclear installation when they agree more with the statement 'Nuclear power endangers the future of our children' (*p=0,009; β=0,222; t(15)=2,65*). Another significant relation is between the risk perception for medical X-rays and the statement 'I do not feel well protected against risks from nuclear installations' (p=*0,006; β=0,208; t(15)=2,76*). When these people do not feel well protected, they will have a higher risk perception. A not significant, but interesting relation is found between the risk perception for an accident at a nuclear installation and gender, suggesting that female respondents have a higher risk perception for an accident at a nuclear installation (*p=0,063; β=0,21; t(15)=1,87*.
The risk perception of the professionally exposed people has no significant relation with other risks. The risk perception of medical X-rays has a significant relation with confidence in authorities (*p=0,003; β=-0,19; t(15)=-3,03*). This relation shows that professionally exposed people who have more trust in the authorities, have a lower risk perception for medical X-rays. Another significant relationship is between medical X-rays and the age of the respondents (*p=*0*,032; β=-0,134; t(15)=-2,26*): the older the respondent, the lower his/her risk perception.

In brief: the four groups have different variables that have a significant relationship with their risk perception of an accident at a nuclear risk and/or medical X-rays. Trust in authorities is a variable that is in many groups significant, meaning that when the authorities do more efforts to increase the trust, it might lower the risk perception of an accident at a nuclear installation or medical X-rays. The different statements about advantages of nuclear power and the management of nuclear power are often in a significant relation with risk perception. People who think that e.g. the transport is not safe or the reduction of nuclear plants is a good cause, have a higher risk perception. The general population with experience have a lower risk perception for medical X-rays, when they think that the disadvantages are outweighed by the benefits. The model used for the linear regressions varies between a low level of explanatory value to high levels of explanatory for the risk perception of the two radiological risks. The highest levels of explanatory value are recorded for the new employees (adjusted R^2 for an accident at a nuclear installation=0,780 and adjusted R^2 for medical X-rays=0,900). The model has the lowest explanatory value for the professionally exposed people (adjusted R^2 for an accident at a nuclear installation= 0,132; adjusted R^2 for medical X-rays=0,114).

Discussion

In this study the goal is to look for differences in risk perception of two radiological risks between the general population without experience, the general population with experience, new employees and professionally exposed people and to study which variables play a role in the risk perception for each group separately. The general population is a good representation of the Belgian population, but the new employees and the professionally exposed people are less representative. Both the new employees and the professionally exposed people are working at the Belgian Study Center for Nuclear Energy, which might influence the results. The results would probably have been different if the selection of the respondents would have been less unilaterally. After all, it is very plausible that the employees of SCK-CEN have a different point of view compared to employees at a hospital in the section radiology. It is desirable that future research would focus on the differences between several types of experts, like experts in nuclear power, experts in radiology, experts in transport of radioactive material, the processors of radioactive waste… Also the number of risks included in this study is limited as only the risk perception of an accident at a nuclear installation and medical X-rays are studied. The hypothesis of this study is that the new employees have a significant lower risk perception for an accident at a nuclear installation compared to the general population without experience, but higher compared to the professionally exposed people. The empirical results reveals that the difference in risk perception of the new employees is significant compared to the general population without experience, but negligible compared to the risk perception of the professionally exposed people. The results for medical X-rays are differently. Here the only significant difference in risk perception between the groups is found between the general population and the professionally exposed people. The general population without experience has a significant lower risk perception compared to the professionally exposed people. Also this result is surprising as in a previous study, Sjöberg et al. (2000) found that experts have a systematic lower risk perception for risk concerning radiation and nuclear technology than the public. Although the two radiological risks included in this paper make use of ionizing radiation, it seems that these two technologies are perceived quite differently by the different groups. Sjöberg (2000b) also found that there is a difference in risk perception for medical X-rays and nuclear power, but the experts had in both cases a lower risk perception compared to the general population. The professionally exposed people at the nuclear research centre have a lower risk perception for an accident at a nuclear installation than for medical X-rays. These people see medical X-rays as more dangerous to the ordinary citizen than an accident at a nuclear installation. If the professionally exposed people have more confidence in the authorities, they will have a lower risk perception. But since this group has less confidence in the authorities to protect them against the risks of medical X-rays compared to an accident in a nuclear installation, it might explain why they have a higher risk perception for medical X-rays. The confidence in the authorities plays a large role in the process of risk perception: the higher the confidence in authorities, the lower the perception of the radiological risk. In general, the professionally exposed

people and the new employees have more confidence in protection from the authorities against an accident in a nuclear installation than the general population (without- with experience). It is interesting that this is not the case for medical X-rays for which the new employees and the professionally exposed people express less trust in the authorities to protect against medical X-rays than the general population.

The significant differences in confidence in authorities between the groups may be explained by a communication problem. Sjöberg et al. (2000b) address this gap to the large cognitive differences. As a consequence, the experts and authorities should explain radiological risks in a more accessible way and their communication should be more transparent. Another possible explanation comes from Siegrist et al. (2007), who claims that the higher the knowledge of the respondents, the more insight they have in the effectiveness of the actions performed by the authorities to protect them against these risks. Sjöberg (1999) considers trust as the main factor: the specialists have more trust than the public. Previous studies (Sjöberg, 1999; Slovic, 1999) showed that the public mistrust the experts. This mistrust is caused by disagreements between experts and the public think that the experts' knowledge is overestimated. The general population also gets most information from the news media and this media principally reports the mishaps and the treats. It is also possible that the different groups consider different actors responsible for their protection against radiological risks (the federal government, the management of hospitals, etc.), while the questionnaire does not differentiate this issue. For instance it is conceivable that nuclear accidents are addressed to the federal government, while accidents with medical X-rays are considered to be more a responsibility of the hospital's management. The general population might have more confidence in the hospitals (for medical X-rays) than the authorities (for an accident at a nuclear installation). Sjöberg (1999) found that the public has less trust in experts, when these experts are working for authorities, but they have more trust in experts when these experts are perceived as independent. The doctors in hospitals are likely to be perceived as independent from the authorities.

The general population might feel certain voluntariness concerning the risk related to medical X-rays. They can decide whether they are exposed to medical X-rays or not, but they cannot choose to be exposed or not to an accident at a nuclear installation.

The professionally exposed people are the only group in this study where age plays a role. This group has a significant relation between risk perception of medical X-rays and age, the older the respondents, the lower the risk perception of medical X-rays, although this relation is not strongly significant. The difference in risk perception between medical X-rays and a nuclear accident can be explained by the study of Slovic, Peters, Grana, Berger and Dieck (2007), comparing the risks and benefits of several medical tests and procedures. The risk related to the use of medical X-rays received a low risk rating of the respondents and a high level of benefit. Also Siegrist et al. (2007) found that the public perceives the benefits of medical X-rays higher than the disadvantages. The general population without might perceive the benefits higher and the risks lower, compared to the other groups.

The general population (with and without experience) has less knowledge of the amount of radiation and the radiation risks of medical X-rays. But does knowledge play a role? It is interesting that although the knowledge level related to radiological risks between the groups is different, the specific knowledge does not play a significant role in the risk perception. There are no significant relations found between the two risks and knowledge. This finding confirms previous research conclusions of Wildavsky and Dake (1990) and Perko et al (2011). These authors also reported that knowledge does not have an influence on risk perception. Opposite to the present study and Wildavsky and Drake (1990) findings, Siegrist et al. (2007) claimed that more knowledge decreases the risk perception.

Related to medical X-rays, Sjöberg (1996) found that medical X-rays are perceived as less risky than nuclear power. This paper shows similar findings related to the risk perception of a nuclear accident: the general population (with and without experience) have a higher risk perception for an accident at a nuclear installation than for medical X-rays. However, the complete opposite is found for the professionally exposed people and the new employees. The new employees and the

professionally exposed people have a higher risk perception for medical X-rays than for an accident at a nuclear installation. Since these two groups have a higher level of knowledge about radiological risk, they might have a better insight into the impact of medical X-rays. Furthermore they have a lower level of confidence in the authorities to protect against medical X-rays, which might cause a higher risk perception of medical X-rays for these two groups.

The results of the linear regression analysis of an accident at a nuclear installation determined that experience has an impact on the perception of risk. The professionally exposed people and the new employees are obviously more familiar with radiological risk than the general population without experience because they work with or are exposed to radiological sources and are informed by the management of Belgian Study Center for Nuclear Energy. This finding corresponds to the study of perception of Siegrist et al (2007) who showed that the people who are more familiar with nanotechnology have a lower risk perception. In the present study the new employees have slightly lower risk perception for an accident at a nuclear installation compared to the professionally exposed people. The professionally exposed people have more years of experience than the new employees, so the finding that new employees have a lower risk perception for an accident at a nuclear installation differs from previous findings where experience does play a role.

The factor gender was in none of both linear regressions a significant independent variable for an accident at a nuclear installation and medical X-rays. Although no significantly results there is an interesting relation between gender and the risk perception of the professionally exposed people for an accident at a nuclear installation. This finding suggests that the female respondents have a higher risk perception for an accident at a nuclear installation, than their male colleagues. One should notice that the man-female ratio is different in all groups and not always representative compared to the Belgian population. The groups of the professionally exposed people and the new employees consist of much more male than female respondents. Given the findings of Sjöberg (2000b; 2005a) that women are more risk averse, the difference in man-female ratio might have an effect on the risk perception of groups with a limited amount of female respondents.

The group of new employees is underrepresented in the scientific literature. Their level of knowledge is comparable with the professionally exposed people. Of all the groups, they have the lowest confidence in authorities to protect against medical X-rays, but the highest confidence to protect against an accident at a nuclear installation. It would be very interesting to further study the risk perception of the new employees, including more respondents and a better diversity of new employees who are confronted with radiological risks, since they seem to have a rather different opinion. Another recommendation for future studies is to follow the risk perceptions of experts on long term. The publics risk perception increases after an accident, but decreases after a period without an accident. It is not clear weather experts are influenced in their risk perception by an accident/incident. It might be that experts are less influenced by accidents like Fukushima.

The last remark is a methodological one. In the present paper linear regression is used to look for significant relations between the dependent variable (an accident at a nuclear installation and medical X-rays) and the independent variable. The methodological choice to use a linear regression instead of a multinomial logistic regression is debatable. The data are considered to be quantitative and not qualitative.

Conclusions

In life people may be directly or indirectly exposed to different radiological risks. Medical X-rays and accidents at a nuclear installation are just two of them. Previous studies (Sjöberg, 2005a, 2005b; Siegrist et al., 2007; Sjöberg et al.,2000a; Sjöberg 2000b, 1999) showed that there is a gap between the risk perception of the general population and the risk perception of experts. In this study the concept 'expert' is replaced by 'professionally exposed people'. Two new groups are also added in the empirical survey: (1) the general population with experience in the nuclear field

(people from the general population who already have had a job that involved the use of radioactivity) and (2) the new employees of the Belgian nuclear research institute SCK-CEN. These two groups are added because they have a slightly different background compared to the general population without experience and the professionally exposed people. The results of the study reveals significant differences in risk perception of an accident at a nuclear installation and medical X-rays between the groups. The largest differences in risk perception are between the general population without experience and the professionally exposed people. The general population (with and without experience) have a higher risk perception for an accident at a nuclear installation, but the new employees and the professionally exposed people have a higher risk perception for medical X-rays. The four groups are different from each other: it is clear that the new employees and the professionally exposed people have more experience with radiological risks and their level of knowledge is higher. However, in this study, knowledge is not identified as a significant predictor for risk perception. One might expect that people with a higher level of knowledge concerning a risk, might have a lower risk perception for this risk, but this statement is rejected based on the results of this study. In this study, gender never shows a significant relation with risk perception, but there is a not significant relation found between gender and the risk perception of an accident at a nuclear installation in the group of the professionally exposed people. There is a significant relation between age of the respondent (general population without experience) and the risk perception for medical X-rays; the older the respondent, the lower the risk perception in this group. Confidence in authorities is determined as an important predictor for the risk perception of the two radiological risks. The authorities might take action to increase the confidence in authorities by offering people a good protection and good information against the radiological risks adjusted to the receiver.

References

Botterill L. & Mazur N. (2004). Risk & Risk Perception, a Literature Review, *RIRDC Publications 04*(043), 1-22.

Douglas, M. & Wildavsky, A. (1982). *Risk and culture: an essay on the selection of Technical and Environmental dangers*. California: University of California Press.

Fischhoff B., Slovic P.& Lichtenstein S. (1983). 'The Public' VS 'The Experts: Perceived VS. Actual disagreements about risks of nuclear power. In V. Covello, G. Flamm, J. Rodericks & R. Tardiff (Eds.), *Analysis of actual vs. perceived risks* (pp. 235-249). New York: Plenum

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1978). How safe is safe enough? A psychometric Study of Attitudes towards technological Risks and Benefits. *Policy Sciences, 9* (2), 127-152.

Hämäläinen R.P. (1991). Facts or values – how do Parliamentarians and Experts see Nuclear Power. *Energy Policy, 19* (5), 464-472.

Kanda, R., Tsuji, S., Yonehara, H. (2012). Perceived risk of nuclear power and other risks during the last 25 years in Japan. *Health Physics, 102*(4), 384-390.

Kasperson, R.E., Renn, O., Slovic, P., Brown H.S., Emel J., Goble, R., Kasperson J.X. & Ratick, S (1988). The social amplification of risk: A conceptual Framework. *Risk Analysis, 8*(2), 177-187.

Kuppens T., Steegmans N., Van Aerschot M., Poot S. & Van Haegendoren M. (2006). *Vrouwen en mannen in België, genderstatistieken en genderindicatoren.* Brussel: Instituut voor gelijkheid van vrouwen en mannen.

Otway, H. & Winterfeldt D. (1992). Expert judgement in risk analysis and management: process, context and pitfalls. *Risk Analysis, 12*(1), 83-93.

Perko, T., Železnik, N., Turcanu, C. & Thijssen, P. (2012). Is knowledge important? Empirical research on nuclear risk Communication in two countries. *Health Physics, 102*(6), 614-625.

Renn O. (2005). *White paper on risk governance: Toward an integrative approach*. Geneva, International Risk Governance Research Council.

Renn O.(2008). *Risk Governance, Coping with Uncertainty in a Complex World*. London: Earthscan.

Savadori L., Stefania S., Nicotra E., Rumiati R., Finucane L.M. & Slovic P. (2004). Expert and Public Perception of Risk from Biotechnology. *Risk Analysis, 24* (5), 1289-1299.

Siegrist, M., Keller, C., Kastenholz, H., Frey, S. & Armin, W. (2007). Laypeople's and Experts' Perception of Nanotechnology Hazards. *Risk Analysis, 27* (1), 59-69.

Sjöberg, L. & Drottz-Sjöberg, B.M. (1994). Risk perception of Nuclear Waste : Experts and the Public. *Rhizikon: Center for risk research, 16*.

Sjöberg, L. (1996). Risk Perceptions by Politicians and the Public. Rhizikon: Center for risk research, 23.

Sjöberg, L. (1999). Risk Perception by the Public and by Experts, A Dilemma in Risk Management. *Human Ecology Review, 6 (*2), 1-9.

Sjöberg L. (2000a). Perceived risk and tampering with nature. *Journal of Risk Research, 3* (4), 353-367.

Sjöberg, L. (2000b). Factors in risk perception. *Risk Analysis, 20* (1), 1-11.

Sjöberg, L. (2005a).Explaining individual risk perception: The case of nuclear waste. *Risk management, 6* (1), 51-64.

Sjöberg L. (2005b). Gene technology in the eyes of the public and experts, Moral opinions, attitudes and risk perception. *Business Administration, 7*, 1-53.

Sjöberg, L., Truedsson, J., Frewer, L. & Prades A. (2000), Trough a glass darkly: Experts' and the public's mutual risk perception. In M. P. Cottam, D. W. Harvey, R. P. Pape & J. Tait (Eds), *Foresight and Precaution* (pp.1157-1162). Rotterdam: Balkema.

Skjong R. & Wentworth B.H. (2001). Expert Judgement and Risk Perception. Offshore and Polar Engineering Conference, *ISOPE, 4* ,537-544 Stavanger.

Slovic, P. (1999). Trust, emotion, sex, politics and science: Surveying the risk assessment battlefield. In M.H. Bazerman, D.M. Messick, A.E. Tenbrunsel & K.A. Wade-Benzoni (Eds), Environment, ethics and behavior (pp.277-313). San Francisco: New Lexington.

Slovic P. & Weber E.U. (2002), Perception of Risk Posed by Extreme Events, 1-21, retrieved on 25/05/2012 from: http://rff.org/Documents/Events/Workshops%20and%20Conferences/Climate%20Change%20and%20Extreme%20Events/slovic%20extreme%20events%20final%20geneva.pdf.

Slovic, P., Peters, E., Grana, J., Berger, S. & Dieck, G.S. (2007). Risk Perception of Perception Drugs: Result of a National Survey. *Drug Information Journal, 41* (1), 81-100.

Turcanu C., Perko T. & Schröder J. (2011). *The SCK-CEN Barometer 2011, Perception and attitudes toward nuclear technologies in the Belgian population*. Mol: SCK-CEN.

Weber E.U. (2001). Personality and risk taking, In P. B. Baltes. & N. J. Smelser (2001). *International Encyclopedia of the Social and Behavioral Sciences* (pp. 11274-11276). Oxford: Elsevier Science Limited.

Wildavsky, A. & Dake, K. (1990). Theories of risk perception: Who fears what and why? *Journal of the American Academy of Arts and Sciences, Risk, 119* (4), 41-60.

Wynne, B. (1996). May the sheep safely graze? A reflexive view of the expert-lay knowledge divide. In S. Lash, S. Bronislaw and B. Wynne (Eds) *Risk, Environment and Modernity*. London: Sage Publications.

Appendix

Appendix A: questionnaire of the Barometer study

2 Questionnaire – English

S 1	Language of the interview	1. Dutch 2. French
S 2	Gender of the respondent	1. Male 2. Female
S 3	Place of residence	…. [zip code]
S 4	Year of birth	.... [year]
S 5	What is the highest diploma obtained?	1. Primary school or no education 2. Lower secondary-general 3. Higher secondary – general 4. Lower secondary – technical or arts 5. Higher secondary – technical or arts 6. Lower secondary-vocational 7. Higher secondary – vocational 8. Higher non-university 9. University
S 6	If S5 = 8 or 9 Are you more familiar with human sciences or natural sciences?	1. Human sciences 2. Natural sciences
S 7	What is your occupation?	*List*
S 8 (if S8=yes go to S11[	Do you provide the main income in your household?	1. Yes (*go to S11*) 2. No
S 9	What is the occupation of the main breadwinner in your household?	*List*
S 10	What is the highest diploma obtained by the main breadwinner in your household?	
S 11	How old is the youngest member in your family?	… [number]
S 12	Is either of your parents of other than Belgian nationality?	1. Yes 2. No
S 13	Do you read scientific magazines such as *Science et Vie, La recherche, National Geographic, Géo, Sciences et avenir* (FR) / *Natuur en Techniek, Eos, National Geographic*	1. Often 2. From time to time 3. Never

	(NL), or scientific supplements in newspapers?	

1.1. Risk perception and confidence in authorities

What follows now is a list of risks among which some might be more important than others. Could you indicate using the following scale how high or how low are these risks in your opinion for an ordinary citizen of Belgium?

RANDOMIZE

RP 1	Road accidents	*1. Very low* *2. Low* *3. Average* *4. High* *5. Very high* *9. Don't know / no answer*
RP 2	Tobacco	
RP 3	Drugs	
RP 4	Cancer	
RP 5	Environmental pollution	
RP 6	Radioactive waste	
RP 7	Chemical waste	
RP 8	An accident in a chemical installation	
RP 9	An accident in a nuclear installation	
RP 10	Radiation from mobile phones (cell phones)	
RP 11	Natural radiation (e.g. radon or radiation from space)	
RP 12	Medical X-rays	
RP 13	Residues of pesticides and herbicides on fruit and vegetables	
RP 14	A terrorist attack with a radioactive source	
RP 15	Residues of radioactivity in food	
RP 16	Fine dust in the air	

I would like now to refer to the same list of risks, but this time we would like to ask you how much confidence you have in the authorities for the actions they undertake to protect the population against these risks? You can use the same scale as before.

RANDOMIZE

RC 1	Road accidents	*1. Very little* *2. Little* *3. Average* *4. Quite a lot* *5. Very much* 9. *Don't know / no answer*
RC 2	Tobacco	
RC 3	Drugs	
RC 4	Cancer	
RC 5	Environmental pollution	
RC 6	Radioactive waste	
RC 7	Chemical waste	
RC 8	An accident in a chemical installation	
RC 9	An accident in a nuclear installation	
RC 10	Radiation from mobile phones (cell phones)	
RC 11	Natural radiation (e.g. radon or radiation from space)	
RC 12	Medical X-rays	
RC 13	Residues of pesticides and herbicides on fruit and vegetables	
RC 14	A terrorist attack with a radioactive source	

RC 15	Residues of radioactivity in food	
RC 16	Fine dust in the air	

1.2. Attitude towards science and technology

I will now read out a number of statements related to the role of science and technology. Please indicate to what extent you agree or disagree with these statements using the following scale:

RANDOMIZE

AX 1	The development of science and technology brings more benefits than harm.	*1. Strongly Disagree* *2. Disagree* *3. Neither agree, nor disagree* *4. Agree* *5. Strongly Agree* *9. Don't know / no answer*
AX 2	Future generations will have more opportunities as a result of science and technology.	
AX 3	Science and technology make our lives easier and more comfortable.	
AX 4	The risks that scientific and technological innovations entail outweigh the advantages.	

RANDOMIZE

AX 5	So many things involve science and technology these days that it makes my life complicated.
AX 6	Science and technology are so difficult to understand that I find it hard to form an opinion about it.
AX 7	I feel I have a better grip on things with the help of science and technology.
AX 8	All the rapid scientific and technological developments often make me feel awkward and out of place.

AX 9 filter for AX10	I am interested in science and technology :	*1. Yes* *2. No*
AX9 (if AX10=No)	If you are not particularly interested in science and technology, can you tell me why?	*1. I have no time* *2. I don't understand it* *3. I don't need it* *4. I never thought about it* *5. I do not care about it* *6. No particular reason*

1.3. Attitude towards nuclear energy

I shall now ask your opinion concerning a number of statements related to the nuclear energy. Please state how much you agree or disagree with the following statements:

RANDOMIZE

RT 1	In general I believe that the benefits/ advantages of nuclear energy outweigh the disadvantages.	*1. Strongly Disagree* *2. Disagree* *3. Neither agree, nor disagree* *4. Agree* *5. Strongly Agree*
RT 2	The reduction of the number of nuclear power plants in Europe is a good cause.	

		6. *Don't know / no answer*
RT 3	What is your opinion about nuclear energy?	I am: *1. totally in favour* *2. rather in favour* *3. neither in favour nor against* *4. rather against* *5. totally against* 6. *Don't know/no answer*

1.4. Arguments pro-against nuclear energy

Concerning nuclear energy in Belgium, several aspects are continuously being discussed. . In your opinion, do the following factors plead against or in favour of nuclear energy?

RANDOMIZE

NE1	The transparency of nuclear industry	*This factor pleads:* *1. Strongly against nuclear energy* *2. Rather against nuclear energy* *3. Neither against, nor in favour of nuclear energy* *4. Rather in favour of nuclear energy* 5. *Strongly in favour of nuclear energy* 9. *I don't know/NA*
NE2	Safety of nuclear installations in Belgium	
NE3	Nuclear waste	
NE4	Possible misuse of nuclear technologies by terrorists	
NE5	High energy production from small number of sites (2 in Belgium)	
NE6	Nuclear energy makes us dependent on large multinationals	
NE7	Nuclear energy helps our national energy independence.	
NE8	The costs of electricity produced in nuclear power plants.	
NE9	Low CO_2 emissions during electricity production in nuclear power plants.	
NE10	Reliability of energy supply by nuclear power plants in Belgium.	

1.5. Public participation in decision processes

Citizens can become involved – participate- to decisions concerning their environment in various ways, for instance a citizens panel, a meeting in the town hall, an internet forum.

ST01	Have you participated in the past in any public involvement activity?	*1. Yes* *2. No*

Suppose there are plans to build an installation for nuclear research in your municipality.

ST02	If there is an initiative for citizens' involvement in decisions related to this installation, how much would you like to be involved?	*1 ANSWER POSSIBLE* *1 =I don't want to be involved* *2=I want to receive information about the installation* *3=I want to receive information and express my opinion* *4=I want to participate in a dialogue towards a consensual decision* *5= I want to be an active partner in decision-making*

ROTATION

ST1.	On a scale from 1 to 7, do you believe that your participation in decisions on this installation for nuclear research would be:	7 points scale: 1=*pointless…-7=worthwhile*
ST2.		7 points scale: 1=*useless…7=useful*
ST3.		7 points scale: 1=*disappointing…7=rewarding*

Please state how much you agree or disagree with the following statements concerning participation in decisions on a new installation for nuclear research in your municipality

ST4.	Most people who are important to me (family, friends) would support my participation.	1. *Strongly disagree* 2. *Disagree* 3. *Neither agree, nor disagree* 4. *Agree* 5. *Strongly agree* 9. *Don't know/NA*
ST5.	I have a duty as a citizen to participate in such activities.	
ST6.	Of the people I know, nobody would participate in such activities.	
ST7.	I feel confident that by participating I can influence the actual decision-making	
ST8.	I do not have enough spare time to participate in such activities.	
ST9.	I would participate only if this activity would be remunerated.	

Such public involvement activities can be organised by different actors. On a scale from 1 to 7, how much would you be willing to participate in a public involvement activity in decisions with regard to nuclear installations if this were organised by:

ST10.	The controlling authority	7 point scale: 1=*not at all… 7=very much*
ST11.	The company managing the project	
ST12.	A non-governmental organisation	
ST13.	An independent institution, e.g. a university	
ST14.	A local action group	

1.6. Confidence in the management of nuclear technologies

Now more in general we would like to ask you about your confidence in the management of nuclear technologies. Please state how much do you agree or disagree with the following statements:

RANDOMIZE

MN 1	Nuclear reactors in Belgium are operated in a safe manner	1. *Completely disagree* 2. *Disagree* 3. *Neutral* 4. *Agree* 5. *Completely agree* 9. *Don't know / no answer*
MN 2	There is insufficient control by authorities on the safety in nuclear installations in Belgium	
MN 3	I believe that in Belgium radioactive waste is stored in a safe manner.	
MN 4	The transport of radioactive materials is not safe.	
MN 5	Production of fuel for NPP's causes environmental damage.	
MN 6	I feel well protected against risks from nuclear installations	
MN 7	Nuclear power plants endanger the future of our children.	

1.7. Actors in the nuclear field

*If you know the following actors can you tell us if you think they are telling the **truth** about the **risks and benefits of nuclear technologies** and if they are technically **competent** in this field?*

Not knowing an Actor is a filter for "telling truth" and "technically competent"

RANDOMIZE

	Know them	NST *Telling the truth*	NSC *Technically competent*	
1. The government	x			*Knowledge:* 1. *Yes* 2. *No* *Truth & comp:* 1. *Strongly Disagree* 2. *Disagree* 3. *Neither agree, nor disagree* 4. *Agree* 5. *Strongly Agree* 9. *Don't know / no answer*
2. Environmental organisations				
3. Electrabel GDF-Suez (owner of nuclear power plants)				
4. The journalists	x			
5. The FANC (Federal Agency for Nuclear Control)				
6. Medical doctors	x			
7. NIRAS (national agency for radioactive waste and enriched fissile materials)				
8. IAEA (International Atomic Energy Agency) in Vienna				
9. IRE (National Institute for Radioelements), Fleurus.				
10. SCK·CEN (the Belgian Nuclear Research Institute) in Mol.				
11. Scientists from Universities				
12. The Belgian nuclear forum				
13. The army				

14. Bel V, a controlling body				
15. Belgoprocess, a company specialised in radioactive waste management and decommissioning of nuclear facilities				
16. PERKO institute for communication on nuclear activities				

1.8. Fukushima

FU 1	Have you heard about the nuclear accident at Fukushima (Japan) following the recent earthquake and tsunami?	1. Yes 2. No

Filtered with FU1=Yes We would like to know what is your opinion about this accident. Please tell me how much you agree or disagree with the following statements:

What happened in Japan:

FU 2 [if FU1=Yes]	Is irrelevant to BE because there is no significant risk of earthquakes or tsunami.	*1. Strongly disagree* *2. Disagree* *3. Undecided* *4. Agree* *5. Strongly agree* *9. I don't know/ no answer*
FU 3 [if FU1=Yes]	Is relevant to BE because there is a flood risk.	
FU 1 [if FU1=Yes]	Makes me more worried about the dangers from BE nuclear installations	
FU 2 [if FU1=Yes]	Makes me feel relieved that our NPP's in Belgium are well managed	
FU 3 [if FU1=Yes]	Makes me feel that we can never predict all possible risks from nuclear installations	
FU 4 [if FU1=Yes]	Prompts me to find out how I could protect myself in a nuclear emergency	

1.9. Knowledge about the nuclear domain

What do you think about the following issues:

AW 1	**Is a dirty bomb the same as an atomic bomb?**	*1. Yes* *2. No* 9. *Don't know / no answer*
AW 2	Does exposure to radiation always lead to contamination with radioactive material?	
AW 3	Is radioactive waste exclusively produced by nuclear power plants?	

AW 4	Which percentage of electric power in Belgium *do you believe* is produced in nuclear plants?	*1. Less than 25 %* *2. Between 25-45 %* *3. Between 45-65 %* *4. More than 65 %* *9. Don't know / no answer*

Please indicate whether the following localities have a nuclear power plant:

RANDOMIZE

AW 5	Doel	*1. Yes* *2. No* 9. *Don't know / no answer*
AW 6	Hasselt	
AW 7	Tihange	
AW 8	Namur	
AW 9	Lier	

Which of the following sectors make use of nuclear technology?

RANDOMIZE

AW 10	production of electricity	*1. Yes* *2. No* 9. *Don't know / no answer*
AW 11	medical sector	
AW 12	food industry	
AW 13	textile industry	

What do you think about the following statement: is it true or false?

AW 14	There exists a plan to ensure the protection of the population in case of a nuclear accident.	*1. True* *2. False* 9. *Don't know/ no answer*

Please answer the following questions:

ROTATION

AW 15	Radioactive waste is collected and treated	*1. separately from other wastes* *2. together with the other waste* *9. don't know/no answer*
AW 16	Radioactivity can be directly measured:	*1. with special equipment* *2. it cannot be measured* *9. don't know/no answer*
AW 17	The measurement unit for radioactivity is:	*1. Becquerel* *2. Hertz* *3. Metres/second* *9. I don't know/ no answer*

1.10. Experiences with "nuclear"

Have you ever:

AW 18	Visited a nuclear power plant or research facility?	*1. Yes* *2. No*
AW 19	Lived in an area close (within a 20 km radius) to a nuclear installation (power plant, nuclear research institute …)	

AW 20	Had a job that involved the use of radioactivity (nuclear power plant, industry or hospital using radioactive sources, natural radioactivity in ores and other materials …)	
AW 21	Had a family member or close friend with a job that involved the use of radioactivity?	

1.11. Iodine campaign

1.11.1. Reception of information

Earlier this year the authorities organised an information campaign and a distribution of iodine tablets.

RI 1	Do you know about the distribution of iodine tablets? [If No, go to AI1]	*1. Yes* *2. No* 9. *Don't know / no answer*

We would like to know how much do you remember from this campaign. Do you know the correct answer for the following questions?

RI 2	Do you know who was invited to collect the iodine tablets?	*1. Everyone in Belgium.* *2. The people living within a certain radius from a nuclear installation* *3. The people working with chemical substances* *4. The people working with radioactivity.* 9. *Don't know/no answer*
RI 3	In case of a nuclear alarm, should the people take tablets immediately or should they wait for instructions?	*1. Wait for instructions,* *2. Take immediately in the case of nuclear alarm* 9. *Don't know/no answer*
RI 4	Where can you get these iodine tablets?	*1. At the local pharmacy* *2. At the special centres near the nuclear installations* *3. At family doctor* 4. *At the municipality* *9. Don't know/no answer*
RI 5	Are these iodine tablets for free or to be paid?	*1. For free* *2. To be paid* 9. *Don't know/no answer*

In your opinion, in case of a nuclear accident, an iodine tablet would protect against:

RANDOMIZE

AW 22	Lung cancer	*1. Yes* *2. No*
AW 23	Leukaemia	
AW 24	Thyroid cancer	

AW 25	Bone cancer	9. *Don't know / no answer*
AW 26	Skin burns	

1.11.2. Acceptance of information from the iodine campaign

[If RI1=2 of 9]: The authorities organised a distribution of iodine tablets in the framework of the nuclear emergency plan for people living within a certain radius from nuclear installations.

[ALL]: To what extent do you agree or disagree with the following statements?

AI 1	The distribution of iodine tablets is a good idea	*1. Strongly Disagree* *2. Disagree* *3. Neither agree, nor disagree* *4. Agree* *5. Strongly Agree* *9. Don't know / no answer*
AI 2	The authorities assure that the iodine tablets can reduce health consequences in case of a nuclear accident. Do you agree?	
AI 3	Do you agree with the distribution of iodine tablets for people living with a certain radius from a nuclear installation?	
AI 4	Have you ever been invited to collect the iodine tablets?	*1. Yes* 2. *No*
AI 5	[If Yes on AI 4] Did you collect your iodine tablets?	
AI 6	If you are invited to collect iodine tablets in the future, would you collect the tablets and store them at home?	
AI 7	Would you like to have iodine tablets at your home even if you do not live in the distribution area?	
AI 8	In case of a nuclear alarm what would you do with the tablets?	1. *I would wait for instructions,* *2. I would take them immediately in case of a nuclear alarm* *3. I would not take them at all* *4. I would decide at the very moment* *9. Don't know/no answer*
AI 9	Do you have these iodine tablets at home?	*1. Yes* *2. No* 9. *Don't know/no answer*

In case of a nuclear accident, would you accept the measures taken by the authorities, if these were:

AI 10	To take iodine tablets if the authorities recommend this	*1. Yes, because they are helpful* *2. Yes, because I have to* *3. No* 9. *Don't know/no answer*
AI 11	To give stable iodine tablets to your children if the authorities recommend this	

Now I would like to ask you few questions about your opinion as regards the iodine tablets.

Do you think that:

AI 12	Iodine tablets give people a false sense of security	1. *Strongly Disagree* 2. *Disagree* 3. *Neither agree, nor disagree* 4. *Agree* 5. *Strongly Agree* 9. *Don't know / no answer*
AI 13	Iodine tablets are a waste of money	

1.11.3. Heuristic vs systematic information processing of the information from the iodine campaign

[If RI1=1] Please tell me how much you agree or disagree with the following statements.

FILTERED WITH RI1=1 (only for those who know about the campaign)

RANDOMIZE

SI 1	In order to be completely informed about the use of iodine tablets, I think that the more viewpoints I get, the better off I will be.	1. *Strongly Disagree* 2. *Disagree* 3. *Neither agree, nor disagree* 4. *Agree* 5. *Strongly Agree* 9. *Don't know / no answer*
SI 2	I have been very attentive to the information presented in the information campaign on iodine tablets.	
SI 3	When the topic of iodine tablets came up, I tried to learn more about it.	
SI 4	It was important for me to clarify how I should use the iodine tablets	
SI 5	When I encountered information about iodine tablets, I carefully considered it.	
HI 1	On issues like that I just go with my gut feeling.	
HI 2	Past experiences with health related issues have made it easier for me to make an opinion about the use of iodine tablets.	
HI 3	On the use of iodine tablets I shall simply place my trust in the experts and respect their recommendations.	
HI 4	Related to decisions concerning the iodine tablets, I follow the people from my environment, e.g. family, neighbours.	
HI 5	I could easily make an opinion about the use of iodine tablets without seeking additional information, based on my existing knowledge.	

1.12. Radioactive waste

Radioactive waste is classified in different categories. Somewhat simplified, a distinction is made between two main categories. The high-level waste radiates intensely and will remain radioactive for a very long time (thousands of years); the low-level waste radiates less intensely and becomes harmless after ca. 300 years.

The following questions concern the high-level radioactive waste.

In the summer of 2010 a public consultation was organised to ask people's opinion about the way high level radioactive waste should be dealt with. Information was given under the form of 2 documents, the "Waste Plan" and the "Strategic Environmental Assessment".

RW 1	Were you aware about this public consultation? FILTER for the following two questions	*1. Yes* *2. No*
RW 2	If RW1= YES Did you send comments to give your opinion?	*1. Yes* *2. No*
RW 3	If RW1 = YES and RW2 = NO Why didn't you send your comments? Choose one answer	*1. I didn't have time* *2. I wasn't interested* *3. The topic is too difficult* *4. It doesn't concern me* *5. It has little influence on the final decision* *6. I didn't have any comments* *7. Other reasons*
RW 4	If a similar consultation is organized in the future would you participate?	*1. Yes* *2. No*
RW 5	If RW4=NO, why not?	*1. I have no time* *2. I have no interest* *3. The topic is too difficult* *4. It doesn't concern me* *5. It has little influence on the final decision* *6. Other reasons*

Currently deep geological disposal is proposed for the long-term management of high-level radioactive waste. The option entails that waste will be packed and permanently buried a couple of hundred metres under the surface in a dedicated construction in a clay layer. When the disposal is filled up, for safety and security reasons it will be sealed to prevent access.

Please state how much you agree or disagree with the following statements concerning the geological disposal of high level radioactive waste:

RW 6	Geological disposal solves the issue of high level radioactive waste.	1. *Strongly disagree* *2. Disagree* *3. Neither agree, nor disagree* *4. Agree* *5. Strongly agree* *9. Don't know / no answer*
RW 7	Geological disposal is not an acceptable management option for high level radioactive waste.	
RW 8	Future generations should be able to access the geological disposal, even if this maybe jeopardizes safety and security.	
RW 9	If geological disposal is chosen for managing high-level radioactive waste, what is your opinion about further development of nuclear energy?	*1. totally in favour* *2. rather in favour* *3. neither in favour nor against* *4. rather against* 5. *totally against* 9. *Don't know/don't know*

Please answer the following question:

RW 10	If plans existed to construct an underground disposal site for high-level radioactive waste near your home, with which of the following statements do you agree the most?	*1 ANSWER POSSIBLE* *1=I don't want to be involved* *2=I want to receive information about the disposal* *3=I want to receive information and express my opinion* *5= I want to be a partner in decision-making* *6 = I would never agree to have a disposal site near my home and I would protest against it.*

And now I would like to ask you some final, more general questions on the management of high level nuclear waste:

RW 11	The generation using nuclear power should be responsible for dealing with its waste, not the future generations	1. *Strongly disagree* *2. Disagree* *3. Neither agree, nor disagree* *4. Agree* *5. Strongly agree* *9. Don't know / no answer*
RW 12	Since radioactive waste will remain hazardous for many generations, future generations should be able to make decisions about it...	
RW 13	Since no good solution exists for radioactive waste yet, its long term management should be left to future generations.	

1.13. META

Please state your opinion about the usefulness of this type of research:

MET 1	This questionnaire was interesting and gets me thinking.	*1. Disagree completely* *2. Disagree* *3. Neutral* *4. Agree* *5. Agree completely*
MET 2	I need more information to answer questions on such complicated issues properly.	
MET 3	I felt limited by the answering categories	

Interviewer's opinion about the interview

INT1	Interviewer's note about the interviewee: what describes best the attitude of the interviewee?	1. *Interested* 2. *Bored* 3. *Engaged* *4. Confused*

Appendix B: questionnaire of the professionally exposed people

Dear Colleague,

We are kindly asking for your help with a research project of the unit “Nuclear Science and Technology Studies (NST)”. Our group is currently conducting research into risk perception of radiation in different population groups, among them radiation professionals. Your participation in the study is therefore of great importance.

We are kindly asking you to answer the questions in an electronic survey. The entire exercise should take less than ten minutes of your time.

Enquete - Enquête - Survey

Voter language

S 1 Have you already participated in the Barometer study 2011 or new employee study?	1. Yes 2. No 3. I don’t remember

S2	Gender of the respondent	1. Male 2. Female
S4	Age group	Younger than 25 years 25 - 30 years 31 - 35 years 36 - 40 years 41 - 45 years 46 - 50 years 51 - 55 years 56 - 60 years Older than 60 years
S5	What is the highest diploma obtained?	1. Primary school or no education 2. Lower secondary-general 3. Higher secondary – general 4. Lower secondary – technical or arts 5. Higher secondary – technical or arts 6. Lower secondary-vocational 7. Higher secondary – vocational 8. Higher non-university 9. University

S7 Number of years of experience in nuclear applications / radiation (including education). **.....year(s)**

S8 How often are you in average professionally exposed to radiation?	1. Not exposed at all 2. Less than 1x a month 3. About 1 x month 4. Several times in a month 5. Almost every day 9.Other (explain)
S 11 What is the radiation dose that you received in last year mSv/y?	1. mSv/y 2. I don't know 9.I don't want to answer
S 12 What is your status at SCK/CEN?	Employee Doctoral student Post Doctoralstudent Master student Scientific visitor (linked to a project) Others (explain)
S 14 What kind of work did you perform in the controlled area in last year?	Radiation control FS14_1 Manipulation of sources FS14_2 Maintenance in controlled area FS14_3 Laboratory work in controlled area FS14_4 Transport of radioactive sources FS14_5 Inspection or supervision in controlled area FS14_6 Only visit of controlled area FS14_7 Safety or security function in controlled area FS14_8 Other (what) S14_9

What follows now is a list of risks among which some might be more important than others. Could you indicate using the following scale how high or how low are these risks in your opinion for an ordinary citizen of Belgium?

RP 6	Radioactive waste	*1. Very low* *2. Low* *3. Average* *4. High* *5. Very high* *9. Don't know / no answer*
RP 9	An accident in a nuclear installation	
RP 12	Medical X-rays	
RP 11	Natural radiation (ex. Radon or radiation from space)	

RPP 1 How do you evaluate the health risks due to ionising radiation for an ordinary citizen in Belgium as compare to your own health risks.	1. Much higher 2. Higher 3. The same 4. Lower 5. Much lower 9.Don't know / no answer

I would like now to refer to the list of risks, but this time we would like to ask you how much confidence you have in the authorities for the actions they undertake to protect the population against these risks? You can use the same scale as before

RC 6	Radioactive waste	*1. Very little* *2. Little* *3. Average* *4. Quite a lot* *5. Very much* 10. *Don't know / no answer*
RC 9	An accident in a nuclear installation	
RC 12	Medical X-rays	
RC 11	Natural radiation (ex. Radon or radiation from space)	

I shall now ask your opinion concerning a statement related to the nuclear energy. Please state how much you agree or disagree with the following statements:

In general I believe that the benefits/ advantages of nuclear energy outweigh the disadvantages.	*1. Strongly disagree* *2. Disagree more or less* *3. Agree* *4. Strongly agree* *9.Don't know / no answer*

I shall now ask your opinion concerning statements related to the nuclear energy. Please state how much you agree or disagree with the following statements: - The reduction of the number of nuclear power plants in Europe is a good cause.	*1. Strongly disagree* *2. Disagree more or less* *3. Agree* *4. Strongly agree* *9.Don't know / no answer*

RT 4	Please state how much you agree or disagree with the following statement: - What is your opinion about nuclear energy? I am:	I am: *1. totally in favour* *2. rather in favour* *3. neither in favour nor against* *4. rather against* *5. totally against* *9.Don't know/no answer*

What do you think about the following issues:

AW 27	**Is a dirty bomb the same as an atomic bomb?**	*1. Yes* *2. No* *9. Don't know / no answer*
AW 28	Does exposure to radiation always lead to contamination with radioactive material?	
AW 29	Is radioactive waste exclusively produced by nuclear power plants?	

Which of the following sectors make use of nuclear technology?

AW 10	production of electricity	*1.Yes2. No* 10. *Don't know / no answer*
AW 11	medical sector	
AW 12	food industry	
AW13	textile industry	

AW 15	Radioactive waste is collected and treated	*1. separately from other wastes* *2. together with the other waste* *9. don't know/no answer*
AW 16	Radioactivity can be directly measured:	*1. with special equipment* *2. it cannot be measured* *9. don't know/no answer*
AW 17	The measurement unit for radioactivity is:	*1. Becquerel* *2. Hertz* *3. Metres/second* *9. don't know/ no answer*

Now more in general we would like to ask you about your confidence in the management of nuclear technologies. Please state how much do you agree or disagree with the following statements:

MN 8	Nuclear reactors in Belgium are operated in a safe manner	*1. Strongly disagree* *2. Disagree* *3. More or less agree* *4. agree* *5. Strongly agree* *9. Don't know / no answer*
MN 9	There is insufficient control by authorities on the safety in nuclear installations in Belgium	
MN 10	I believe that in Belgium radioactive waste is stored in a safe manner.	
MN 11	The transport of radioactive materials is not safe.	
MN 12	Production of fuel for NPP's causes environmental damage.	
MN 13	I feel well protected against risks from nuclear installations	
MN 14	Nuclear power plants endanger the future of our children.	

FU 4	Have you heard about the nuclear accident at Fukushima (Japan) following the recent earthquake and tsunami?	1. Yes 2. No

We would like to know what is your opinion about this accident. Please tell me how much you agree or disagree with the following statements:

What happened in Japan:

FU 5 [if FU1=Yes]	Is irrelevant to BE because there is no significant risk of earthquakes or tsunami.	*1. Strongly disagree* *2. Disagree* *3. More or less agree* *4. Agree* *5. Strongly agree* *9. I don't know/ no answer*
FU 6 [if FU1=Yes]	Is relevant to Belgium because there is a flood risk.	
FU 4 [if FU1=Yes]	Makes me more worried about the dangers from Belgium nuclear installations	
FU 5 [if FU1=Yes]		
FU 6 [if FU1=Yes]	Makes me feel that we can never predict all possible risks from nuclear installations	
FU 7 [if FU1=Yes]	Prompts me to find out how I could protect myself in a nuclear emergency	

Appendix C: correlation between the independent variables

Table : Correlation between the independent variables

	Gender	Age	Knowledge	Confidence in authorities accident at nuclear installation	Confidence in authorities medical X-rays	Benefits outweigh the disadvantages	Reduction of the number of NPP is a good cause	Opinion on nuclear power	Reactors in Belgium are operated safe	There is insufficient control by authorities	Transport of radioactive materials is not safe	Produ-ction fuel fuel NPP causes environmental damage	I feel well protected against risks NP	In Belgium nuclear waste is stored in a safe way	Nuclear power endanger the future of our children
Gender	1														
Age	0,012	1													
Knowledge	-0,300 **	-0,056 *	1												
Confidence accident at nuclear installation	-0,047	-0,033	0,155 **	1											
Confidence medical X-rays	0,022	0,002	0,039	0,370 *	1										
Benefits outweigh the dis-advantages	0,190 **	0,035	0,302 **	0,284 **	0,077 *	1									
The reduction of number of NPP is a good cause	0,187 **	0,014	-0,335 **	-0,245 **	-0,030	-0,553 **	1								
Opinion on nuclear power	0,213 **	0,024	-0,376 **	-0,272 **	-0,034	-0,620 **	0,604 **	1							
Reactors in Belgium are operated safe	-0,161 **	0,014	0,274 **	0,371 **	0,129 **	0,432 **	-0,360 **	-0,435 **	1						
There is insufficient control by authorities	0,087 **	0,004	-0,123 **	-0,279 **	-0,152 **	-0,162 *	0,287 **	0,264 *	-0,316 **	1					
Transport of radioactive materials is not safe	0,175 **	-0,001	-0,321	-0,304 **	-0,124 *	-0,310 **	0,389 **	0,351 **	-0,362 **	0,414 **	1				
Production fuel for NPP damages the environment	0,167 **	-0,061 *	-0,262	-0,149 **	-0,004	-0,225 **	0,415 **	0,371 **	-0,312 **	0,211 *	0,309 **	1			
I feel well protected against risks NPP	-0,168 **	0,222 **	0,222 **	0,386 **	0,117 **	0,446 **	-0,391 **	-0,481 **	0,558 **	-0,316 **	-0,387 **	-0,315 **	1		
Nuclear waste	-0,152 **	0,034	0,274 **	0,347 **	0,113 *	0,435 **	-0,386 **	-0,451 **	0,454 **	-0,317 **	-0,407 **	-0,257 *	0,563 **	1	
Endanger the future of our children	0,236 **	0,045	-0,342 **	-0,265 **	-0,034	0,442**	0,601 **	-0,516 **	-0,411 **	0,340 **	0,426 **	0,452 **	-0,467 **	-0,454 **	1

**= significance level p<0,001

*=significance level p≤0,05