

Lay Public Mental Models of Nuclear or Radiological Emergency Situations. Findings from Spain.

R. Sala Escarrabill

S. Germán Prats

S. López-Asensio

C. Oltra Algado



Publicación disponible en el [Catálogo general de publicaciones oficiales](#).

© CIEMAT, 2019
Depósito Legal: M-26385-2011
ISSN: 1135-9420
NIPO: 693-19-017-7

Maquetación y Publicación:
Editorial CIEMAT
Avda. Complutense, 40 28040-MADRID
Correo: editorial@ciemat.es
[Novedades editoriales CIEMAT](#)

El CIEMAT no comparte necesariamente las opiniones y los juicios expuestos en este documento, cuya responsabilidad corresponde únicamente a los autores.

Reservados todos los derechos por la legislación en materia de Propiedad Intelectual. Queda prohibida la reproducción total o parcial de cualquier parte de este libro por cualquier medio electrónico o mecánico, actual o futuro, sin autorización por escrito de la editorial.

Lay Public Mental Models of Nuclear or
Radiological Emergency Situations.
Findings from Spain

R. Sala Escarrabill
S. Germán Prats
S. López Asensio
C. Oltra Algado

Lay Public Mental Models of Nuclear or Radiological Emergency Situations. Findings from Spain

Sala Escarrabill, R.; Germán Prats, S.; López-Asensio S.; Oltra Algado, C.

23 pp., 19 refs., 2 f gs., 2 tables

Abstract:

Off-site nuclear emergency plans consider the actions to be carried out in case of nuclear or radiological emergency. However, there is little scientific evidence about the knowledge of these emergency plans by the population living near nuclear power plants. This study, based on the mental models approach, aims to understand citizens' cognitive representations of a nuclear emergency and its associated response plan. Data was collected through interviews to 15 citizens living near a Spanish nuclear power plant (NPP). The results show that participants have a general idea of the basic elements of the emergency plan, but only a vague understanding of each of the specific protective measure. There is a clear awareness among participants that, in case of an accident, it would be better to comply with governmental instructions; but it co-exists a belief that people would not necessarily follow the instructions by the authorities. Participants believe that there is not enough information regarding how to act during a nuclear or radiological emergency. They suggest the need to improve the current communication campaigns.

Modelos mentales del público en situaciones de emergencia nuclear o radiológica. Resultados de España

Sala Escarrabill, R.; Germán Prats, S.; López-Asensio S.; Oltra Algado, C.

23 pp., 19 refs., 2 figs., 2 tablas

Resumen:

Los planes de emergencia nuclear exterior contemplan las acciones a realizar en caso de emergencia nuclear o radiológica. Sin embargo, hay poca evidencia empírica en relación al conocimiento, de la población residente alrededor de las centrales nucleares, sobre los planes de emergencia. Este estudio, basado en el enfoque de modelos mentales, tiene como objetivo comprender las representaciones cognitivas que tienen los ciudadanos sobre una emergencia nuclear y sobre el plan de respuesta asociado. Los datos se recopilieron a través de entrevistas a 15 ciudadanos que viven cerca de una central nuclear española. Los resultados muestran que los participantes tienen una idea general de los elementos básicos del plan de emergencia, pero solo una vaga comprensión de cada una de las medidas de protección específicas. Existe una clara conciencia entre los participantes de que, en caso de accidente, sería mejor cumplir con las instrucciones de las autoridades; pero coexiste la creencia de que las personas no necesariamente seguirían estas instrucciones. Los participantes creen que no se dispone de suficiente información sobre cómo actuar en caso de emergencia nuclear o radiológica y sugieren la necesidad de mejorar las campañas de comunicación existentes.

TABLE OF CONTENTS

- 1 INTRODUCTION..... 1**
- 2 METHOD..... 3**
 - 2.1 SAMPLE 3**
 - 2.2 PROCEDURE..... 4**
 - 2.3 DATA ANALYSIS 5**
- 3 FINDINGS 6**
 - 3.1 FAMILIARITY WITH AND KNOWLEDGE OF THE EMERGENCY PLANS..... 6**
 - 3.2 RISK PERCEPTION 7**
 - 3.3 FORESEEN MEASURES FOR A RADIOLOGICAL AND NUCLEAR EMERGENCY..... 9**
 - 3.4 UNDERSTANDING OF MEASURES 9**
 - 3.4.1 SHELTERING..... 9*
 - 3.4.2 IODINE PROPHYLAXIS..... 10*
 - 3.4.3 EVACUATION..... 10*
 - 3.4.4 ACCOMMODATION AND CARE OF EVACUATED POPULATION..... 12*
 - 3.4.5 DECONTAMINATION 12*
 - 3.4.6 FOOD SAFETY MEASURES 12*
 - 3.5 COMPLIANCE OF GOVERNMENTAL INSTRUCTIONS 12**
 - 3.6 INFORMATION ISSUES 14**
 - 3.7 TRUST..... 15**
 - 3.8 MENTAL MODEL MAP 16**
- 4 SUMMARY OF FINDINGS 18**
- 5 REFERENCES 20**
- 6 ANNEX. PROTOCOL OF INTERVIEWS 22**

LIST OF FIGURES

Figure 1. Location of Vandellós II NPP and the municipality of L'Hospitalet de l'Infant.....	4
Figure 2. Mental model map.....	17

LIST OF TABLES

Table 1. Socio-demographic profile.....	3
Table 2. Topics considered in the interview.....	4

1 INTRODUCTION

Off-site nuclear emergency plans are intended to prevent or at least reduce the adverse effects of ionising radiation on the public and the environment (Consejo de Seguridad Nuclear, 2019). The nuclear emergency plans contemplate the actions to be carried out in case of a radiological emergency or nuclear accident and, among them, the protective and prevention measures to apply to citizens who live near a nuclear power plant (NPP).

However, there is little information about the public's knowledge of these emergency plans and how citizens would act in case of a real radiological or nuclear emergency. In this sense, there are different questions to answer: Do citizens know the nuclear emergency preparedness and response plans? Do they know how they would act in case of a nuclear or radiological emergency in their city? Do they know the protective measures that should be adopted? Do they trust the responsible institutions? Would they follow the instructions given by the public authorities?

Mental models research is characterized by careful examination of the way people understand some domain of knowledge (Gentner & Stevens, 2014). Mental models can be defined as personal and internal representations of external reality that people use to interact with the world (Jones, Ross, Lynam, Perez, & Leitch, 2011) or as cognitive representations of some domain or situation, which support understanding, reasoning, and prediction (Gentner, 2002). These representations are constructed from individual experiences, perceptions and understandings of the world. Mental models are used by individuals to make decisions that can be the basis of individual behaviours such as the response to a nuclear emergency.

Mental models have been previously investigated in a number of fields such as space and motion, physics, flowing waters, education, climate change, etc. (Gentner & Stevens, 2014). In many cases, the findings are used to prepare more effective education, information materials and communication strategies. In this study we apply a mental models approach (Gentner, 2002; Morgan, Fischhoff, Bostrom, & Atman, 2002) to investigate citizens' cognitive representations about the preparedness and response to nuclear or radiological emergency situations.

Very few previous research exists on lay public mental models of ionizing radiation. In 2016, Železnik et al. found that in four European countries (France, Poland, Romania and Slovenia) members of the public possess a non-negligible amount of knowledge on the topic of ionizing radiation and its risks and they hold strong views on related concepts, despite they profess very little formal knowledge of types of radiation or its main characteristics. Also, Perko (2014) examined lay people's and expert's mental models of five different radiological risks. Her results showed that experts perceive radiological risks differently from the general public. Specifically, experts' perception of medical X-rays and natural radiation is significantly higher than in general population, while for nuclear waste and an accident at a nuclear installation, experts have lower risk perception than the general population.

Other studies have examined the perception of nuclear power (Hämäläinen, 1991; Kanda, Tsuji, & Yonehara, 2012; Sjöberg & Drottz-Sjöberg, 1991), nuclear testing (Purvis-Roberts, Werner, & Frank, 2007) or nuclear waste (Sjöberg, 2002) or nuclear waste disposal by using mental models approach (Skarlatidou, Cheng, & Haklay, 2012).

Furthermore, research on public responses during real nuclear emergencies has been examined on previous research. The reactions and responses of the public during and after the Three Mile Island (TMI) accident have been studied by various authors. Flynn (1979) survey studied the areas of evacuation behaviour, information processing, short-term accident effects, continuing effects of the accident, and respondent's evaluation of TMI. Characteristics influencing decision to evacuate and to remain in place were studied by different authors (Cutter & Barnes, 1982; Houts et al., 1984). Cutter & Barnes (1982) found, among other aspects, that the proximity to the NPP, the stage in life cycle and the actions of friends and family can influence the decision to evacuate. Prince-Embury (1989) examined the importance of attitudinal and demographic variables in discriminating residents who had moved from those who remained before the restart of the TMI nuclear reactor in 1985. Findings show differences by demographic factors such as age and length of residence in the vicinity.

The hypothetical response of the public during nuclear emergencies was also studied by authors like Johnson Jr. & Zeigler (1983). Their work showed that less than one-third of the households on Long Island were likely to follow instructions in the event of an accident at the Shoreham NPP. Among the families who would not follow instructions, some would underreact but most would overreact. Findings suggested that perceived distance from the plant and age of household head appear to be the strongest discriminators among those who are most likely to follow orders. Chung & Yeung (2013) conducted a survey to study the attitudes of Hong Kong residents toward the safety of operations of Daya Bay NPP and their possible actions in case of leakage. This study indicates that only 34.5% of the respondents are confident about the operational safety of the NPP. The degree of confidence is significantly related to the perceived ability of the government and the knowledge of the emergency plan by the NPP. The study suggest that a higher perceived ability of the government and NPP are also significantly associated with less likelihood of residents immediately leaving Hong Kong in case of leakage.

This study has been carried out within the framework of the CONFIDENCE project (Coping with uNcertainties For Improved modelling and DEcision making in Nuclear emergenCiEs) and is part of Task 5.2 *Socio-psychological study of understanding, processing and management of uncertainties and improved communication tools* of the EJP (European Joint Programme for the Integration of Radiation Protection Research) funded Confidence project (H2020 Grant Agreement 662287 – CONCERT).

2 METHOD

2.1 SAMPLE

We implemented a qualitative study based on semi-structured interviews with residents living close to a nuclear power plant (NPP). The interviews were carried out during the months of October and November 2018. A total of 15 participants made up the sample. Details about the socio-demographic profile of participants are presented in Table 1.

Table 1. Socio-demographic profile

VARIABLES	LABELS	FREQUENCY	PERCENTAGE
Age	Less than 35 years old	1	6%
	From 35 to 55 years old	7	47%
	More than 55 years old	7	47%
Gender	Female	6	40%
	Male	9	60%
Education	Primary education	5	33%
	Secondary education	6	40%
	Vocational training	3	20%
	Bachelor's degree	1	7%
Employment status	Retired	7	47%
	Employee	5	33%
	Self-employed	3	20%
Years in the town	Less than 10 years	3	20%
	From 10 to 30	6	40%
	More than 30 years	6	40%
Worked in a NPP	No	12	80%
	Yes	3	20%

2.2 PROCEDURE

Two members of the research team carried out the interviews in L’Hospitalet de l’Infant (Tarragona), a town located in the northeast of Spain. This town was selected because it is located in the area between 0 to 3 kilometres from Vandellós II Nuclear Power Plant. The off-site nuclear emergency plan would be applied in this perimeter in case of a radiological emergency (Figure 1).



Figure 1. Location of Vandellós II NPP and the municipality of L’Hospitalet de l’Infant.

The protocol for the interviews was developed by members of the international research team and adapted to the Spanish context. Interviews were carried out face-to-face or by telephone, with an average duration of 15 minutes. Interviews were carried out in Spanish or Catalan and all of them were audiotaped and transcribed in their original language. The interviews were treated as confidential and written or oral informed consent was given by each participant.

Table 2. Topics considered in the interview

A. Warming up questions
Knowledge of emergency preparedness and response plan (EP&R plan)
B. Emergency management
Understanding of basic elements of EP&R plan
Knowledge of past emergencies
Risk perception on nuclear emergencies
Understanding and compliance with various Protection Measures
Sheltering
Iodine prophylaxis
Evacuation
Accommodation and care of evacuated population
Decontamination of people, animals and equipment
Food safety measures
Information source and trust
C. Socio-demographic data

The interview guide used in the interviews is shown in Table 2. Firstly, the interviewers introduced themselves and explained the purpose, the procedure and the ethics of the interview. After that, warming up questions were introduced to the participants in order to become comfortable with the topic. Later, the main questions about the mental models of emergency management were introduced. Within this set of questions, there were questions about the Emergency Preparedness and Response plan (EP&R plan), past emergencies and risk perception. Questions about the understanding of the possible measures such as sheltering, iodine prophylaxis, evacuation, decontamination, and food safety measures were included, along with questions about the level of information received and the trust in decision-makers. Finally, a set of socio-demographic data questions were presented. The detailed protocol used in these interviews is shown in the Annex.

2.3 DATA ANALYSIS

The coding of the excerpts was carried out by two researchers. The codes were derived from the interview protocol. New codes were generated after the analysis of the interviews, such as risk perception and observance of governmental recommendations. To draw the mental model map, the software Cmap Tools has been used.

3 FINDINGS

3.1 FAMILIARITY WITH AND KNOWLEDGE OF THE EMERGENCY PLANS

Most of the interviewees reported having heard about “Emergency Preparedness and Response plans” for nuclear emergencies. Once they were asked about what do they know about EP&R plan, most of them gave very simple descriptions such as “plans in case there was a nuclear emergency” (Interview 3) or “how to act in case of an emergency” (Interview 13). Some of the interviewees recognized they hardly know something: “I don’t know. The truth is I do not know” (Interview 1). No references to how it is developed or at what level were provided by respondents.

Participants mentioned some basic elements of the EP&R plan:

- Sirens / alarm. Most of the interviewees were aware of an alarm system installed in the village to warn the population in case of a nuclear accident.
- Public Address system (PA system). Many of the interviewees informed about the existence of a PA system that would give information to the population in case of a nuclear accident. They mentioned that this system is tested regularly, but some complaints appear because it is not well heard in all areas of the municipality.
- Information on how to act. Many of the interviewees mentioned they expected that the EP&R plan would give instructions on what to do in case of a nuclear emergency: “the steps to follow in case of emergency” (Interview 8)
- Sheltering or evacuation. Some participants referred to “if we have to run away or stay at home” (Interview 9).
- Medicine / pills. A couple of participants mentioned the existence of some medicine to be taken in the case of an accident but they are not sure for whom is it.
- To assemble or congregate people is another measure mentioned by some participants: “Find the assembly area and wait for instructions” (Interview 15).

Some **uncertainties** coming from these elements of the emergency plan were highlighted by participants:

1. What to do? Those mentioning uncertainties related to what to do, expressed mainly doubts about whether to stay at home or go away: “I think the main question for the population would be if they leave or if they stay” (Interview 3) or “What do you have to do? Do you have to leave home or stay indoors? These are the first questions that will come to mind. What will happen if you leave home, if you have to stay indoors... these are the first uncertainties” (Interview 7).
2. Where to go? “Where to go and what to take, of course” (Interview 12).

3. How will the population be informed? Those mentioning the issue of who is going to inform, also mentioned the lack of available information and the consequent lack of trust in information sources: “what is missing is written information that says: if this happens you have to follow these instructions” (Interview 10).
4. What are the risks they will face? “If the contamination has arrived...” (Interview 3) or “are we in danger?” (Interview 6).

Regarding previous radiological or nuclear emergencies in the country, some participants mentioned the accident occurred in 1989 in Vandellós Unit 1 (INES 3), especially those living in the town for more than 30 years. Those who experienced the accident declared that there was not any risk for the population: “I hardly remember the accident of Unit 1, many years ago. I do not remember exactly but we did not have any fear here in the town. No, because everything was very controlled and everything was very well” (Interview 2) or “the emergency plan for the population was not activated” (Interview 3). They remember it was something related with a fire. Other participants stated: “there have been incidents and we have not even heard about them” (Interview 9) or “we feel better informed by television, the NPP managers do not say anything” (Interview 13).

3.2 RISK PERCEPTION

When participants were asked what they think it could happen during a radiological or nuclear accident, two main believes came out:

- If something very serious occurs, they think they will die and it will be not necessary to do anything. Some of the images that appeared were: “I think it's an explosion and that everything disappears” (Interview 9) or “If it explodes, it is no necessary to go anywhere” (Interview 14). Nonetheless, some participants stated that, in that case, it is better to live close to the NPP because you will die faster. Another related idea is that, in the case of a serious accident, all the country will be affected, not only NPP surroundings.
- In case of a minor accident, the risk of radiological contamination was mentioned. The exact risks for health from a radiological contamination seem to be unknown.

When we asked what they remember about Fukushima or Chernobyl accidents, most of them mentioned destruction as the main consequence: “Yes, of course. Chernobyl and Fukushima. These were real emergencies. From Chernobyl I remember the reactors burning and the destruction of the area. The tsunami in Japan was also the same. Firefighters extinguishing the fire, carrying water from the sea... What TV shows you” (Interview 3) or “I remember the destruction” (Interview 11) or “Everything disappeared in a moment. Everything was devastated” (Interview 13).

When we asked them if they were afraid that a similar accident occurred in their town, most of them state that they are not. Three main reasons were given:

- They were less prepared than we are: “In Chernobyl, they were not as prepared as here. It was a very precarious plant” (Interview 2).
- After the accidents, great improvements in safety systems have been done: “After these accidents new criteria, new techniques and an improvement of all systems have been applied” (Interview 15).
- “It is not the same because here we do not have tsunamis” (Interview 6).

In general, a low level of risk perception existed among the interviewees. Participants stated that they were not really worried about this and that it did not affect their daily lives. Indirectly, many issues came out about the reasons why it is not necessary to be worried about the NPP:

- It is clean: “...the beach around the nuclear is the cleanest one of all the town” (Interview 1) and “For me, it is worse when I pass near the petrochemical plant in Tarragona, because you see all those fumes... that must be worse than it is living next to the NPP” (Interview 1) or “The worst thing would be if something happened, but in a day-to-day we are not contaminated” (Interview 2).
- It is safe: “It is very controlled. The power plants have a very large safety system. Nowadays CSN [the regulatory body] is standing over them continuously. A NPP is more secure than any construction site or any other company. The nuclear power stations have had their failures, but failures that have not been very important” (Interview 4).
- The probability of accident is low: “You have the same probabilities or less than having a car accident” (Interview 11).
- Managers are worried about safety issues: “I am calm because I know they care about it” (Interview 3).
- In case of accident the effects will be wider: “If the NPP explodes, Barcelona inhabitants will be shattered. We will not notice anything. I would prefer to be here” (Interview 10) or “If something happens everybody must be prepared. Because when the Chernobyl accident happened, all my canaries died” (Interview 2) or “If it explodes, the population that is next to the NPP is not going to notice it. The problem is the radiation that exists when you are at 200km. Those from here are not going to suffer” (Interview 11).
- It is not a main concern for the public: “I do not think about it. You know you have the nuclear power station next door but do not think it. If not, I could not live here” (Interview 7) or “In general, it is as if the NPP does not exist” (Interview 2).

3.3 FORESEEN MEASURES FOR A RADIOLOGICAL AND NUCLEAR EMERGENCY

We asked participants what kind of protective measures they think that are foreseen for the population living close to a NPP (in the area from 0 to 10 km) after a radiological or nuclear emergency. Different measures came out spontaneously:

- Most participants had in mind that the population will be warned by the PA system and sirens, others expected to be warned by the radio or by phone.
- Some interviewees expected to receive instructions for sheltering (staying indoors) or evacuating. One participant declared that in case of evacuation, school-children would be evacuated first.
- One participant mentioned iodine tablets. He thought that the distribution of iodine tablets would be one of the first measures in case of an accident.
- One participant declared that it would be necessary to use a mask and that it would be forbidden to consume tap water.

3.4 UNDERSTANDING OF MEASURES

3.4.1 SHELTERING

The first question of this subset, was about sheltering in place. Most of the respondents related it with staying indoors: “They leave you in a closed place” (Interview 10) or “When there is a radiation leak you have to be at home and be informed until you can leave” (Interview 12). We also found out some allusions to underground sites, bunkers or similar places: “Get into a bunker. It would be like getting a lot of people into a bunker for a while until the radiation is checked” (Interview 11). The descriptions that came out were short and not so detailed.

When we asked what they would do in case that sheltering in place is advised by the local authorities, some ideas came out:

- Closing the windows
- Lowering the blinds
- Isolating air conditioners
- Isolating doors with wet towels.
- Seeking out information (on the radio, TV) and follow instructions.

We then asked participants for how long they would remain indoors. Participants were divided regarding how many days they could remain indoors. Some declared that they would not be able to remain indoors for more than one day whilst some declared that they would be able to remain indoors for a week or more. Those that stated they would not remain indoors

for more than one day explained that they would lack enough food and drink or that they would not tolerate it: “I would not bear it, I would have claustrophobia” (Interview 1). In general, participants did not feel prepared to stay indoors for a long time in terms of food and drink: “Scarcely. Nowadays there are supermarkets just around the corner. We do not store food at home” (Interview 12).

With regard to what they would do with their pets, those who have it, declared very firmly that they would shelter their pets with them: “I have three dogs. I would put them at home, inside the garage” (Interview 4); “I would take it with me. If I have to stay at home, at home. If I have to go outside, outside. I could not abandon it.” (Interview 8).

3.4.2 IODINE PROPHYLAXIS

Respondents had very little knowledge about iodine prophylaxis. They had a general idea that iodine tablets would protect them from radiation and they provide very limited descriptions when asked what the tablets are used for: “I think they would be specific for internal radiation” (Interview 3). Only one participant out of 15 referred to the specific health protection effects: “It seems to me that iodine... can it be to help the nervous system? I do not know specifically” (Interview 6).

A great deal of confusion was found regarding where to get iodine tablets in case of a nuclear emergency. There are two general ideas: those that would expect that someone would distribute the tablets through the houses (for instance, the police or the emergency services, with protective clothes) and those who thought that they would have to get the tablets outside (in pharmacies, in the health centre, or in the City Council).

Most of the respondents did not know when they should take the iodine tablets. Most of them responded that they do not know but they expect someone would explain it in case of an emergency: “They would give us instructions” (Interview 7). A general feeling of “as soon as possible” also came out: “I suppose when you have the news, at that moment, if not it won’t be useful” (Interview 10).

It is generally believed by respondents that everybody should take the iodine tablets: “I think that everyone who is affected by radiation must take it” (Interview 6). One participant (retired but having worked in the NPP) declared that these iodine tablets were only for NPP workers: “we had it inside the nuclear power plant. There are not for outside, not for the population” (Interview 4).

3.4.3 EVACUATION

Participants were familiar with the term “evacuation”. Different beliefs about where to go in case of evacuation came out. These beliefs can be divided into two cases:

- If the evacuation is led by authorities.
 - o Instructions will be given: “I suppose they would say it through the PA system... at least the direction we should take...” (Interview 5)

- It will depend on the plume and the direction of the wind: “I imagine that in the opposite direction where the danger is...” (Interview 7).
- There would be an assembly area in the town to bring together the population and start the evacuation. This assembly area is thought to be in the City Council or in the way out of the town. One of the interviewees give this complete explanation: “There would be some buses by the public administration. We would all be informed through the mobile phone, television or radio about the steps that we should follow. The assembly areas would be at the entrance of the village. There would be the army there indicating if you should go to Mora d’Ebre or to Barcelona. These would be the two ways of escaping” (Interview 7).
- If the evacuation is spontaneous:
 - People would drive as far as possible: “Of course, I know where I have to go. At least 200km away from where the NPP is located” (Interview 4).
 - Leaving to a second residence: “We would leave somewhere, but I do not know exactly where. I suppose where we had a house to live” (Interview 2).

Regarding what to take during an evacuation, three aspects were highlighted apart from the family members:

- Money, credit cards and documentation (for instance, ID card).
- Food and water.
- Clothes and blankets.

Some awareness existed regarding the fact that children would be evacuated from the school. A clear opposition came out from participants with children or grandchildren at school. They expressed that they would not follow these instructions and would go by themselves to pick up the children: “It would be myself who would go for my granddaughters at school” (Interview 4) or “No, honestly not. I could not leave my children in the hands of anyone” (Interview 6).

Most interviewees said they would use their car in case of evacuation. Nonetheless, some of them were aware that this could lead to traffic problems and believed that the evacuation would probably be done with buses in order to avoid this, mainly if evacuation is done by authorities.

Some participants were aware of the existence of zoning areas: “I suppose they would evacuate first the people who live in the most affected area. From the most affected by radiation to the least” (Interview 11).

In the same way as sheltering, those participants who have pets stated they will take their pets with them: “As well. All with me” (Interview 11); “The animals with me. That's why I would use my car” (Interview 12).

3.4.4 ACCOMMODATION AND CARE OF EVACUATED POPULATION

Limited knowledge existed among participants regarding the existence of shelters and the accommodation of evacuated population. Some participants referred to movies about technological or natural disasters to make sense of sheltering. One participant stated: “I cannot imagine it in a different way because I have neither information nor I have lived it. The only way I can imagine it is like in the movies” (Interview 9). Some participants explain that bunkers or sports halls will be prepared to accommodate people. Only one participant seems to be aware of the existence of a shelter: “Well, I think there was one in an area near Lleida” (Interview 15).

Participants were asked about how many people they think would be relocated and all agreed that it should be all the population in the village. Most of them specified that the tourists should also be considered: “It's very complicated because here it is not the same in winter than in summer. There is a lot of difference. In winter we are around 4.000 but in summer we can be the double” (Interview 3).

Only three participants gave a response regarding how long the relocation could last. These participants think that the duration of the relocation would depend on the contamination but could not give specific time periods.

3.4.5 DECONTAMINATION

Most of the participants knew very little about decontamination. Once again, a couple of them in fact state that the word refers them to science fiction films: “What you see in the movies... They go through these tunnels and they are poured with liquids to decontaminate them, but... no idea...” (Interview 11).

Only a couple of participants seemed to have better knowledge of how decontamination is done. Both differentiated between external and internal contamination. The following quote illustrates this knowledge: “If it is external contamination, first it is necessary to shower it with hot water, with soap and to rub well the areas where there is the contamination. When the contamination is inside, medical services should act” (Interview 6).

3.4.6 FOOD SAFETY MEASURES

In general, participants reported very vague ideas about food safety measures. They were aware about the contamination that a nuclear emergency can produce in food. Specifically, milk, vegetables and water were mentioned. Most of the interviewees declared that they would not eat food from the contaminated area. Only one participant stated that there will be no effects on food: “Well I think that in principle it would be edible as usual” (Interview 15).

3.5 COMPLIANCE OF GOVERNMENTAL INSTRUCTIONS

We also asked participants if they would follow the instructions by the authorities during a real nuclear accident. Most of participants reported not feeling prepared to follow instructions.

Some of them argued that in case of a real accident they would try to leave the area. The main concern was linked to the need to pick up children at school: “I would try to do it [follow instructions] but, as I am a father, it would be impossible for me. I would go to school to pick up my children. If both my children and my wife are with me, then I could stay at home” (Interview 6).

Other participants stated that they were not sure about what they should do in a real situation. Respondents think that the local population would not follow instructions: “I believe that 100% of the population would not do it, because of fear or ignorance” (Interview 7). Others were also concerned about the consequences of spontaneous evacuation: “if we all went out at the same time, will not be good...” (Interview 14).

We found the following beliefs regarding the potential compliance of official instructions by the local residents:

1. “People will not react as predicted”. Respondents believe that it is not the same what they think they would do in the case of an accident (intended behaviour) than what they would really do in a real accident (real behaviour): “You do not know how you'll end up reacting” (Interview 1).
2. “It is better for all to follow instructions”: “In the end, instructions are set to follow them. If people do not follow, for instance, an evacuation; then the evacuation will not help. I think it would be riskier not complying with instructions” (Interview 7).
3. “Being informed in advanced would make compliance with instruction easier”. Previous information, such as brochures. Because you can read it. If you tell me: stay home, you don't know anything... But if you know what the protocol is and what you have to follow and how it works... maybe you're quieter” (Interview 13).

Generally, reactions from the participants to authorities' instructions can be categorized in the three following responses:

- Some participants state that they would leave the area and go as far as possible with their car, and they will not follow any instruction: “If there was an emergency, I would run away and I would forget the assembly areas and everything else...” (Interview 15).
- Other participants admit they would follow instructions without any doubt. One participant clearly admit that the main reason is because “we do not know what do in that case” (Interview 2).
- A third group of participants' state that they will follow instructions under some conditions:
 - o If their family is with them
 - o If they can keep calm and do not panic
 - o If instructions seem logic
 - o If they trust the information sources

3.6 INFORMATION ISSUES

Participants generally perceived that they are not properly informed regarding what to do in case of a nuclear emergency. Participants claimed for more information in order to be better prepared. Some of the interviewees stated that some information meetings have been organized at the City Council: “They do not stop informing the people. But if the people do not attend to these meetings, it is not the fault of neither the NPP managers nor the City Council. It's people's fault, our fault” (Interview 1). But most of the interviewees did not agree with this: “Well, I think there is very little information. Maybe they do not say anything not to worry people, but I think there should be a bit more information” (Interview 3) or “There have been drills but none about outside evacuation, never. At least during the period that I have been living here [28 years living there]” (Interview 10) or “That is what it is lacking, to have written information that says if this happens you have to follow this protocol” (Interview 11).

Interviewees believed that, in case of an emergency, they would get information mainly from the City Council, the Regional Government, the NPP, and the emergency services (especially firefighters). The channels that participants would rely on are:

- Public Address System. It is the most cited channel. It seems that the population is really aware of this channel. Only one participant complain about this system: “But I have never heard the PA system saying that something has happened at the NPP. I mean... probably because so far nothing important has happened for that. But I’m not sure if it would be effective to use it... It sounds very bad” (Interview 8). Interestingly, there is no apparent association between this channel and the City Council or any other public authority.
- Mass media: television and radio.
- Internet.
- Telephone (mainly mobile phone).
- Family members or acquaintances working in the NPP.
- Neighbours.

Participants generally perceived that during the emergency information should be updated continuously; that is, every time there was a significant change. One participant stated that too much information could be counter-productive: “It should be constant information, but not harping on the same because it will make the situation even more difficult” (Interview 7).

Regarding where to check information, three main sources were mentioned: the City Council (“I suppose the City Council. Yes, I would call them”, Interview 2), Civil Protection or Police (“Well, it is very difficult to say it... I’m not sure whether if Civil Protection, the City Council or the Municipal Police... would we have access to them at that time? Because everything could be collapsed... It is very difficult. But, yes, I think I would call the

Municipal Police”, Interview 3), and mass media (“I suppose the press and television, I suppose they would tell us what's going on, right?” (Interview 5).

A special mention was made during a situation of lack of electricity: some participants reported they would use a battery-operated radio while others would try to inform through the neighbours: “It's complicated because without a telephone and without electricity... with a battery-operated radio, little else. We would have to go back to the time of the blackout and use word of mouth” (Interview 6) or “I would try to contrast information with someone, with neighbours, with the well-known people” (Interview 10). A feeling of defencelessness is expressed when participants imagine a situation without electricity and telephone: “If there is no electricity, I would be waiting. Only waiting. There is no other option” (Interview 11).

Participants clearly state that the information should be provided at least in three languages: Catalan, Spanish and English, because it is a municipality that receives a lot of tourism, especially in summer. Some participants declared there are a lot of people from France and Germany, so it would probably be needed to provide the information also in French and German: “Catalan, Spanish, English and French. This is a tourist area, so mainly Catalan and Spanish but also in English, French and probably German” (Interview 6).

3.7 TRUST

We asked participants who they would trust in case of a nuclear emergency. Some of the interviewees declared they would not trust neither NPP managers nor authorities. The main reason they give is that there is an important lack of information from the NPP managers to the population. One of the interviewees illustrated this believe in the following quote: “There is a lot of secrecy. You do not know anything. You find out that something has happened once the time has passed or through the environmentalist groups. They are the only ones who take things out, but of course not the NPP managers. Only if it is very serious” (Interview 13) or “If we have to rely on politicians, badly” (Interview 15).

Others stated they trust NPP managers. The main reasons they gave are: there is a lot of safety, they are ready to manage a nuclear emergency and they care about people’s health: “There is a lot of safety” (Interview 9), “Yes, I trust because I have realized that when there is a small leak or any other risk the NPP is stopped” (Interview 3) or “When the accident happened in Unit 1 they showed that they were prepared, because there was no risk for the population” (Interview 2).

A third group of participants declared they would trust other institutions or organizations, such as:

- Emergency services, for instance Civil Protection, Police or Firefighters. “I trust local police, firemen... any emergency service” (Interview 7).
- Mass media (TV or Internet).

3.8 MENTAL MODEL MAP

Figure 2 summarizes the mental model map depicting lay understanding of measures to manage nuclear emergency situations among the Spanish lay public. This map illustrates how lay people in our study understand nuclear emergency and its related emergency plans. It describes their beliefs about what a nuclear accident could be as well as their understanding of the emergency plans: their knowledge about the main components (channels, actors, and measures) and their beliefs about the protective measures.

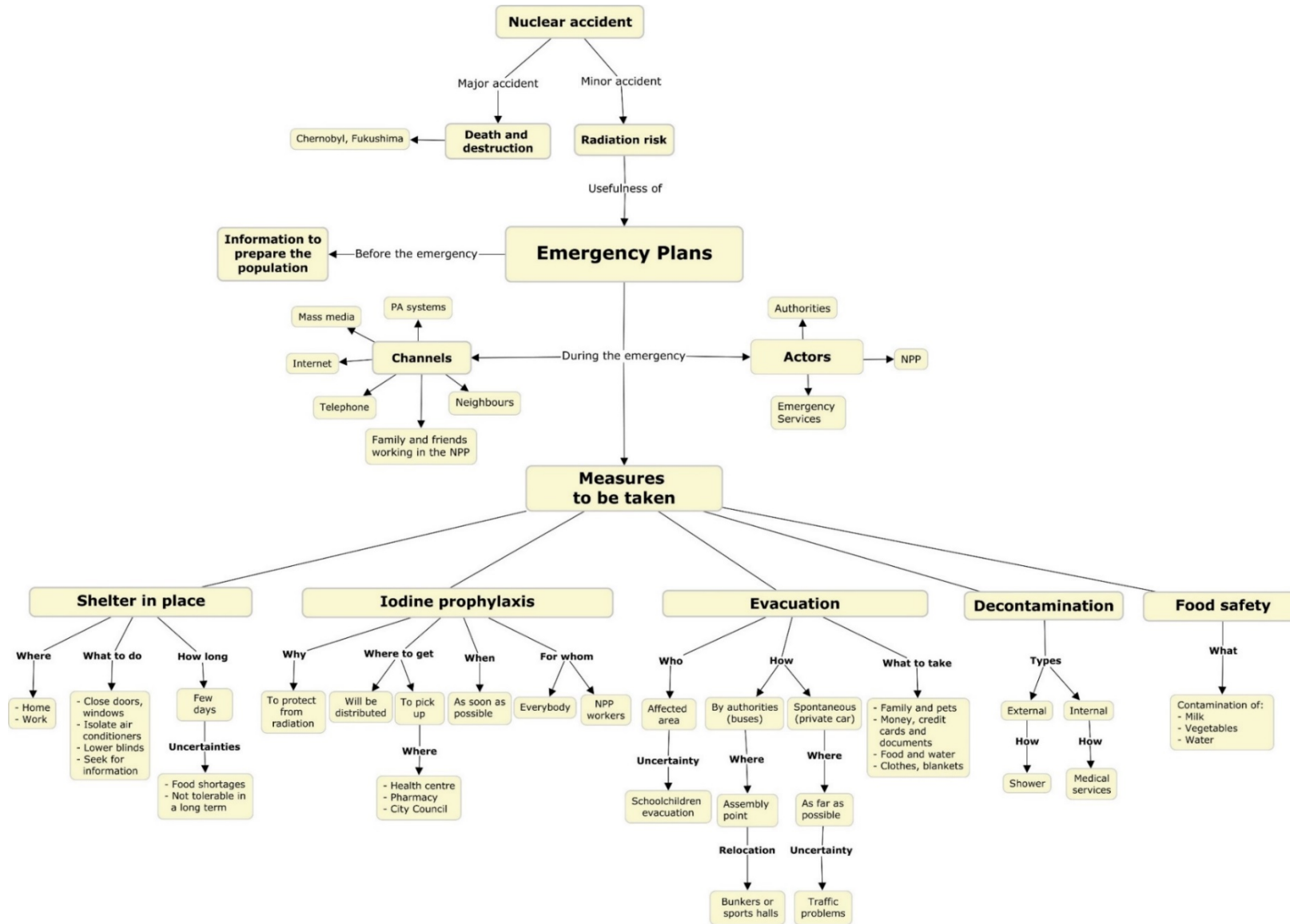


Figure 2. Mental model map

4 SUMMARY OF FINDINGS

To sum up, our study suggests that participants have a general idea of the basic elements of EP&R plan, but only a vague understanding of each of the specific protective measure.

Interestingly, interviewees differentiate two possible situations: a major accident and a minor accident. In case of a major accident, participants tend to report fatalistic beliefs regarding the probability of survival. They imagine a scenario of death and devastation and they do not see the utility of an EP&R plan in that situation. In case of a minor accident, they believe it will be risk of radiation and the emergency plan would be useful. The memory of big major nuclear accidents in Fukushima and Chernobyl is still present and it influences the models people have in relation to a nuclear accident. Nevertheless, a low level of risk perception existed among the interviewees. Participants stated that they were not really worried about nuclear or radiological accidents.

Participants refer spontaneously to some of the measures considered in the interview protocol such as sirens, the Public Address system, or evacuation. When asked about sheltering, interviewees think they would be confined indoors (for instance, at home or at work) and they would have to be there for many days. Some related protective measures such as to close doors and windows or to isolate air conditioners were also mentioned. The main concern reported by participants is whether they would have enough food and drink.

Regarding evacuation, participants differentiate between evacuation led by authorities and spontaneous or private evacuation. Regarding an evacuation led by the authorities, participants believe that coaches would be used to take persons to the assembly areas. Participants think the evacuation would affect the whole village. They would take with them mainly money, credit cards and documentation, food and water, and clothes; and, of course, their family and pets. The evacuation of schoolchildren is mentioned as an important uncertainty. Participants imagine they would be confined in bunkers or in sports halls, but they are unsure about this.

In general, participants have very little knowledge about iodine prophylaxis and they do not know what the tablets are used for. An important uncertainty is where to get iodine tablets in case of a nuclear emergency. In the same sense, interviewees have a poor understanding of decontamination. Few participants related it with having a shower if the contamination is external or with the need of medical care if the contamination is internal. Participants believe that milk, vegetables and water would be affected in case of accident but they do not have any idea of what food safety measures will be taken.

Overall, there is a clear awareness among participants that in case of an accident it would be better to comply with governmental instructions but it co-exists a belief that people would not necessarily comply the instructions by the authorities. Main

uncertainties mentioned will be what to do, where to go, and how would they be informed about the recommended measures.

People believe that there is no sufficient and relevant available information for the population and that the NPP managers and the responsible authorities poorly communicate with public. Some actors are mentioned as reliable sources of information during an emergency: NPP managers, authorities (both local and regional) and the emergency services (Police, Fire Department, and Civil Protection). Also some channels are mentioned: sirens and PA system, mass media, Internet, telephone, neighbours, and family and friends working in the NPP. It is important to highlight that people expect to be informed by the PA system but there is no reference of who is informing through it.

Findings highlight that information regarding the EP&R plans need to be intensified. A public information campaign should include the development of information material (like leaflets, Q&A, etc.) and other outreach activities. Likewise, involvement of local authorities shall be considered in order to increase the impact of these campaigns at the local level. Besides, tailored information campaigns to the local communities need to be assessed in order to evaluate their efficacy. This could help professionals to adjust their practices in the domain of public information and communication about emergency preparedness.

5 REFERENCES

- Chung, W., & Yeung, I. M. H. (2013). Attitudes of hong kong residents toward the daya bay nuclear power plant. *Energy Policy*, 62(March 2011), 1172–1186. <https://doi.org/10.1016/j.enpol.2013.07.081>
- Consejo de Seguridad Nuclear. (2019). Off-site Nuclear Emergency Plans. Retrieved July 23, 2019, from <https://www.csn.es/en/planes-de-emergencia/nuclear-exterior-pen>
- Cutter, S., & Barnes, K. (1982). Evacuation behavior and Three Mile Island. *Disasters*, 6(2), 116–124.
- Flynn, C. B. (1979). *Three Mile Island Telephone Survey*. Retrieved from http://www.threemileisland.org/virtual_museum/march28_1979.html
- Gentner, D. (2002). Psychology of mental models. In *International encyclopedia of the social and behavioral sciences* (pp. 9683–9687).
- Gentner, D., & Stevens, A. L. (2014). *Mental models*. Psychology Press.
- Hämäläinen, R. P. (1991). Facts or values — how do parliamentarians and experts see nuclear power? *Energy Policy*, 19(5), 464–472. [https://doi.org/10.1016/0301-4215\(91\)90023-H](https://doi.org/10.1016/0301-4215(91)90023-H)
- Houts, P., Lindell, M., Hu, T., PD, C., Tokuhata, G., & Flynn, C. (1984). Protective Action Decision Model Applied to Evacuation During the Three Mile Island Crisis. *International Journal of Mass Emergencies and Disasters*, 2(1), 27–39.
- Johnson Jr, J. H., & Zeigler, D. J. (1983). Distinguishing Human Responses to Radiological Emergencies. *Economic Geography*, 59(4), 386–402.
- Jones, N., Ross, H., Lynam, T., Perez, P., & Leitch, A. (2011). *Mental models: an interdisciplinary synthesis of theory and methods Publication Details*. Retrieved from <http://ro.uow.edu.au/smartpapers/81>
- 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. <https://doi.org/10.1097/HP.0b013e31823abef2>
- Morgan, M. G., Fischhoff, B., Bostrom, A., & Atman, C. J. (2002). *Risk communication: A mental models approach*. Cambridge University Press.
- Perko, T. (2014). Radiation risk perception: a discrepancy between the experts and the general population. *Journal of Environmental Radioactivity*, 133, 86–91. <https://doi.org/10.1016/j.jenvrad.2013.04.005>

- Prince-Embury, S. (1989). A Comparison of Residents Who Moved Versus Those Who Remained Prior to Restart of Three Mile Island. *Article in Journal of Applied Social Psychology*, 959–975. <https://doi.org/10.1111/j.1559-1816.1989.tb01232.x>
- Purvis-Roberts, K. L., Werner, C. A., & Frank, I. (2007). Perceived Risks from Radiation and Nuclear Testing Near Semipalatinsk, Kazakhstan: A Comparison Between Physicians, Scientists, and the Public. *Risk Analysis*, 27(2). <https://doi.org/10.1111/j.1539-6924.2007.00882.x>
- Sjöberg, L. (2002). Risk communication between Experts and the Public: Perceptions and Intentions. *Questions de Communication*, (2), 19–35. <https://doi.org/10.4000/questionsdecommunication.7065>
- Sjöberg, L., & Drottz-Sjöberg, B. -M. (1991). Knowledge and Risk Perception Among Nuclear Power Plant Employees. *Risk Analysis*, 11(4), 607–618. <https://doi.org/10.1111/j.1539-6924.1991.tb00650.x>
- Skarlatidou, A., Cheng, T., & Haklay, M. (2012). What Do Lay People Want to Know About the Disposal of Nuclear Waste? A Mental Model Approach to the Design and Development of an Online Risk Communication. *Risk Analysis*, 32(9). <https://doi.org/10.1111/j.1539-6924.2011.01773.x>
- Železnik, N., Constantin, M., Schneider, N., Mays, C., Zakrzewska, G., & Diaconu, D. (2016). Lay public mental models of ionizing radiation: representations and risk perception in four European countries. *Journal of Radiological Protection*, 36, 102–121. <https://doi.org/10.1088/0952-4746/36/2/S102>

6 ANNEX. PROTOCOL OF INTERVIEWS

QUESTION	OBSERVATIONS AND RECORDS
Section 1 – Warming up questions	
<ul style="list-style-type: none"> - Do you know what an off-site nuclear emergency plan is? - From where you have such knowledge? 	<u>Discuss and use IAEA definition</u>
Section 2 – Mental models of emergency management and related uncertainties	
<u>EP&R plan and risks</u>	
<p><u>Basic elements of an EP&R plan</u></p> <ul style="list-style-type: none"> - What should be the content of an off-site nuclear emergency plan according to your understanding? - What are the main uncertainties that can come in the population? - Where the main disagreements would come from? 	<u>Discuss</u>
<p><u>Past emergencies</u></p> <ul style="list-style-type: none"> - Do you remember any radiological or nuclear emergency that has occurred? - Do you remember Fukushima and Chernobyl accidents? - What do you remember about them? What were the consequences? - Are you worried that a similar accident could happen here? - To what extent have these accidents influenced your knowledge and your perception of radiation? 	<u>Discuss</u>
<p><u>Risks</u></p> <ul style="list-style-type: none"> - What you think it could happen during radiological or nuclear accident? - What kind of risks do you think the population should face? 	<u>Discuss</u>
<u>Understanding of measures</u>	
<ul style="list-style-type: none"> - Do you know what type of protective measures are foreseen in the event of a nuclear or radiological accident? - If he/she does not know: what do you imagine they can be? 	
<p><u>Sheltering</u></p> <ul style="list-style-type: none"> - Do you know what sheltering consists of? - What do you think you have to do during sheltering? - For how long time you would stay there? Why? - What would you eat and drink? (any limitation for water and food) - Do you have animals? What will you do with them? 	<u>Discuss</u>

QUESTION	OBSERVATIONS AND RECORDS
<p><u>Iodine prophylaxis</u></p> <ul style="list-style-type: none"> - What do you know about Iodine prophylaxis? (ingestion of potassium iodine tablets) - Do you know why are the tablet used for? - Do you know where to get them? - Who need to take them? - When you would take them? - What about animals? 	<p><u>Discuss</u></p>
<p><u>Evacuation</u></p> <ul style="list-style-type: none"> - What do you know about evacuation? - Do you know when and where to go? - Do you know what you should take from home? - Who will take kids? (in case they are in school/kinder garden) - What will you use for transport? - What to do with animals? 	<p><u>Discuss</u></p>
<p><u>Accommodation and care of evacuated population</u></p> <ul style="list-style-type: none"> - Do you know where they would take the population in case of evacuation? - How many people would be relocated? - Who will cover the costs? - How long the relocation could last? 	<p><u>Discuss</u></p>
<p><u>Decontamination of people, animals and equipment</u></p> <ul style="list-style-type: none"> - Do you know what the decontamination is? - Do you know how is it done? - How to treat irradiated persons? 	<p><u>Discuss</u></p>
<p><u>Food safety measures</u></p> <ul style="list-style-type: none"> - Do you know what the food safety measures are? - How is it done? - Do you know what is controlled? - What about the animals? - How long it is performed. 	<p><u>Discuss</u></p>

QUESTION	OBSERVATIONS AND RECORDS
<u>Information and trust</u>	
<ul style="list-style-type: none"> - From whom or from where would you get the information in case of declaring a nuclear emergency? - Would you follow the instructions? 	<u>Discuss</u>
<ul style="list-style-type: none"> - How often the information should be updated to the population. 	<u>Discuss</u>
<ul style="list-style-type: none"> - Where you would check the information? - What would you do if there would be no electricity and no telephone option? 	<u>Discuss</u>
<ul style="list-style-type: none"> - Whom would you trust? 	<u>Discuss</u>
<ul style="list-style-type: none"> - What languages the information should be provided 	<u>Discuss</u>
Section 3 – Socio-demographic data	
<ul style="list-style-type: none"> - Age - Gender - Education - Profession - Place of residence 	

