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D9.26 Planned behaviour in nuclear emergency situations

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Abstract

Understanding people's and emergency actors' sense making of uncertainties in nuclear emergency situations and their subsequent behaviour is critical to improving preparedness plans and communications strategies. This study provides insights into how people (expect) to react to a nuclear or radiological emergency; what is their perception of protective actions; what is their willingness to follow official recommendations; and how well people think that they are informed about protective actions in case of an emergency. Data underlying the study originate from large scale opinion surveys carried out in Belgium, Spain and Norway.

Main social uncertainties revealed by the study are the following. A rather large group of population might not comply with protective actions (e.g. leave the area when advised to shelter) or apply the protective action wrongly (e.g. take iodine tablets before official advice is issued). Compliance with food or water restrictions is perceived as easy and effective. The uncertainty here lies in the potential for boycott of not contaminated food and water from the affected region. This has not been investigated in this research and should be the subject of a follow-up study.

Results of this research will inform the CONFIDENCE WP5 research and the development of the CONFIDENCE communication tools.

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1. Introduction

The Fukushima accident indicated several challenges in public response to a nuclear emergency, among others: communication of protective actions to the affected population during the accident (e.g. evacuation or intake of stable iodine), potentially over-protective behaviour of non-affected population (unnecessary evacuation, boycott of products), non-compliance with official advice (e.g. not to consume salt in order to get iodine), public information (lack of transparency, timeliness, unclear or factually incorrect information) and overload of information (use of a variety of units and technical terms), perception of uncertainties related to health effects of radiation (e.g. effects of low radiation doses), public fears (e.g. how the contamination from the accident will affect children's health, including thyroid abnormalities). These challenges resulted in improper public response and difficulties in the recovery from the Fukushima accident as well as citizens' anxiety and distrust in emergency management, the government, the safety regulators and the experts.

Understanding people's concerns, motivations, beliefs and value judgments underlying individual decision-making in an emergency situation, is crucial to improving the governance of nuclear or radiological accidents and incidents.

Burns and Slovic (2012), Eiser et al (2012) and others note that society's vulnerability to disasters arises not only from their magnitude or unpredictability, but also from the manner in which people and institutions respond to it.

Notwithstanding the inherent limitations, previous research highlights the importance of studying behavioural expectations as a reliable indicator of actual behaviour in the event of an emergency (Fischbein and Ajzen and, 1980). However, the issue on how people might react to a nuclear accident remains largely unaddressed and leads to important uncertainties regarding the effectiveness of emergency measures such as sheltering and evacuation (Giordano, 2005). Consequently, emergency plans must take into account behavioural intentions of a population which perceives itself at risk. Furthermore, studying expected behaviour enables emergency plans to anticipate and address the problems of over-reaction and under-reaction of the public with respect to official advice from the authorities.

This deliverable reports results from empirical studies on expected behaviour in the case of a nuclear emergency in three European countries. It aims at providing insights into how people expect to react in an emergency; what their willingness is to follow official advice concerning protective actions; and which factors are associated with expected behaviour. The latter include descriptive norm (perceived social norm), hazard and resource related attributes, self-efficacy aspects.

Data underlying the study originate from large scale national surveys in Belgium, Spain and Norway. In addition, additional samples of people living in the vicinity on nuclear installations have been taken in Belgium and Spain to compare and contrast the expected behaviour and concerns of the general public and the potentially affected populations. The three countries have different nuclear energy policies. Belgium is in phase-out of nuclear energy since 2003. However, in 2018 Belgium has seven nuclear power plants providing 54% of national energy needs, reactors in decommissioning, research reactors and active research and development of the generation IV reactor. All residents from local communities in the vicinity of nuclear installations should have iodine tablets at home (pre-distribution campaign in 10 km radius of IRE site and 20 km radius of nuclear power plants and the SCK•CEN site). On 30th of November 2015 a law was adopted in Belgium that allows the nuclear power plants Doel 1 and Doel 2 to remain open for another 10 years. These were supposed to be closed in 2015; however after a short operational break they will continue to produce nuclear energy until 2025. Nuclear risks

and potential nuclear accident in Belgium gradually became a more salient issue, as different events over the past years (e.g. micro-cracks in nuclear reactors, series of incidents e.g. shut-down due to sabotage, fire in non-nuclear zone, technical defect, threat of nuclear terrorism, etc.). At the end of 2017 (during the field work for this study), the Belgian government issued a public opinion survey in order to investigate citizen's views related to energy (to support the governmental energy pact accepted end of the 2017). Safety events, amended Nuclear Safety Directive, new Basic Safety Standards, social imperative for public involvement in nuclear emergency preparedness and response led to a revision of the nuclear emergency plan and broad public information campaign to increase public awareness for their response in potential nuclear emergency (the field work for this study has been finished just before start of the campaign).

In Spain there are seven nuclear reactors in 5 sites (Almaraz I and II in Cáceres, Ascó I and II in Tarragona, Cofrentes in Valencia, Trillo in Guadalajara, and Vandellós II in Tarragona) letting the production in the Spanish electricity system (in 2017 they produced 21.17% of total gross electricity). Norway does not have nuclear power plants, but has a nuclear research facility and has had previously been affected by the Chernobyl accident. The selection of countries in the study allows us to identify differences planned behaviour in nuclear emergency situations in countries with different nuclear and radiological hazards.

The study is carried out in the framework of the European project CONFIDENCE (COping with uNcertainties For Improved modelling and DEcision making in Nuclear emergenCiEs), which aims, among others (work package 5), at identifying and reducing scientific and societal uncertainties in the event of a nuclear emergency, particularly in the short and intermediate term (up to one year from the event).

This deliverable reports on and preliminary results from the study. More detailed analysis will be reported elsewhere.

2. Theoretical background

2.1 Understanding behaviour in emergency situations: insights from theory

Research in the field of social psychology has led to development of several models that seek to elucidate and predict public response to disaster and emergency situations, especially in the context of natural disasters and health threats.

The Protective Action Decision Model (Lindell and Perry, 2011) integrates the pre-decision processes related to emergency information processing (attention, reception, and comprehension of warnings or exposure, and interpretation of environmental/social cues) with three core perceptions (threat perceptions, protective action perceptions, and stakeholder perceptions). The model postulate that these form the basis for individuals' decisions about how to respond to imminent or long-term threats. Different protective actions tend to be evaluated depending on hazard-related attributes (e.g. protective efficiency) and resource-related attributes (e.g. required time, skill, effort, collaboration with others) (Lindell et al, 2017).

In the case of the Three Mile Island accident in 1979, advice for evacuation was given only to pregnant women and women with preschool children in a 5 miles radius from the nuclear power plant. However, people evacuated also in other areas, in a radius of up to 55 miles, with numbers of evacuees decreasing with distance from the installation. In this case, perceived severity and susceptibility (e.g. having children under 6 years old or pregnant women in house) were significantly related to evacuation

behaviour (Houts et al., 1984). The same study suggests that reluctance of some houses to evacuate was related mostly to waiting for an official evacuation order from the authorities. Interestingly, as opposed to natural hazards, conflicting information was a reason cited for evacuating.

Another prominent paradigm proposing a model for behavioural intentions is the Theory of Planned Behavior (Ajzen, 1991). This suggests that attitudes towards behaviours (evaluative judgments), subjective norms (capturing the social pressure of exercising a behavior) and perceived behavioural control are major predictors of behavioural intentions, which in turn, can be used as proxy for real behaviours. Perceived behavioural control reflects one's perception whether she/he has the resources, abilities and other prerequisites required to perform the behaviour successfully. Ajzen (2002b, p.667) proposes, on the basis of a number of studies reported in the literature, that two inter-related components of perceived behavioural control may be distinguished: self-efficacy (a person's perception of his/her capability to successfully execute the behaviour) and controllability (the degree to which the performance of the behaviour depends on the actor him/herself). In a survey in Georgia(USA), Paek et al (2010) have found for instance positive correlations between subjective norm, self-efficacy and media exposure with respondents' possession of emergency items and their stages of emergency preparedness (e.g. thinking about emergencies trying to learn more about, taking actions to prepare oneself).

Several studies in the literature suggested extending the set of predictors derived from the Theory of Planned Behaviour with past behaviour (Ajzen, 2002a); descriptive norm, or perceived social norm, determined by the belief that specific referent groups perform the behaviour in a similar situation (Chassin et al., 1984); and moral norm, expressing the perceived moral correctness of performing the behaviour (Beck and Ajzen, 1991). Actions of friends and neighbours were also shown to predict evacuation behaviour in the case of the Three Mile Island accident (Cutter & Barnes, 1982).

Information processing models can give additional insights into the decision-making behaviour of the different publics during a nuclear emergency. Most information processing models describe reception as a result of attention, ability and motivation (Chaiken & Stangor, 1987; Eagly, 1992; Eysenck, 2005; Lang, 2006; Lang, Bolls, Potter, & Kawahara, 1999; McGuire, 1973; Shiffrin & Schneider, 1984; Trumbo, 2002; Zaller, 2006). Attention, refers to signals for getting the message out of the environment and starting the information processing. Ability, involves the physical capacity of the receiver to follow the information without any distractions. Finally, motivation is considered as the willingness and interest of the receiver to process information or, at a later stage, to actively get involved in the communication. In the RAS model for systematic information processing, motivation, attention and ability are assumed to depend on the cognitive engagement with the communicated subject. According to Zaller, *"The greater a person's level of cognitive engagement with an issue, the more likely he or she is to be exposed to and comprehend – in a word, to receive messages concerning that issue"* (Zaller, 2006, p.42). Translated to our study, this would imply that countries with phase-out policy (e.g. Belgium) and nuclear countries (Spain) are expected to have higher cognitive engagement than non-nuclear countries (Norway). Zaller identifies two possible cognitive engagement characteristics of a message: intensity and familiarity. The weaker the intensity of the message and the receiver's familiarity with it, the stronger is the effect of cognitive engagement. Zaller's RAS model suggests that reception is mainly influenced by specific factual knowledge, but that it can also be affected by the level of participation of the receiver, his/her interest in the issue and the media use (Zaller, 2006, p. 333-339). Empirical tests for these claims have been recently applied for studies on nuclear emergency preparedness and response (Perko, Thijssen, C., & Van Gorp, 2014; Perko, van Gorp, Turcanu, Thijssen, & Carlé, 2013). This research showed that heuristic predictors of communication about iodine tablets

have a limited influence in the reception stage of information processing. Among the information processing predictors studied, specific knowledge plays a dominant role in the reception of emergency preparedness communication. People with high specific knowledge related to radiological risks were identified as particularly attentive, motivated and able to recollect information related to nuclear emergency preparedness. Education, hazard experience, confidence, risk perception and affective response (fear) - although statistically significant - do not play an important role in the reception of nuclear emergency preparedness communication (Perko et al., 2013). In a study related to nuclear emergency communication (after an accidental release of radioactive iodine in the environment) authors demonstrated that specific knowledge is only dominant at the level of the reception of nuclear emergency communication, while predictors such as psychometric risk characteristics, trust in nuclear emergency management and attitudes toward science and technologies are most influential for the level of agreement with protective actions applied (acceptance) (Perko et al., 2014). For instance, people who were more knowledgeable about nuclear issues in general were more likely to know when and where the accident happened and which protective actions were advised by the authorities; however, they did not necessarily agree with these actions. Several differences with respect to information processing were identified between the general population and the affected population. The more one is affected by the risk, the less important factors such as gender, age or education will be for information processing (Perko et al., 2014).

The RISP model (Risk Information Seeking and Processing) developed by Griffin et al. (1999) suggests that motivation is influenced by information sufficiency: affective response to a risk (e.g. worry, anger) and informational subjective norms (e.g. desire for information); the more worried or anxious people feel toward the risk issue, the more likely they are to seek information regarding the topic. In this model, ability reflects one's perceived capacity to perform the information processing steps and the non-routine gathering of information (e.g. additional effort to get the information).

Finally, in the heuristic or peripheral processing mode as described in the ELM model (Elaboration Likelihood Model) of Petty and Cacioppo (1986), motivation is believed to depend on three factors: the personal relevance of the risk information, the need for cognition and personal responsibility. The ability to process the information depends, among other things, on distraction, repetition, prior knowledge and message comprehensibility.

2.2 Expected and actual behaviour in nuclear emergencies

Nuclear emergency response and recovery is confronted with both scientific and societal uncertainties that influence each other and, in turn, the effectiveness of protective actions for people and the environment. For instance, uncertainty about the effects of low doses raises uncertainties with regards to people's willingness to return in a previously evacuated area, or consume food products with low levels of radioactivity. In turn, public's uncertainty about what to do in case of an emergency raises uncertainties for experts' assessment of health effects from implementing a particular protection action, since these are based on assumptions about people's behaviour, e.g. that they will shelter when being told to do so, or have available and take stable iodine tablets at the right time.

The study of ENCO (2014) showed that most European countries with nuclear installations (with the exception of UK) would recommend evacuation prior to a release, based on an assessment of the nuclear power plant status and/or predictions of potential releases. All these assessments are however affected by various uncertainties, which can create concerns among the local population whether for instance sheltering is a better action then self-evacuation.

In the case of the Fukushima accident*, "problems with the way evacuations were handled and information was conveyed to the public led to a breakdown of trust"* in government and industry (Hobson, 2015). Insufficient preparation for evacuation led to residents in some areas having to move multiple times and, as a consequence, receiving higher radiation exposure or increased stress due to (NAIC, 2012, pp. 19). In addition, many authors report that evacuation and relocation of residents from many villages in the Fukushima region caused more harm than good (Callen & McKenna, 2018; Hasegawa, Ohira, Maeda, Yasumura, & Tanigawa, 2016; Yasumura, 2014). There was additional, potentially dangerous public response to protective actions in Japan, with some people swallowing gargling agents containing povidone-iodine as a substitute for stable iodine tablets, an action which can actually be quite detrimental to someone's health (Kanda, Tsuji, & Yonehara, 2012; NAIIC, 2012). A study in France (thus on a non-affected population, also revealed "*uncontrolled preventive behaviours resulting in potentially unjustifiable consumption of available drugs*" after the Fukushima accident (Crépey. P, Pivette. M, & Bar-Hen. A, 2013, p. 1).

Potential challenges for emergency planning are also highlighted by studies on emergency preparedness in Europe or worldwide. For instance, a survey in October 2012 in Slovenia showed that, despite planning, communicating and training in Slovenia, three out of four people living within a 3 km radius of Krsko Nuclear Power Plant do not know the locations of the reception centers; and two thirds are unfamiliar with the evacuation routes (Malešič et al, 2013). At the same time, institutions (e.g. responsible for transport) have a fatalistic attitude ('*if the disaster occurs there will be no time to evacuate*'), poor nuclear disaster planning, low attendance of personnel at trainings, poor coordination, scarce attention; and none or limited resources devoted to the management of a possible disaster.

Johnson and Zeigler (1983) argued that radiological emergencies are likely to give rise to higher levels of extreme behaviour than have been observed in other types of emergencies, due to a high degree of fear and distrust of nuclear power. Perceived distance from the plant, age of household head, stage in life cycle and social status, attitudes toward nuclear power, and nuclear accident risk perception were shown to be predictors for real or expected compliance with instructions (Johnson & Zeigler, 1983; Johnson, 1985; Flynn, 1979).

Immediate most likely responses reported in previous studies with hypothetical scenarios include calling family members, washing off radioactive material, seeking shelter indoors, calling emergency services, and trying to get back home or leaving the city (Taylor et al., 2011; Chung & Yeung, 2013).

3. Method

3.1 Data collection

In Belgium, the field work was carried out by a company specialised in opinion research (IPSOS-Belgium), with professional interviewers. The method used was Computer Assisted Personal Interviews, at the home of the respondent. The interviews were carried in Dutch or French language, according to the choice of the respondent. For the national survey, the sample consists of N=1083 Belgian adults and is representative for the (18+) Belgian population with respect to gender, age, education, level of urbanisation of the living habitat and province. For the local population, respondents were adults aged 18 years and older, living within 20 km around the nuclear installations of Tihange and Doel, in private households. The radius of 20 km around nuclear power plants corresponds to the area of preventive distribution of stable iodine tablets, and the current emergency planning zone for sheltering[1]. Respondents in all samples were selected using a random walk approach, in a number of randomly selected Primary Sampling Units (Communes). The samples are representative of the population aged 18 or older in Belgium, respectively Doel/Tihange areas for the local population samples. The timing of the field work was as follows: i) field work Doel sample (N=159): September 29, 2017 – January 15, 2018; ii) fieldwork Tihange sample (N=156): November 8, 2017 – January 25, 2018; iii) fieldwork national sample (N=1083): November 27, 2017 – February 25, 2018. The two samples of local population were not joined for the purpose of analysis, but treated separately on account of the cultural differences between the French and Flemish speaking regions of Belgium (e.g. in terms of risk perception, trust in authorities, stakeholder involvement activities) highlighted by previous research (e.g. Perko et al, 2010).

In Spain, respondents were recruited from online panels by a market research company operating in Spain. A first sample of 302 participants was selected from online database living within an area of 30 km around one of the five operating Spanish nuclear power plants (Vandellós, Ascó, Cofrentes, Trillo and Almaraz). This radius corresponds to the area of application of the protection measures in case of an accident (area of urgent protection measures (0-10 km) and area of long-term measures (10-30 km). A second sample of 506 participants was recruited from a database of population living within an area of 31 km to 100 km around one of these power plants. This second area was stratified in two areas: 31-65 km and 65-100 km. The distance of 30-100 km was chosen for comparability with Belgium, where almost each municipality is located within 100 km from a nuclear power plants. A disproportionate stratified sampling was adopted to avoid an excessive representation of residents in big capitals in the sample. Soft-quotas were introduced to control for gender, age and education. Data was collected in November 2017 and January 2018.

In Norway, data collection was performed as part of a national opinion survey on radiation protection issues that has been conducted every three-four years since 2004 by the Norwegian Radiation Protection Authority (NRPA). It thus included only a selection of topics investigated in Belgium and Spain. The field work for the survey was carried out in the last half of September 2017 through nationwide telephone interviews using by NIVI Analyse AS, which performs social science analyses for the public sector. A representative, randomized sample of 1000 persons was used, from adults of at least 18 years old. The socio-demographic characteristics of the samples in the three countries are summarised in Table 1.

[1] The emergency planning zone for sheltering was 10 km at the time of the study

Table 1 Socio-demographic characteristics of the national samples in Belgium, Spain and Norway

	Belgium			Spain		Norway
	National (N=1083)	**Local, <20 km Doel (N=159)**	**Local, <20 km Tihange (N=156)**	**National, 30-100 km nucl. inst. (N=506)**	**Local, <30 km nucl. Inst. (N=302)**	**National Norway (N=1000)**
Gender						
Men	47.9%	50.3%	50.6%	52.6%	41.1%	50%
Women	52.1%	49.7%	49.4%	47.4%	58.9%	50%
Age						
18-34 y	23.7%	22.6%	23.7%	19.6%	34.1%	20.5% (18-30 y
35-54 y	34.9%	38.4%	35.9%	23.1%	34.4%	26% (30-44 y)
55-64 y	17.4*	18.9%	17.3%	39.3%	26.8%	25.4% (45-59 y)
65+ y	24%	20.1%	23.1%	18%	4.6%	28.1% (60+ y)
Education level						
Primary	5.7%	5.7%	9.6%	3.8%	4.3%	n/a
Lower secondary	17.9%	9.4%	17.3%	9.1%	6.3%	5.6%
Higher secondary	36.6%	40.9%	39.1%	47.4%	48.7%	27.7%
Post-sec. or higher	39.8%	44.0%	34%	39.7%	40.7%	66.7%

3.2 Survey items

Expected behaviour in case of a nuclear accident was measured in two ways: i) perceived likelihood of following recommended actions (local and national samples) and ii) expected behaviour in two particular emergency scenarios (only local population).

The direct measurement of expected behaviour was done with the question:

"*We will now go through a number of actions that authorities may advise people to do in case of a nuclear accident. Can you tell me for each of the following actions if you will follow these actions or not, if advised to do so:"*

- stay indoors or go indoors;
- avoid the use of phone (landline and mobile);
- leave the children at school (only respondents with children aged 16 or less in Belgium; aged 12 or less in Spain);
- take an iodine tablet yourself;
- give stable iodine tablets to your children (only respondents with children aged 16 or less in Belgium; aged 12 or less in Spain; aged 18y or less in Norway);
- not consume local food products (in Norway: follow dietary advice given by authorities);
- leave the affected area for few days (only local population);
- not drink tap water.

A 6-point Likert scale was used in Belgium and Spain, with the answering categories: "definitely not", "probably not", "maybe not", "maybe yes", "probably yes", "definitely yes". In Norway, a 5-point Likert scale was used: "yes, definitely", "yes, probably", "no, probably not", "definitely not", "not sure".

The two scenarios were used in Belgium and Spain (see Table 2) and were adapted from Johnson and Zeigler (1983) with reference to the nuclear power plant closest to the respondent's home.

Table 2 Scenarios used to investigate expected behaviour

Scenario 1: Suppose that authorities advise that people in the neighbouring village or municipality should **stay indoors**, **but no actions are needed in your area**. What would you do?	***Answering categories:*** 1. Nothing special 2. Stay indoors 3. Leave the area (go to another place, farther away) 4. Something else: OPEN 5. Don't know / no answer
Scenario 2 Belgium: And what if authorities advise that people in the neighbouring village or municipality should leave the area (evacuate), but people in your area should **stay indoors.** What would you do? ***Scenario 2 Spain:*** And if the authorities have advised the population of the nearest villages or municipalities that they should **leave the area** (evacuate), but the population in your area should **stay indoors**. What would you do?	

Perceived effectiveness (only BE, ES) of specific protective actions (all except leaving children at school and avoiding the use of phone) was measured with the question: "*And to what extent do you believe the following actions would protect you against the harmful health effects due to a radioactive release in the air"*. Answers ranged from "not at all", though to "not much", "moderately", "quite a lot", "completely".

Perceived ease (only BE, ES) of carrying out *an action* was measured as follows: "*How easy or how difficult do you think it would be for you and your family to undertake the following actions in case of a nuclear emergency?"*. The answers ranged from "very easy", through to "easy", "neither difficult nor easy", "difficult", "very difficult". In the case of the sheltering action, the timing was specified as one day.

Information about protective actions was measured with one item, capturing the perceived level of information about protective actions in case of a nuclear accident: *"I feel well informed about what to do in case of a nuclear accident"*, with answers on a 5-point Likert scale: "strongly disagree", "disagree" , "neither agree nor disagree" , "agree", "strongly agree". In Norway, a different, but similar question was used to measure knowledge with actions to protect oneself from radiation, with answers ranging from "very bad knowledge", through to "bad knowledge", "moderate knowledge", to "good knowledge" and "very good knowledge".

Descriptive norms (only BE, ES) were measured with the question: *"And, in your opinion, would people from your neighborhood comply with this official advice?"*, with reference to the same protective actions.

4. Results

4.1 Expected behaviour

Results suggest differences between countries in terms of expected compliance, as well as between local and national population (Table 3). The latter is particularly significant in Spain, where people living in the emergency planning zone of 30 km report significantly higher levels of compliance than people living outside this area. In Belgium (both local and national samples) and Norway the percentages of respondents who would definitely or probably carry out protective actions such as staying indoors or taking an iodine tablet with 10% or more higher than in Spain. For dietary restrictions there are high levels of expected compliance in all three countries. At the same time, in both countries where these actions were investigated (Belgium and Spain) less than 50% of respondents are likely to avoid the use of phones or leave children at school.

Table 3 Expected compliance with protective actions: % respondents who would definitely or probably carry out the action.

	Respondent's COMPLIANCE with protective actions*:							
	Stay indoors or go indoors [i]	**Avoid use of phone (landline &mobile)**	**Leave my children at school [ii]**	**Take an iodine tablet myself [iii]**	**Give stable iodine tablets to my children [ii]**	**Not consume local food prod. [iv]**	**Leave affect-ed area for few days**	**Not drink tap water**
Belg. local (<20km Doel)	79%	52%	43%	85%	89%	80%	81%	88%
Belg. local (<20 km Tihange)	83%	47%	33%	83%	84%	90%	88%	91%
Belg. national	86%	47%	39%	77%	75%	81%	N/A	84%
Spain local (<30 km NPP's)	56%	42%	15%	52%	N/A	67%	76%	80%
Spain (30 -100 km NPP's)	35%	24%	6%	28%	N/A	43%	54%	61%
Norway	94%	N/A	N/A	79%	88%	91%	N/A	N/A

[i]Norway: Stay indoors for 2 days; [ii]Only respondents with children, of 16 y or younger (Belgium); 12y or younger (Spain); 18 y or younger Norway; [iii]Norway: only respondents less than 40 y old; [iv]Norway: Follow the dietary advice given by authorities
**Only respondents who would definitely or probably carry out the protective action*

When respondents in Belgium and Spain are asked if they think the majority of people living in the area would follow these actions, they tend to think that it is less likely that people would follow the actions. For instance, while around 80% of the Belgian respondents living in a radius of 20 km from Doel and Tihange nuclear installations say they would probably or definitively take an iodine tablet, only 70% believe that their neighbours would probably or definitively take an iodine tablet.

Table 4 Perception of expected compliance of other residents with protective actions: % respondents who think that other residents would definitely or probably carry out the action

	Perception of other residents' COMPLIANCE with protective actions*:							
	Stay indoors or go indoors	**Avoid the use of phone (landline &mobile)**	**Leave the children at school**	**Take an iodine tablet themselves**	**Give stable iodine tablets to their children**	**Not consume local food products**	**Leave the affected area for few days**	**Not drink tap water**
Belg. local (<20km Doel)	65%	30%	26%	71%	78%	70%	64%	74%
Belg. local (<20 km Tihange)	58%	23%	24%	70%	79%	72%	60%	75%
Belg. national	68%	29%	29%	69%	71%	68%	N/A	70%
Spain local (<30 km NPP's)	36%	19%	14%	40%	N/A	49%	56%	61%
Spain (30 -100 km NPP's)	32%	15%	8%	25%	N/A	36%	47%	52%

* Respondents who think that other residents would definitely or probably carry out the protective action

4.2 Perceived ease and effectiveness of protective actions

Avoiding the use of phone and leaving the children at school appear easy for only a minority of Belgian and Spanish respondents: less than 20% of respondents with children in case of the latter. Only one in three respondents in the local population in Spain think that taking iodine tablets would pose no specific difficulties, whereas in Belgium this percentage is higher, between 50% and 60% (Table 5).

Table 5 Perceived ease of protective actions: % respondents who find these easy or very easy.

	EASE of protective actions**:						
	To stay indoors for an entire day	**Avoid the use of phone (landline & mobile)**	**To leave my children at school***	**To find and take iodine tablets**	**Not to consume local food products**	**To leave your home for few days, as part of an organised evacuation.**	**Not to drink tap water**
Belg. local (<20km Doel)	78%	40%	17%	58%	88%	66%	83%
Belg. local (<20 km Tihange)	78%	42%	6%	54%	89%	56%	89%
Belg. national	72%	42%	20%	N/A	78%		78%
Spain local (<30 km NPP's)	58%	37%	16%	29%	62%	63%	79%
Spain (30 -100 km NPP's)	57%	39%	17%	N/A	64%	57%	73%

** Only respondents with children of 16 y or younger (Belgium); 12 y or younger (Spain)*

***Only respondents who find the protective action easy or very easy.*

If we consider the proposed actions in terms of the perceived usefulness and the perceived ease of carrying them out, there are three actions that are generally considered by respondents as easy and useful: avoiding local products, leaving the area and avoiding drinking tap water. Staying indoors is perceived, on average, as relatively easy, but less effective (Table 6).

Table 6 Perceived effectiveness of protective actions: % respondents thinking these protect completely or quite a lot against harmful health effects due to a radioactive release in the air

	EFFECTIVENESS of protective actions*:				
	Staying indoors	**Taking iodine tablets to protect oneself against radioactive iodine**	**Leaving the area, as part of an organised evacuation**	**Not consume local food products**	**Not drink tap water**
Belg. local (<20km Doel)	35%	59%	69%	64%	71%
Belg. local (<20 km Tihange)	17%	28%	39%	60%	67%
Belg. national	42%	56%	N/A	59%	65%
Spain local (<30 km NPP's)	28%	33%	72%	65%	70%
Spain (30 -100 km NPP's)	21%	24%	73%	67%	72%

*Only respondents who think these actions can protect completely or quite a lot against the harmful health effects due to a radioactive release in the air

In Belgium, the general public is more confident in the effectiveness of sheltering than the population living in the vicinity of nuclear power plants; in Spain the opposite is noticed: residents living farther away from nuclear installations are more negative about this protective action than those living in a 30 km radius.

Residents of the Tihange area in Belgium are particularly skeptical about the effectiveness of sheltering and stable iodine intake. Taking an iodine tablet is perceived as not too easy and only moderately effective. In case of Belgium, there are significant differences in perception between residents in the Doel area compared to Tihange area, the latter being less confident in the effectiveness of staying indoors, taking an iodine tablet or leaving the area.

Not consuming local food products and not drink tap water are perceived as more effective on average than staying indoors or taking iodine tablets.

4.3 Perceived level of information concerning self-protection in case of nuclear accidents

Results show that a majority of respondents in all countries evaluate their level of information or knowledge about protective actions in case of a nuclear accident as very low or low, particularly people living close to nuclear installations. This indicates the need for improved public information and increased awareness about protective actions for the case of a nuclear emergency.

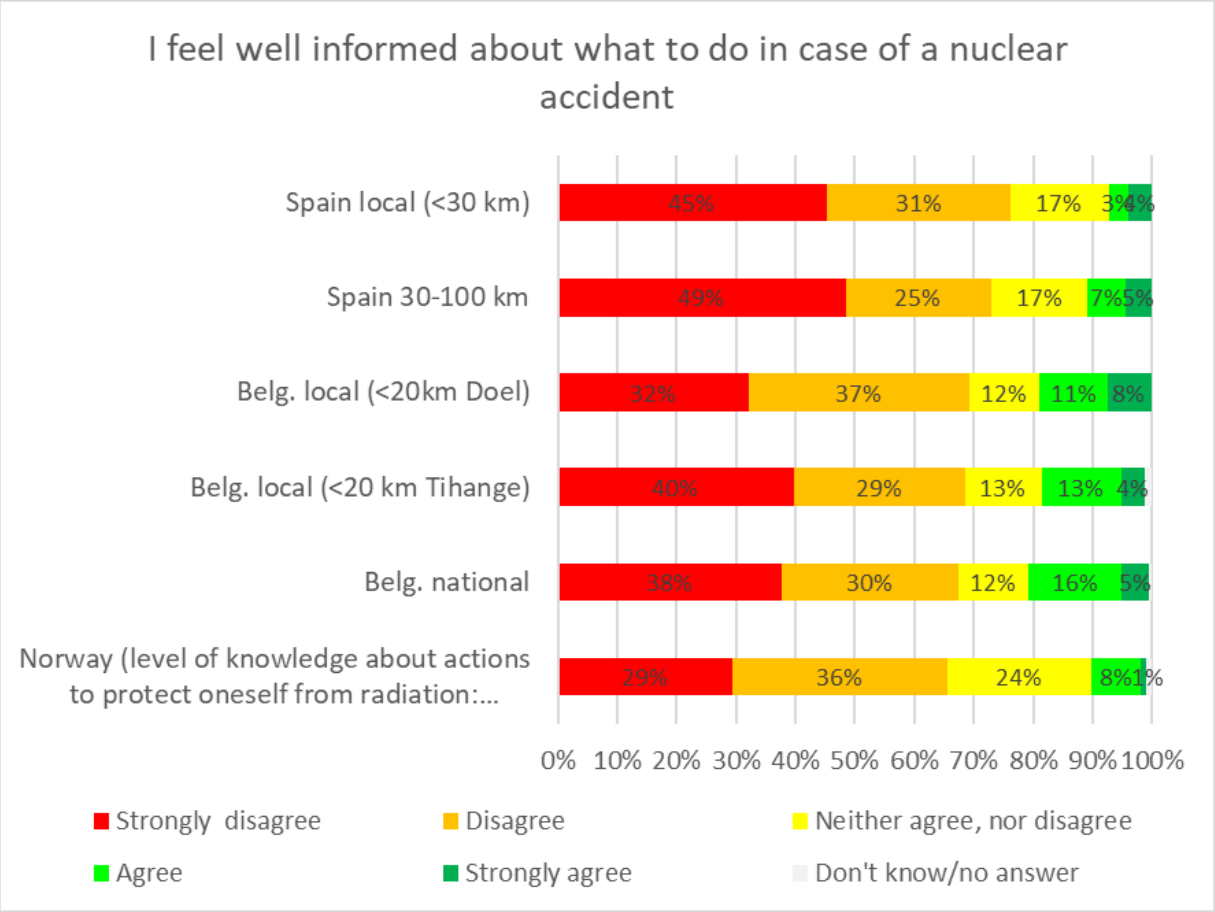

Fig. 1 Self –reported level of information about protection in case of a nuclear accident*

* In Norway, answers ranging from "very bad knowledge", through to "bad knowledge", "moderate knowledge", to "good knowledge" and "very good knowledge"

4.4 Awareness gaps

As regards iodine tablets in Belgium, it is important to note that many respondents in both target populations would not wait for instructions for intake; instead, they would take the iodine tablets immediately, as soon as they learn the news about an accident or hear the sirens (Fig. 2). Moreover, 37% of the respondents in the Tihange area and 43% in the Doel area say they would probably or definitely take the iodine tablets in case of an emergency, even if the authorities do not recommend it.

Remarkably, 57% of Spanish respondents living in a radius of 30 km around nuclear power plants do not know when iodine tablets should be taken, whereas 18% would intake the tablets immediately. This indicates a great challenge for emergency management in Spain and Belgium, as large percentages among the local populations may wrongly understand or apply this protective action in an incorrect way.

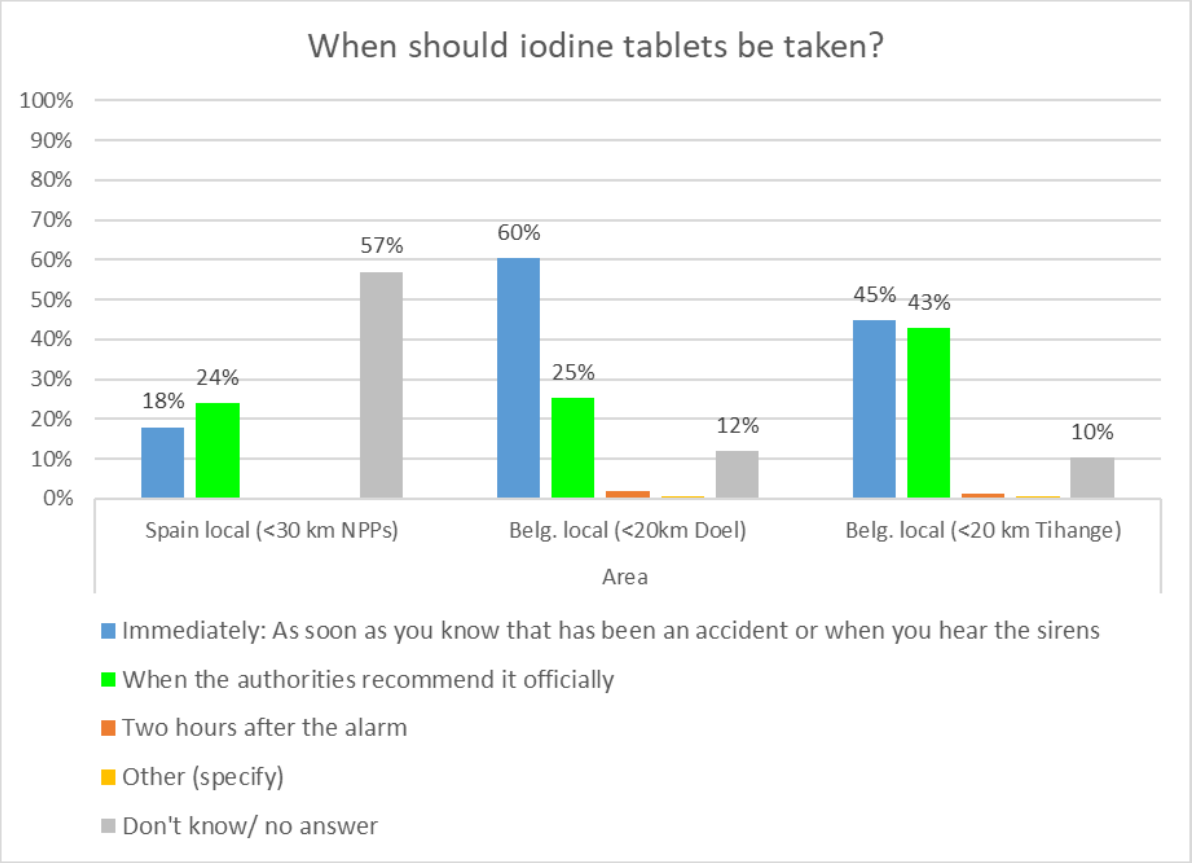

Fig. 2 Knowledge about the proper moment for iodine tablets intake

Furthermore, 52% of the respondents in the Belgian Tihange area and 58% in the Doel area know that stable iodine tablets protect against thyroid cancer, while 38% in Tihange area and 34% in the Doel area think that iodine tablets protect (also) against any health effects from ionising radiation.

4.5 Scenario-based behaviour

Two scenarios were also used to assess expected behaviour under two hypothetical protective actions scenarios.

In the first scenario (Fig. 3, lower part), respondents were asked to imagine an accident had taken place in the nuclear power plant closest to their home. The authorities had advised residents living in the neighbouring municipality to remain indoors, but no actions were needed in the area of the respondent. The results show that about 10% of respondents in the local populations in Spain and Belgium Doel area, and only about 20% in the Spanish population living farther than 30 km from an NPP would not take any action. About 40% of respondents in the local population in Spain responded they would remain indoors, while this above 60% in the case of Belgium. However, 20 to 40% would leave the area. In Spain, overreaction is higher among residents living within 30 km around a nuclear power plant (41% of respondents would leave the area instead to remain indoors).

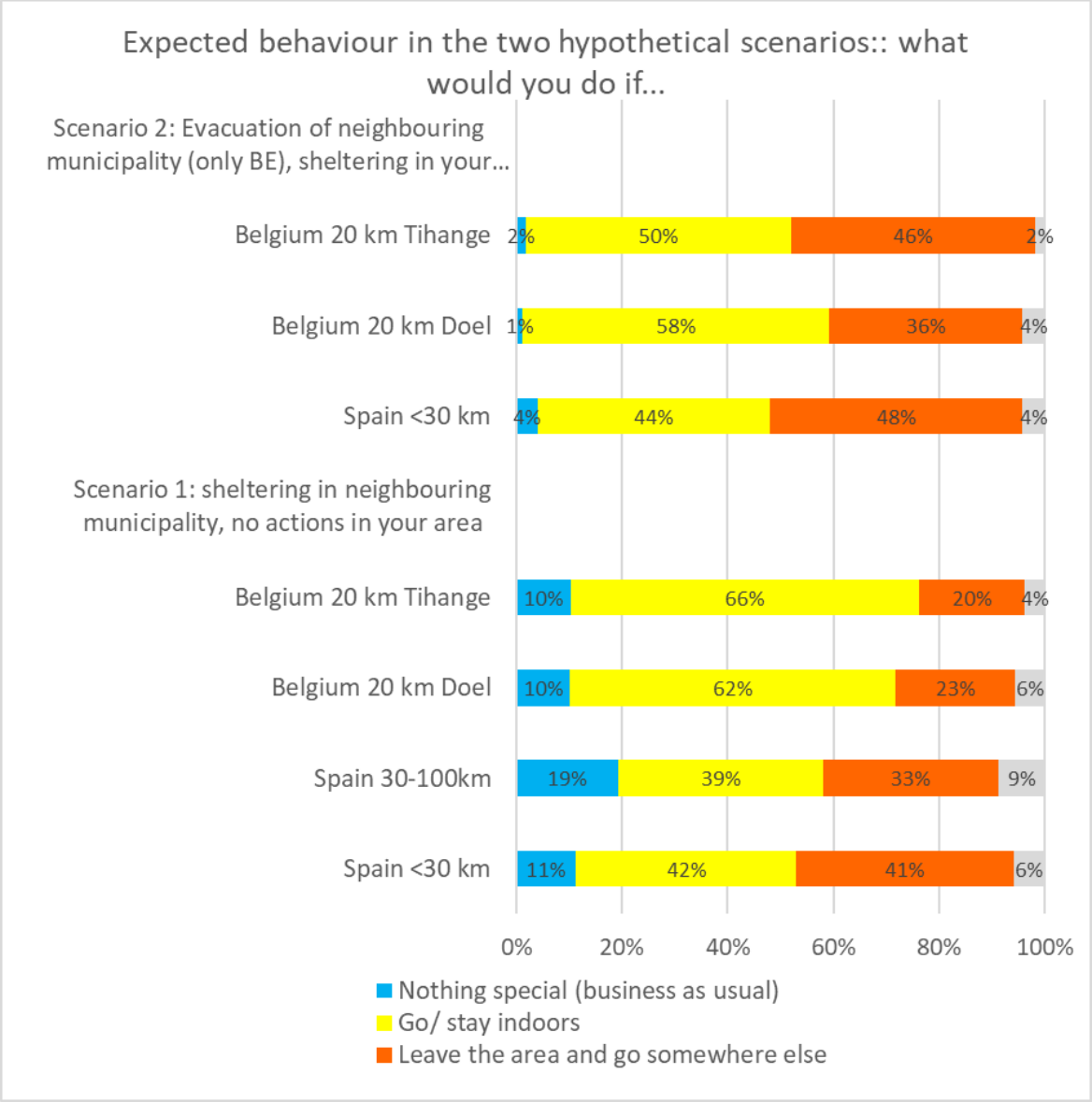

Fig. 3 Expected behaviour under hypothetical scenarios

In the second scenario (Fig. 3, upper part), people in the area of the respondent's home (everyone living within 30 km of the nuclear power plant in Spain) was advised to remain indoors (shelter). The scenario also mentioned that people from the neigbouring municipality would need to evacuate. The results show that 44-58% of respondents living in the area would follow instructions, but at least one in three would overreact, with almost half of respondents in the Tihange area and among the Spanish local population saying that would leave the area. Evacuation in a neighbouring municipality would be a strong trigger for self-evacuation among respondents in the local population of the Tihange area and the 30 km radius around NPP's in Spain, but this tendency is somewhat less pronounced in the Doel area.

5. Discussion

One of the objectives of CONFIDENCE project is to highlight social uncertainties in the case of an emergency.

This study reports on an empirical investigation in three countries of the expected compliance with protective actions in case of a nuclear accident. Results suggest that most respondents expect to comply with emergency actions, except for leaving children at school or avoiding the use of phone. In case of the latter, less than 50% of respondents say this is likely to happen. However, the investigation of specific scenarios showed that large fractions of the local population are likely to overreact towards a more conservative course of action, for instance mirroring the actions taken in a neighbouring, more affected, municipality.

Some differences are noted in terms of expected compliance between countries, as well as between local and national population, and different local populations in the same country, showing that the emergency management approaches have to be tailored to the specific national and cultural context. More research is needed to understand why respondents in Spain report lower levels of compliance than in Belgium and Norway. Such differences have to be investigated and revealed in the preparedness phase.

In Belgium and in Spain descriptive norm, perceived ease and effectiveness of actions, as well as the perceived level of information have been studied in connection with behavioural expectations concerning protective actions. Dietary restrictions are perceived as both easy and effective. In turn, sheltering is perceived as easy, but not very effective.

With respect to iodine tablets, it is important to notice that more effort is needed to explain the purpose of iodine tablets and the proper moment for intake.

The self-reported level of information about protective actions is low in all three countries. This shows that information campaigns have to be repeated regularly to bring people's attention to emergency information.

Future work will investigate in detail the factors influencing expected behaviour and the development of communication tools addressing the uncertainties revealed by this study.

6. Limitations of the study

One limitation of our study is the use of different methods for data collection. However, the samples used are representative for the target populations with respect to gender, age and education. Furthermore, it would be helpful to investigate also group psychology.

7. Conclusions important for the CONFIDENCE project

The empirical findings from this study will inform future research and development in the context of the CONFIDENCE project as well as the project training activities.

WP1 should take the challenges identified in this empirical research (e.g. self-evacuation, early intake of iodine tablets, not-leaving children at school…) as a societal uncertainty that should be treated as one of the uncertainties in pre- and early release phase of the accident. The population's behavioural intentions should be taken into account in the activity concentrations, dose assessment, and reference levels calculations.

The development of comprehensive software tools for the quick and efficient assessment of cancer risk to affected populations to be used as an input in the overall decision making process (WP2) should also take these planned responses into account. In the case of an emergency, there may be a lot of people not following the protective actions. WP5 should link strongly with WP2 since the health risks from non-compliance with protective actions should be clearly communicated to the affected population.

WP3 should be informed by this empirical study in what concerns restrictions on local food products or consumption of tap water. In general, people would comply with such restrictions; however, there may be challenges arising from unnecessary boycott of food products and avoidance of tap water. This has not been investigated in this empirical research; however experiences of past accidents indicate that people often overreact in this aspect. WP3 should therefore improve the capabilities of radioecological models to predict activity concentrations in foodstuffs and communicate also negative results to the public in order to avoid unnecessary boycott and additional economic and societal consequences.

WP4 should discuss the protective actions also with the potentially affected population, in the light of the revised European Basic Safety Standards. This study clearly points out that there are cultural differences between countries, as well as within a country. For instance, the general population has different behavioural expectations as the population living in the vicinity of nuclear installations. These differences should be taken into account in discussions with different stakeholders, although the Basic safety Standards require quite generally and without specification of cultural differences that "Member States shall ensure that the members of the public likely to be affected in the event of an emergency are given information about the health protection measures applicable to them and about the action they should take in the event of such an emergency." (article 70) and "Member States shall ensure that, when an emergency occurs, the members of the public actually affected are informed without delay about the facts of the emergency, the steps to be taken and, as appropriate, the health protection measures applicable to these members of the public." (article 71).

The most significant input from this empirical research will be given to WP5, since results indicate social issues/uncertainties for emergency actors (e.g. will people comply with the protective action or not) and for the affected population (e.g. shall I and my family comply with the advice on the protective action). Uncertainties indicated by this research could be reduced by sound risk communication that will be developed in WP5. The insights in planed behaviour can support and improve communication of uncertainties (WP5 and WP6) and facilitate robust decision making taking into account the variability of the radiological situation and decision makers' preferences (WP6).

The results of this empirical research will also be integrated in the training courses and educational material for professionals and students related to the issues and activities addressed in CONFIDENCE (WP7).

8. References

Ajzen, I. (1991). The theory of planned behavior, Organizational Behavior and Human Decision Processes 50: 179-211.

Ajzen, I. (2002a). Residual effects of past on later behavior: Habituation and reasoned action perspectives. Personality and Social Psychology Review 6: 107-122.

Ajzen, I. (2002b). Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behaviour. Journal of Applied Social Psychology 32: 665-683.

Burns, W.J., Slovic, P. (2012). Risk perception and behaviors: anticipating and responding to crises. Risk Analysis, 32(4): 579-582.

Callen, J., and McKenna, T. (2018). Saving lives and preventing injuries from unjustified protective actions—Method for developing a comprehensive public protective action strategy for a severe NPP emergency. Health Pysics, 114(5), 511-526.

Chaiken, S., and Stangor, C. (1987). Attitudes and Attitude Change. Annual Review of Psychology, 38, 575-630.

Chassin, L., Presson, C. C., Sherman, S. J., Corty, E. and Olshavsky, R. W. (1984) Predicting the onset of cigarette smoking in adolescents: A longitudinal study, Journal of Applied Social Psychology 14: 224-243.

Chung, W. and Yeung, I.M. (2013). Attitudes of Hong Kong residents toward the Daya Bay nuclear power plant. Energy policy, 62, pp.1172-1186.

Crépey. P, Pivette. M, and Bar-Hen. A. (2013). Quantitative Assessment of Preventive Behaviors in France during the Fukushima Nuclear Crisis. PLoS ONE, 8(3), e58385. doi:10.1371/journal.pone.0058385

Cutter, S. and Barnes, K. (1982). Evacuation behavior and Three Mile Island. Disasters, 6(2), pp.116-124.

Eagly, A. H. (1992). Uneven Progress - Social Psychology and the Study of Attitudes. Journal of Personality and Social Psychology, 63(5), 693-710.

Eiser, J. R., Bostrom, A., Burton, I., Johnston, D. M., McClure et al (2012). Risk interpretation and action: A conceptual framework for responses to natural hazards. International Journal of Disaster Risk Reduction, 1: 5-16.

ENCO (2014). Review of current off-site nuclear emergency preparedness and response arrangements in EU Member States and neighbouring countries. https://publications.europa.eu/en/publication-detail/-/publication/e6f9c4fb-8720-44e7-8ae5-331da3b1bfb8/language-en

Eysenck, M. W., Keane, M. T. (2005). Cognitive psychology (5 ed.). London: Psychology Press.

Fishbein, M. and Ajzen, I. (1980). Predicting and understanding consumer behavior: Attitude-behavior correspondence. Understanding attitudes and predicting social behavior, 148-172. Prentice Hall Englewood Cliffs, NJ

Flynn, C. (1979). Three Mile Island Telephone Survey: Preliminary Report on Procedures and Findings. Seattle: Social Impact Research, Inc.

Giordano, A. (2005).The people and the plan: intended reactions to a nuclear emergency in New York State. Risk Management: An International Journal 7(3), 41–56.

Griffin, R. J., Dunwoody, S. and Neuwirth, K. (1999). Proposed Model of the Relationship of Risk Information Seeking and Processing to the Development of Preventive Behaviors. Environmental research, A80, 230-245.

Hasegawa, A., Ohira, T., Maeda, M., Yasumura, S. and Tanigawa, K. (2016). Emergency responses and health consequences after the Fukushima accident; evacuation and relocation. Clinical Oncol., 28, 237–244.

Hobson, C. (2015). Rebuilding Trust after Fukushima (No. 4). United Nations University Working Paper, UNU-IAS.

Houts, P.S., Lindell, M.K., Hu, T.W., Cleary, P.D., Tokuhata, G. and Flynn, C.B., 1984. Protective action decision model applied to evacuation during the Three Mile Island crisis. International Journal of Mass Emergencies and Disasters, 2(1), pp.27-39.

Johnson, J.H. and Zeigler, D.J. (1983). Distinguishing human responses to radiological emergencies. Economic Geography, 59(4), 386-402.

Kanda, R., Tsuji, S. and Yonehara, H. (2012). Perceived Risk of Nuclear Power and Other Risks During the Last 25 Years in Japan. Health Physics, 102(4), 384-390. doi:10.1097/HP.0b013e31823abef2

Lang, A. (2006). Using the Limited Capacity Model of Motivated Mediated Message Processing to Design Effective Cancer Communication Messages. Journal of Communication, 56, S57-S80.

Lang, A., Bolls, P., Potter, R. F. and Kawahara, K. (1999). The Effects of Production Pacing and Arousing Content on the Information Processing of Television Messages. Journal of Broadcasting & Electronic Media, 43(4), 451-475.

Lindell, M.K. and Perry, R.W., 2012. The protective action decision model: theoretical modifications and additional evidence. Risk Analysis, 32(4): 616-632.

Lindell, M.K., Mumpower, J.L., Huang, S.K., Wu, H.C., Samuelson, C.D., Wei, H.L. (2017). Perceptions of protective actions for a water contamination emergency. Journal of Risk Research, 20(7): pp.887-908.

Malešič, M., Prezelj, I., Juvan, J., Polič, M. and Uhan, S. (2015). Evacuation in the event of a nuclear disaster: planned activity or improvisation? International journal of disaster risk reduction, 12, 102-111.

McGuire, W. J. (Ed.) (1973). Persuasion, Resistance, and Attitude Change. Chicago: IL:Rand McNally.

NAIIC. (2012). Fukushima Nuclear Accident Independent Investigation Commission Report. Retrieved from Tokio, Japan:

Nuclear Accident Independent Investigation Commission. 2012. The Official Report of The Nuclear Accident Independent Investigation Commission. The National Diet of Japan. http://www.nirs.org/fukushima/naiic_report.pdf.

Paek, H. J., Hilyard, K., Freimuth, V., Barge, J. K. and Mindlin, M. (2010). Theory-based approaches to understanding public emergency preparedness: implications for effective health and risk communication. Journal of health communication, 15(4), 428-444.

Perko T., Turcanu C., Schröder J. and Carlé B. (2010). Risk perception of the Belgian population. Results of the public opinion survey in 2009. Open Report of the Belgian Nuclear Research Centre BLG-1070, Mol: Belgium.

Perko, T., Thijssen, P., C., T. and Van Gorp, B. (2014). Insights into the reception and acceptance of risk messages: nuclear emergency communication. Journal of Risk Research, 17(9), 1207-1232.

Perko, T., van Gorp, B., Turcanu, C., Thijssen, P. and Carlé, B. (2013). Communication in Nuclear Emergency Preparedness: A Closer Look at Information Reception. Risk Analysis, 10.1111/risa.12048. doi:10.1111/risa.12048

Petty, E. R. and Cacioppo, J. T. (1986). The Elaboration Likehood Model of Persuasion. In A. D. Berkowitz (Ed.), Advances in Experimental Social Psychology (Vol. 19, pp. 124-192). New York: Academic Press.

Shiffrin, R. M. and Schneider, W. (1984). Automatic and Controlled Processing Revisited. Psychological Review, 91(2), 269-276.

Taylor, M., Joung, W., Griffin, B., Hill, D., Chisari, R., Hesketh, B. and Raphael, B. (2011). The public and a radiological or nuclear emergency event: threat perception, preparedness, and anticipated response-findings from a preliminary study in Sydney, Australia. Australian Journal of Emergency Management, 26(1), p.31.

Trumbo, W. C. (2002). Information Processing and Risk Perception: An Adaption of the Heuristic-Systematic Model. Journal of Communication, 52, 367-382.

Yasumura, S. (2014). Evacuation effect on excess mortality among institutionalized elderly after the Fukushima Daiichi nuclear power plant accident. Fukushima J Med Sci, 60, 192–195.

Zaller, J. (2006). The Nature and Origins of Mass Opinion. New York: Cambridge university press