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How would citizens react to official advice in a nuclear emergency? Insights from research in three European countries

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Abstract

Nuclear emergencies confront decision-makers, emergency actors and publics with several challenges, many of which are related to social, ethical and communication aspects. Based on empirical data from three European countries, this paper investigates citizens' potential behaviour in an emergency situation. It analyses relationships between self-assessed compliance with protective actions and a number of variables, including knowledge about protective actions, trustworthiness of communicators, perceived social norm (expectation of other residents' behaviour), perceived effectiveness and perceived difficulty of protective actions. Results suggest that most respondents expect to follow actions advised by authorities, except for leaving children at school or avoiding the use of phones. Moreover, large fractions of local and wider publics may seek to avoid risks by rejecting food produced in affected areas even when it satisfies legal norms or taking iodine tablets when not needed. Self-assessed compliance with protective actions is positively correlated with perceived social norm, perceived effectiveness and compliance with other actions; and negatively correlated with perceived difficulty. Higher trust in the regulator is associated with higher compliance with some actions, but mostly among the local populations. We argue that clarifying and anticipating societal concerns contributes to enhancing societal resilience and the response to nuclear accidents.

KEYWORDS

behaviour, nuclear emergency, protective actions

1 | INTRODUCTION

Nuclear accidents confront scientific experts, safety authorities and publics with specific challenges, such as potentially large-scale, long-lasting environmental contamination, perceived asymmetry in the distribution of risks and benefits, disagreement between experts on what constitutes a safe level of radiation, differing appreciations of radiological risks by experts and affected populations and the potential for stigmatization of populations and goods in affected areas (Allen et al., 1996; FBPC, 2016; IAEA, 2006; Oughton et al., 2018; Perko, 2014; Slovic, Fischhoff, & Lichtenstein, 1982; Tateno & Yokoyama, 2013). This may lead to inappropriate public response,

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citizens' anxiety and distrust in emergency management, the government, the safety regulators and the experts, and hamper the environmental, social and economic reconstruction of affected areas.

As noted by Burns and Slovic (2012), Eiser et al., (2012), Perry and Lindell (2003) and others, society's vulnerability to disasters is not only determined by their magnitude or unpredictability, but also the manner in which people and institutions respond to these events. To this end, nuclear emergency plans are currently set up at national, regional or local level to prepare the response and help mitigate the impacts.

However, the setup of emergency plans may in turn introduce vulnerabilities, as certain assumptions underlying decision-making (e.g., people's reactions to an accident situation) may not be valid in practice. Identifying and acknowledging these vulnerabilities, particularly those of social nature, may contribute to enhancing societal resilience and stimulating creative thinking on new strategies to cope with a hazard (Bijker, Hommels, & Mesman, 2014: 23; Rossignol, Turcanu, Fallon, & Zwetkoff, 2017).

Literature studies addressing social vulnerability identified factors characterizing population groups that are more at risk in emergency or disaster situations, such as socio-economic status, gender, age or belonging to cultural/ethnical minorities (Lemyre, Gibson, Zlepnig, Meyer-Macleod, & Boutette, 2009; Morrow, 1999). Metrics have been developed to highlight temporal and spatial variations on social vulnerability maps (Cutter & Finch, 2008; Flanagan, Gregory, Hallisey, Heitgerd, & Lewis, 2011).

Furthermore, literature in the field of disaster research investigated public behaviours in disaster situations (see Ejeta, Ardalan, & Paton, 2015, for a review). A relatively limited number of studies have also addressed citizens' actual or expected compliance with protective actions in nuclear accident situations and the potentially influencing factors (e.g., Crépey, Pivette, & Bar-Hen, 2013; Cutter & Barnes, 1982; Hasegawa, Ohira, Maeda, Yasumura, & Tanigawa, 2016; Houts et al., 1984; Malešič, Prezelj, Juvan, Polič, & Uhan, 2015; Verbeeck, Bergmans, & Cools, 2017). However, such studies remain sparse, particularly in Europe where there is no systematic research carried out with representative samples of the population. Understanding citizens' potential behaviour intentions should reduce uncertainties regarding the effectiveness of nuclear emergency measures (Giordano, 2005; Malešič et al., 2015) and enable emergency actors to anticipate and address the problem of potential sub-optimal decisions from members of the public. Some studies suggest a "significant degree of correspondence between behavioural expectations and much later behaviour" in an emergency situation in the context of natural disasters (Kang, Lindell, & Prater, 2007: 887; Huang, Lindell, & Prater, 2016). This indicates that information on potential behaviours of different publics is valuable for planning purposes, not least because it gives indications of things that could go wrong in a real emergency and thus deserve attention. Other studies highlighted discrepancies between behaviour in a real emergency and hypothetical responses (Prater, Wenger, & Grady, 2000 compared to Ruch & Schumann, 1997, in Kang et al., 2007), possibly due to different information processing modes, for example heuristic instead of systematic (Chaiken, 1980, and subsequent studies). Rather than providing very accurate predictions of actual behaviour, these studies can highlight potential gaps between experts' expectations and public behaviour, distinguish factors influencing behaviour and identify possible new stakeholders (e.g., parents hesitating to leave children at school) that should be included in discussions and decisions about emergency plans.

While some findings may be common to both natural disasters and nuclear or chemical accidents, there are important differences in the psychological characteristics of related risks, the perceived effectiveness of protective actions and the hazard impact characteristics (e.g., natural versus. anthropogenic risk, immediate vs. delayed effects, familiar vs. unfamiliar risk, equal vs. unequal distribution of risk and benefits, catastrophic potential, controllability, dread) (Baan & Klijn, 2004; Sjöberg, 2000; Slovic et al., 1982). Already in the 1980s, Johnson and Zeigler (1983) argued that nuclear emergencies are likely to give rise to more extreme behaviour than other types of emergencies, due to a high degree of fear of nuclear power and distrust in nuclear risk governance. Furthermore, although some studies did not observe large differences (Lindell, 1994; Lindell & Barnes, 1986), the effect of specific predictor variables may differ in a natural, compared to a technological hazard context (e.g., Houts et al., 1984; Johnson, 1985). This warrants specific attention to the specific context of nuclear emergencies.

Based on empirical data from three European countries, this paper investigates self-assessed compliance with protective actions in the event of a nuclear emergency. By self-assessed compliance, we refer to citizens' own assessment on whether they would or would not follow the recommended actions in the event of a nuclear accident. This is particularly relevant since decision-making under conditions of uncertainty is influenced by people's interpretation of risks, which in turn, is "shaped by their own experience, personal feelings and values, cultural beliefs and inter-personal and societal dynamics" (Eiser et al., 2012: 5). Furthermore, the study seeks to clarify the associations between compliance with official advice and a number of variables, including nuclear risk perception, self-assessed knowledge about protective actions, trust in the nuclear regulator, perceived social norm, perceived effectiveness and perceived difficulty of carrying out the actions. Section 2 summarizes findings from previous nuclear accidents, notably the Fukushima disaster, and other literature on disaster management with a focus on behaviour concerning health-related issues. Drawing on these, we formulate the hypotheses of our study. Section 3 describes the methodology, whereas subsequent sections report on the results obtained and discuss the findings in light of existing literature.

Data underlying the study originate from large-scale national surveys in Belgium, Spain and Norway. Additional samples of people living in the vicinity of nuclear installations have been taken in Belgium and Spain, to compare and contrast the behaviour and concerns of the general public and the local populations. The three countries face or have faced different nuclear risks. Belgium has seven nuclear reactors in two sites, which will be in operation until 2025,

whereas Spain has seven nuclear reactors in five sites, which will be progressively closed from 2027 to 2035. Norway does not have nuclear power plants, but has two nuclear research facilities and has previously been severely affected by the Chernobyl accident (Liland, Lochard, & Skuterud, 2009; Liland & Skuterud, 2013). This selection of countries in the study allows us to identify differences as regards the potential behaviour in nuclear emergency situations in countries with different nuclear and radiological hazards.

2 | POTENTIAL BEHAVIOUR IN NUCLEAR EMERGENCIES: INSIGHTS FROM THE LITERATURE

The Fukushima accident highlighted several challenges in the public response to a nuclear accident and the communication of protective actions during and after the accident (Callen & McKenna, 2018; Crépey et al., 2013; Hasegawa et al., 2016; Hobson, 2015; Kanda, Tsuji, & Yonehara, 2012; NAIIC, 2012; NAIIC, 2012; Yasumura, 2014). Examples include over-protective behaviours (e.g., unnecessary evacuation or intake of iodine, boycott of products), non-compliance with official advice (e.g., not to consume salt in order to get iodine) and elevated public concern about health effects due to the accident (e.g., concern about how the contamination from the accident will affect children's health, including thyroid abnormalities). Communication with the public was criticized for lacking of transparency and timeliness, overloading the public with details, containing factually incorrect or unclear information (e.g., use of a variety of units and technical terms) and failing in communicating uncertainties related to the health effects of radiation (e.g., effects of low radiation doses).

Research on natural disasters identified key factors increasing response to warning messages in disaster situations, such as the presence of physical or social cues, knowledge about the hazard, level of education, family size, community involvement, socio-economic status, being female versus male, having children, personal warning versus impersonal and proximity to threat (see Sorensen, 2000, for a synthesis). Opposite to this, fatalistic beliefs, membership of ethnic minorities and time to impact were found to be negatively correlated with response to warning messages. Studies relating to actual or intended behaviour in a nuclear accident situation also confirmed that proximity to the installation, perceived severity and susceptibility (e.g., households having children under 6 years old or a pregnant woman) are significant determinants of evacuation behaviour (Houts et al., 1984; Johnson & Zeigler, 1983).

Health behaviour models such as the Protection Motivation (Rogers, 1983), the Protective Action Decision Model (Lindell & Perry, 2012) or the Theory of Planned behaviour (Ajzen, 1991, 2002) provide theoretical frameworks explaining actual or planned behaviour in response to health threats. These models suggest several factors underlying individual decisions in response to imminent or long-term threats: threat perceptions (of the hazards and its consequences), protective action perceptions (e.g., self-efficacy or coping appraisal; task demands; protective effectiveness) and stakeholder perceptions (e.g., own or other stakeholders' expertise, trustworthiness, responsibility or knowledge about the hazard).

Threat perceptions relate to the hazard characteristics, such as likelihood of a major event or likelihood of prevention; expected personal consequences (e.g., of health or economic nature); impact (e.g., duration of the event); and affective and behavioural reactions (e.g., dread). Higher threat or risk perception should increase compliance with protective actions or the recommended level of preparedness (Bakker, van Bommel, Kerstholt, & Giebels, 2018; Lindell et al., 2016; Sun & Xue, 2020; Wang et al., 2018). However, this is not always the case, leading to the "risk perception paradox" (Wachinger, Renn, Begg, & Kuhlicke, 2013). In the particular case of nuclear accidents, higher risk perception may lead to adoption of actions contradicting official advice, such as unnecessary evacuation (Johnson & Zeigler's, 1983) or intake of stable iodine when not recommended (Crépey et al., 2013). Based on this, we formulated the following hypotheses:

Hypothesis 1a *Risk perception of an accident in a nuclear power plant is positively related to self-assessed compliance with protective actions*

Hypothesis 1b *Higher risk perception is associated with higher intention to reject food with residual radioactivity, take iodine tablets when not recommended or evacuate when advised to stay inside*

Lindell et al. (2016) suggest that perception of protective actions is influenced by their *hazard-related attributes* (e.g., perceived protective effectiveness) and *resource-related attributes* (e.g., required time, skill, knowledge, effort or collaboration with others). *Protective effectiveness* was highlighted as the strongest or one of the strongest correlates of potential compliance with recommended actions, for instance in relation to fire protection or the management options for contaminated water (Bakker et al., 2018; Lindell et al., 2016). Therefore, we tested the following hypothesis:

Hypothesis 2 *Perceived effectiveness of protective actions is positively related to self-assessed compliance with protective actions*

A particular resource-related attribute is *self-efficacy* or coping appraisal, that is own capacity to cope with the hazard and reduce the risk. Higher self-efficacy (measured as confidence in own ability to manage an emergency) was found to be positively correlated with the emergency preparedness level (Paek, Hilyard, Freimuth, Barge, & Mindlin, 2010) or the likelihood of applying protective actions in the context of a hypothetical fire hazard (Bakker et al., 2018, one of the two studies described in the paper). A number of studies addressed the interactions between hazard perception and coping appraisal. Lindell et al. (2016) argue that, provided they have access to the needed critical resources, "people prefer to implement protective actions that are highest on hazard-related attributes and lowest on resource-related attributes" (Lindell et al., 2016: 3). Connected to that, de Boer Wouter, Botzen, & Terpstra (2015) suggest that protective behaviours are favoured when both threat and coping appraisal

are high. Opposite to this, a high threat appraisal combined with a low coping appraisal could lead to a non-protective response (Bakker et al., 2018; Mertens et al., 2018). Drawing on this, the following hypothesis was formulated:

Hypothesis 3 *Perceived difficulty of performing an emergency action is negatively related to self-assessed compliance*

Perceived social norm referring to an individual's perception of specific referent groups' behaviour in a similar situation can also be strongly associated with planned health behaviour (Chassin, Presson, Sherman, Corty, & Olshavsky, 1984). Actions of friends and neighbours predicted for instance evacuation behaviour in the case of the Three Mile Island accident in 1979 (Cutter & Barnes, 1982). More recently, Bakker et al. (2018) show that supporting reactions to official advice from other citizens may lead to higher intentions to perform behaviours aimed at preventing the negative consequences of a crisis, compared to opposing reactions. Therefore, we expected that:

Hypothesis 4 *Perceived social norm is positively associated with self-assessed compliance with protective actions*

Lower *knowledge* about protective actions was also found to be associated with lower likelihood to cooperate with protective instructions in a dirty bomb situation (Lasker, 2004). Additionally, specific knowledge was shown to have an important role in facilitating the reception of nuclear emergency preparedness communication (Perko, Thijssen, Turcanu, & Van Gorp, 2014; Perko, Van Gorp, Turcanu, Thijssen, & Carle, 2013), but to be less influential for the acceptance of protective actions (Perko et al., 2014). Consequently,

Hypothesis 5 *The level of self-assessed knowledge about protective actions in case of an emergency is positively related to self-assessed compliance with emergency actions*

Although *trust* is defined in different ways (Arlikatti, Lindell, & Prater, 2007), it has been recognized as a multidimensional concept which includes, among others, perceived competence, objectivity, fairness, consistency, sincerity, faith, trustworthiness, commitment, caring, transparency, public interest, honesty, empathy and social trust (Earle & Siegrist, 2006; Perko et al., 2013; Poortinga & Pidgeon, 2003; Renn, 2005; Siegrist, Cvetkovich, & Roth, 2000). Earlier research has identified trust as one of the key indicators for the acceptance of nuclear risks (Ibitayo & Pijawka, 1999; Sjöberg, 2004; Slovic, Flynn, & Layman, 1991) and nuclear risk messages (Perko, Zeleznik, Turcanu, & Thijssen, 2012). In our study, we explored trust expressed as confidence in the nuclear safety authorities to provide correct and objective information and whether it is associated with higher expected compliance with recommended actions. In the presence of uncertainty, people rely on others (experts, authorities, peers) for information, and the quality of these relationships influences how they deal with uncertainty (Eiser et al., 2012). Terpstra (2011) argues that a higher level of trust reduces citizens' perceptions of flood likelihood and the dread of related risk, which in turn reduces their flood preparedness intentions. Opposite to this, higher trust in official instructions or warnings was positively associated with the likelihood to follow official advice in biological and radiological hazard situations (Lasker, 2004) and with the protective action intentions following flash flood warnings (Morss, Mulder, Lazo, & Demuth, 2016). In the present study, we tested that:

Hypothesis 6 *Higher trust in nuclear safety authorities is associated with higher self-assessed compliance with recommended actions*

Concerning the effect of socio-demographic variables, evidence regarding the influence of age is mixed (Sorensen, 2000). The review of Wachinger et al. (2013: 1049) concludes that cultural and individual factors (e.g., age, gender, education, income, social status) "act as mediators or amplifiers of the causal connections between experience, trust, perception, and preparedness to take protective actions". Johnson and Zeigler (1983) found that *age* and *risk perception* discriminated between three types of behaviours in nuclear emergencies: follow orders (primarily younger individuals, who are sufficiently concerned about the dangers of nuclear power to follow instructions), under-reaction (primarily older individuals living close to the installation and having lower nuclear risk perception than the rest of the population) and over-reaction (primarily middle-age individuals with higher risk perception than the other two groups).

Another study in the United States (Giordano, 2005) found that gender, age, education, presence of children in the household, household income and working at the nuclear installation are not decisive in explaining respondents' expected reactions to an emergency. This study suggests nevertheless, concurrent with Sorensen's review (2000), that *women* are slightly more likely to follow the emergency directives. Additionally, Perko et al. (2014) found that women and respondents with primary education from the general public accepted communicated messages after an accidental release of radioiodine more than men and respondents with higher education level; however, these relationships were not significant among the *local population*.

Drawing on the above findings, the final research hypotheses of our study were formulated as follows:

Hypothesis 7 *Women and respondents with higher level of education have higher levels of self-assessed compliance with protective actions, than men and respondents with lower education levels*

Hypothesis 8 *The strength of association between socio-demographic variables (gender, education and age) and self-assessed compliance is lower in the local populations compared to the general public*

3 | METHOD

Surveys in three countries (Belgium, Norway and Spain) were used to assess potential behaviours in case of a nuclear accident,

self-assessed knowledge about protective actions and trust in emergency communicators. Additionally, in Belgium and Spain the aforementioned hypotheses were tested in the general and local populations (people living in predefined emergency zones). The determination of the areas corresponding to the "local population" in Belgium and Spain was done on the basis of areas foreseen for the implementation of emergency actions in national nuclear emergency plans.

3.1 | Data collection

In Belgium, data were collected using computer-assisted personal interviews, from November 2017 to February 2018 for the national sample and September 2017 to January 2018 for the local population sample. The national sample is representative for Belgian adults older than 18 years 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 in private households within 20 km around the nuclear installations of Tihange (156 respondents) and Doel (159 respondents). This radius corresponds to the area of preventive distribution of iodine tablets at the time of the survey (currently extended to 100 km).

In Spain, respondents older than 18 years were recruited from online panels. Data were collected in November 2017 and January 2018. A first sample of 302 participants was selected from residents living within 30 km from 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 protective 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 population living from 31 to 100 km around one of these power plants. This sample was stratified in two areas: 31–65 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.

In Norway, data collection was part of a national opinion survey on radiation protection issues. It 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. A representative, randomized sample of 1,000 persons was used, from adults of at least 18 years old. Due to different nuclear contexts, not all questions were applicable in Norway since it had only nuclear research installations, while Belgium and Spain have operational nuclear power plants at different locations in the country. For the same reason, only a sample of the general population was considered in Norway.

While the formulation of survey items in Norway was not identical to Belgium and Spain, the information provided is comparable, justifying the cross-country analysis.

Differences in data collection methods (face-to-face, telephone or online survey) are due to exogenous logistic constraints.

The socio-demographic characteristics of the samples in the three countries are summarized in Table 1.

3.2 | Survey items

The items included in each of the three national surveys are summarized in Table 2.

Self-assessed compliance with protective actions was measured as the likelihood of following a number of actions that authorities may advise in case of a nuclear accident. In Belgium and Spain, respondents

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

	Belgium		Spain		Norway
	National (N = 1,083), %	Local, <20 km (N = 315), %	National, 30–100 km nucl. inst. (N = 506), %	Local, <30 km nucl. Inst. (N = 302), %	National Norway (N = 1,000), %
Gender					
Men	47.9	50.5	52.6	41.1	50
Women	52.1	49.5	47.4	58.9	50
Age					
18–29 years	15.3	16.8	13.0	23.8	20.5
30–44 years	24.5	24.1	31.4	44.7	26
45–59 years	28.6	27.9	34.6	25.2	25.4
60+ years	31.6	31.1	20.9	6.3	28.1
Education level					
Primary or lower secondary	23.6	21	12.9	10.6	5.6
Higher secondary	36.6	40	47.4	48.7	27.7
Post-sec. or higher	39.8	39	39.7	40.7	66.7

TABLE 2 Survey items on potential behaviour in the three countries

	Belgian survey	Spanish survey	Norwegian survey
Self-assessed compliance with actions recommended by authorities			
Stay indoors or go indoors	√	√	√
Avoid the use of phone (landline and mobile);	√	√	N/A
Leave the children at school: only respondents with children;	Respondents with children aged 16 or less	Respondents with children aged 12 or less	N/A
Take an iodine tablet	√	√	Respondents younger than 40 y
Give stable iodine tablets to children	Respondents with children aged 16 or less	N/A	Respondents with children aged 18 or less
Not consuming local food products	√	√	√ ("follow dietary advice given by authorities")
Leave the affected area for few days as part of organized evacuation	Only local population	√	N/A
Not drinking tap water	√	√	N/A
Risk attitudes			
I would continue using local products if authorities say that radioactivity levels do not pose any health risks	√	N/A	N/A
I would respect the request to not leave the area, if advised to stay indoors	√	N/A	N/A
In case of a nuclear accident, I would take iodine tablets even if authorities say it is not necessary	√	N/A	N/A

could provide their answer using 6-point scale, with the following categories: "definitely not," "probably not," "maybe not," "maybe yes," "probably yes," "definitely yes" and "I don't know." In Norway, a 5-point scale was used, with categories "yes, definitely," "yes, probably," "no, probably not," "definitely not" and "not sure."

Additionally, specific *risk attitudes* were assessed in Belgium for: *consuming local products* when authorities say they do not pose health risks, *leaving the area when advised to stay indoors* and *taking an iodine tablet even when authorities say it is not necessary*. Response to these items was measured using the 6-point scale ranging from "definitely not" to "definitely yes."

Perceived effectiveness of protective actions (all actions except leaving children at school and avoiding the use of phone) was measured with the question: "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," through to "not much," "moderately," "quite a lot," "completely."

Perceived difficulty of carrying out an action was measured with the question: "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?". A 5-point answering scale was used, ranging from "very easy," through to "easy," "neither difficult, nor easy," "difficult," to "very difficult." For sheltering, timing was specified as one day.

Perceived social norm was measured with the question: "In your opinion, would people from your neighbourhood comply with this official advice?", with reference to the same protective actions. The answering scale was the 6-point scale ranging from "definitely not" to "definitely yes."

Knowledge about protective actions was measured as self-assessed level of information, through the question: "I feel well informed about what to do in case of a nuclear accident." The answering had the categories "strongly disagree," "disagree," "neither agree nor disagree,"

"agree," and "strongly agree." In Norway, respondents were asked to evaluate their knowledge of actions to protect oneself from radiation, with answers ranging from "very bad knowledge," through to "bad knowledge," "moderate knowledge," to "good knowledge," "very good knowledge" and "not sure."

Trust in emergency communicators was evaluated for various actors with the question: "to what extent do you trust the following actors to provide correct and objective information about the measures to protect yourself in case of a nuclear accident," with answers ranging from 1 = "no trust at all," through to 2 = "very little trust," 3 = "little trust," 4 = "some trust," 5 = "quite a lot of trust," to 6 = "complete trust." In Norway, respondents were asked who they would trust during a radiological/nuclear accident if there were contradictory and dissimilar information given from authorities, research institutions and environmental NGO's. In the Belgian national survey, a filter question was applied to filter out respondents who did not know the actor. In the Belgian local population sample and the Spanish samples, the answering category "I don't know the actor" was included as additional category.

Nuclear risk perception (Belgium and Spain) was measured with the question: "How do you evaluate the potential risk to your health in the next 20 years from an accident in a nuclear installation?" The answering scale included the following categories: "no risk at all," "very low," "low," "moderate," "high," and "very high."

All survey items in Belgium and Spain included the answering category "I don't know," whereas the survey items in Norway included the category "not sure."

4 | RESULTS

This section presents the main results of the research. First, we take a closer look at self-assessed compliance with emergency actions, followed by risk attitudes, perceived difficulty and perceived effectiveness of actions, self-assessed knowledge and trust in different communicators in the event of an emergency. Next, the associations (Spearman's rank correlation) are discussed between self-assessed compliance with emergency actions, on the one hand, and the aforementioned variables and the socio-demographic variables on the other hand. *t* tests and analysis of variance were conducted to gain additional insights into the potential role of socio-demographic variables.

For all analyses, each sample was treated separately (per country and per type of population: local or general population).

Last, the results are summarized from regression models conducted for the local populations in Belgium and Spain, with self-assessed compliance as dependent variable.

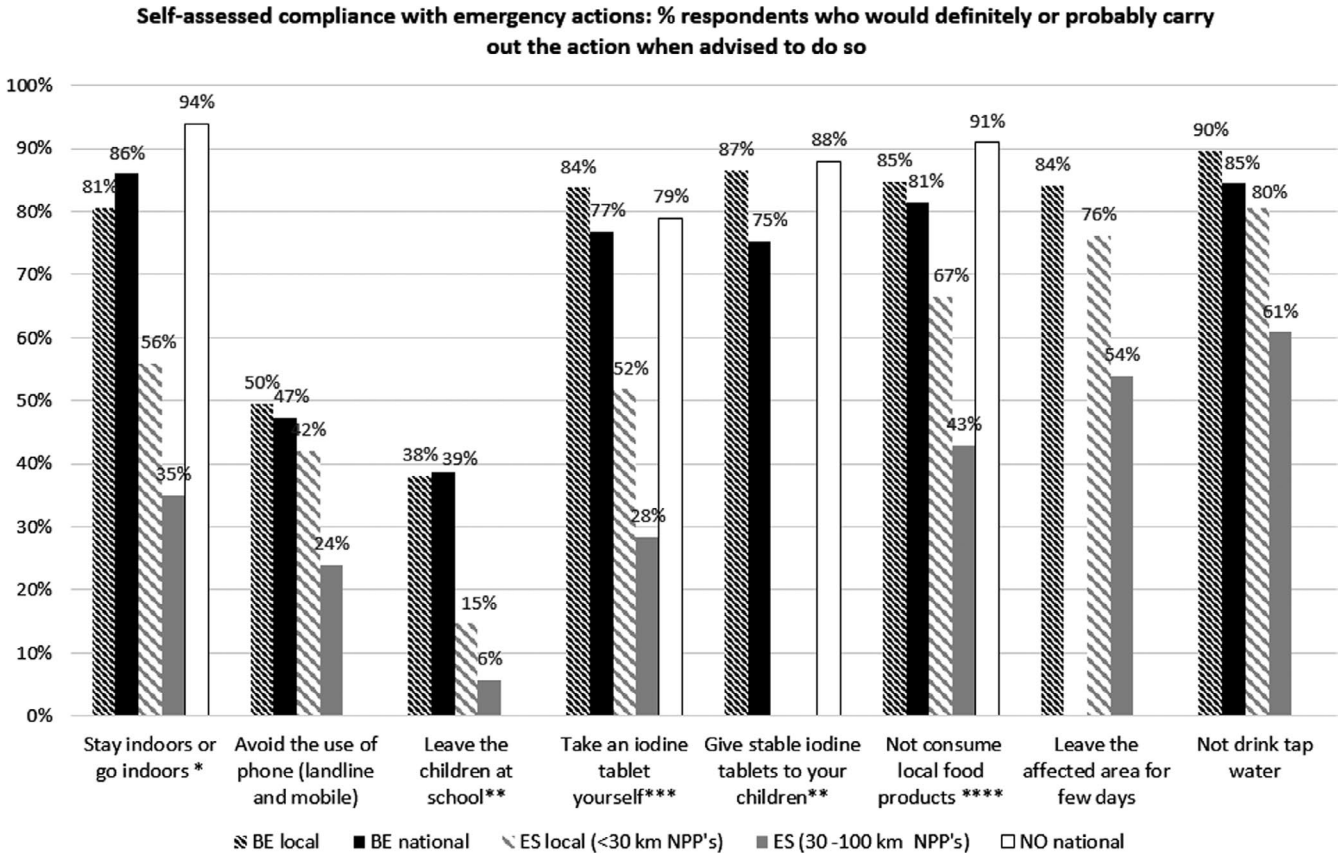

FIGURE 1 Self-assessed compliance with recommended actions. *Norway: Stay indoors for 2 days; **only respondents with children aged 16 years or younger (Belgium); 12 years or younger (Spain); 18 years or younger Norway; ***Norway: only respondents younger than 40 years old; ***Norway: follow the dietary advice given by authorities

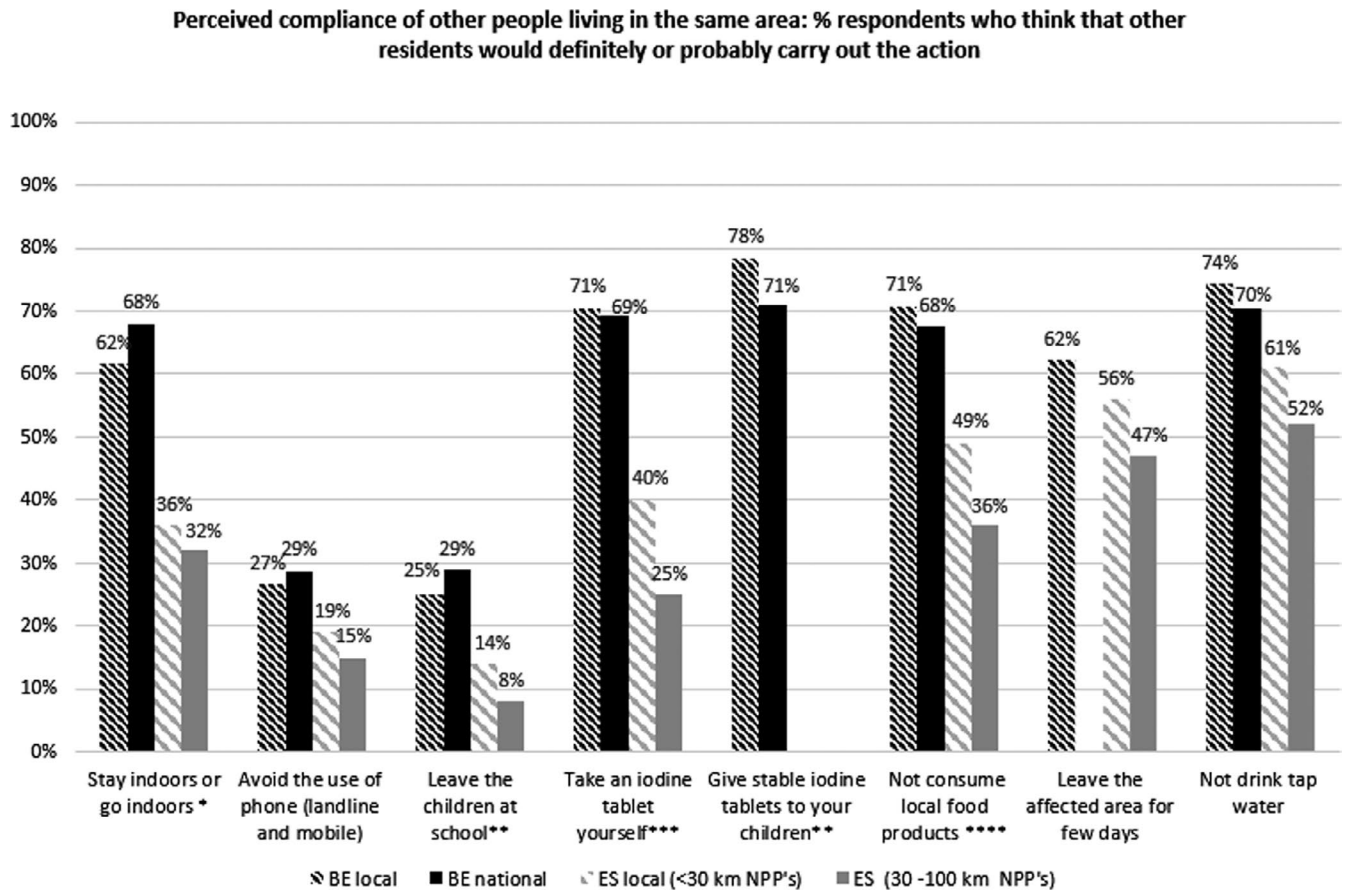

FIGURE 2 Perception of other residents' compliance with protective actions: % respondents who think that other residents would definitely or probably carry out the action

4.1 | Self-assessed compliance with recommended protective actions

4.1.1 | Descriptive analysis

Most respondents expect to follow the advice from authorities, except for leaving children at school or avoiding the use of phones (see Annex 1). Results also show differences in terms of self-assessed compliance, both between countries and between local and national populations (Figure 1). Overall, compliance with protective actions is lower in Spain than the other two countries. Even for going or staying indoors, more than 80% of the Norwegian and Belgian respondents said they would definitely or probably carry out the action, whereas this is 56% or less among the Spanish respondents. Spanish respondents are more hesitant about their behaviour than respondents from Belgium and Norway.

In Spain, people living in the emergency planning zone of 30 km report particularly higher levels of compliance than people living outside this area.

Respondents in Belgium and Spain evaluated other people's compliance as lower than their own (Figure 2). For instance, more than 84% of the Belgian respondents living in a radius of 20 km from Doel and Tihange nuclear power plants said they would probably or definitively take an iodine tablet, but only 71% believed that their neighbours would do the same.

4.1.2 | Risk attitudes

Risk attitudes were measured only in Belgium. As illustrated in Figure 3, between 39% and 48% of the respondents in both the national and local sample would avoid consumption of food products from the affected area, even if the authorities say these products pose no health risks. More than one in three respondents in both local and national samples would also take an iodine tablet even if the authorities advised against it.

In addition, expectation to consume the local food products is highest in the age category 18–29 years among respondents living within 20 km from a nuclear installation in Belgium and lowest in the age category 30–44 years.

4.2 | Perceived difficulty and effectiveness of protective actions

Avoiding the use of phone and leaving the children at school appear easy for a minority of Belgian and Spanish respondents: less than 20% of respondents with children in case of the latter (Figure 4).

Furthermore, only one in three respondents in the Spanish local population thinks that finding and taking iodine tablets poses no

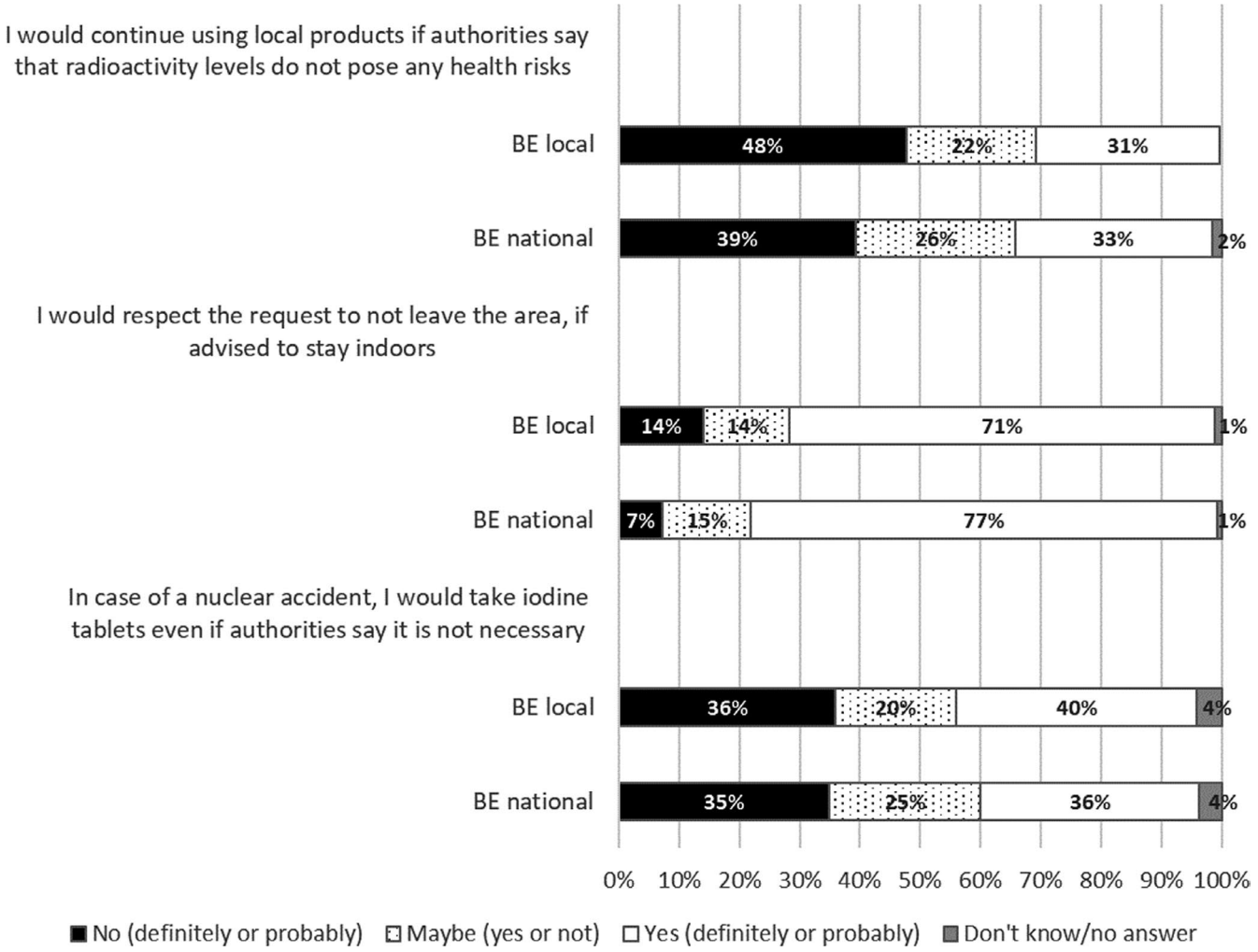

FIGURE 3 Risk attitudes

difficulties, whereas in the Belgian local population this percentage is twice as high.

Perceived effectiveness of protective actions is lowest for staying indoors and highest for refraining from consumption of food products or tap water (Figure 5).

4.3 | Self-assessed knowledge about protection in case of nuclear accidents

A majority of respondents in the three countries evaluate their knowledge about protective actions as very low or low, and this is similar for both local populations and other publics (Figure 6).

4.4 | Trust in communicators in case of a nuclear emergency

As illustrated in Table 3, the most trusted communicators for both Belgium and Spain are national crisis centres, rescue services, research organizations (universities or research centres) and medical doctors. Opposite to this, national politicians and the media have a particularly low level of trust. Moreover, local authorities enjoy more trust than members of the parliament and public representatives.

In Norway, respondents were asked to state who they would trust in case of conflicting messages during emergencies. 47% of the respondents replied that they would trust the Norwegian authorities, 30% would trust research institutions, and 12% would trust environmental NGOs. In addition, the municipality (28%) and the Norwegian Radiation Protection Authority (20%) were the preferred information source if a serious accident happened in their area. Less respondents chose police (9%) and local health and food safety authorities (8%). The category "other" included diverse organizations, friends and acquaintances and was chosen by 15% of the respondents.

4.5 | Correlations between self-assessed compliance with emergency actions and other variables

Correlations between self-assessed compliance and the independent variables perceived social norm, perceived difficulty, perceived

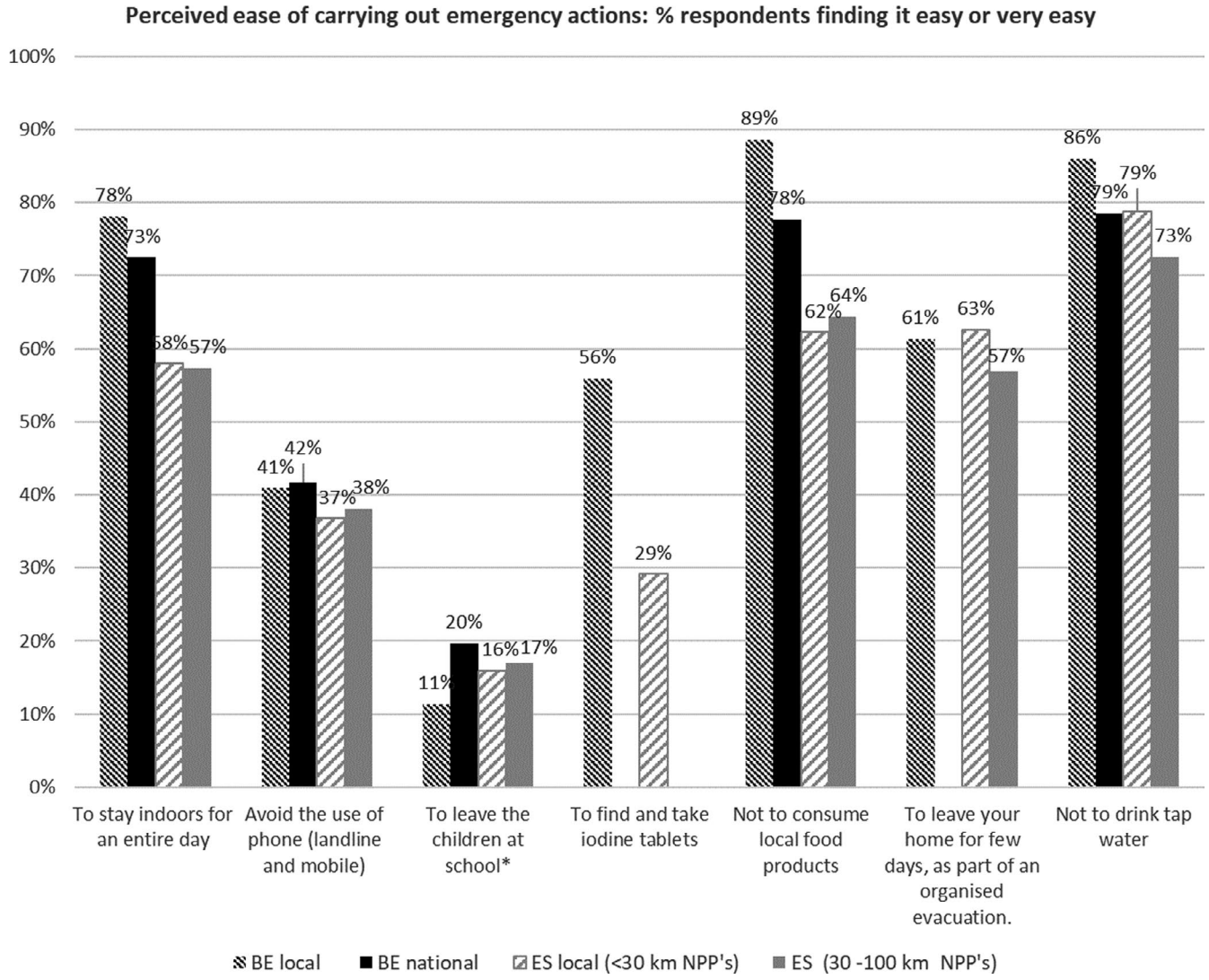

FIGURE 4 Perceived ease of carrying out protective actions: % respondents who find these easy or very easy. *Only respondents with children aged 16 years or younger (Belgium); 12 years or younger (Spain)

effectiveness, self-assessed level of information about protective actions and trust in nuclear safety authorities are summarized in Table 4. Due to the large number of statistical tests, we only retained in this table the correlations with a significance value $p < .01$. The strongest correlates of self-assessed compliance with emergency actions were the perceived difficulty and effectiveness of the action and the perceived social norm. Respondents who perceived an action as difficult and not effective and those who believed that others living in the same neighbourhood would not comply with the action expressed lower compliance. Correlations between self-assessed compliance, on the one hand, and nuclear accident risk perception, subjective (self-assessed) knowledge about protective actions and trust in the nuclear regulator as emergency communicator, on the other hand, were only in few cases statistically significant, and in those cases, the correlation values were generally low.

Additionally, we evaluated the correlations between the behavioural expectations related to the different emergency actions (Annex 2) and between variables measuring risk attitudes and a number of independent variables (Table 5). Giving an iodine table to children was strongly correlated with taking an iodine tablet oneself (Spearman's rho = 0.8, $p < .01$ in both local and general population in Belgium). Notably, strong correlations were noted for compliance with actions referring to similar behaviours, for example not consuming local food products or tap water (Spearman's rho between 0.4 and 0.6, $p < .01$ in both national and local samples in Belgium and Spain).

In Belgium, intention to continue using the local food products from the affected areas was most strongly associated with a lower perception of risk from a nuclear accident (Spearman's rho = −0.21, $p < .01$). Respecting the request not to leave the area was most strongly related to the perceived

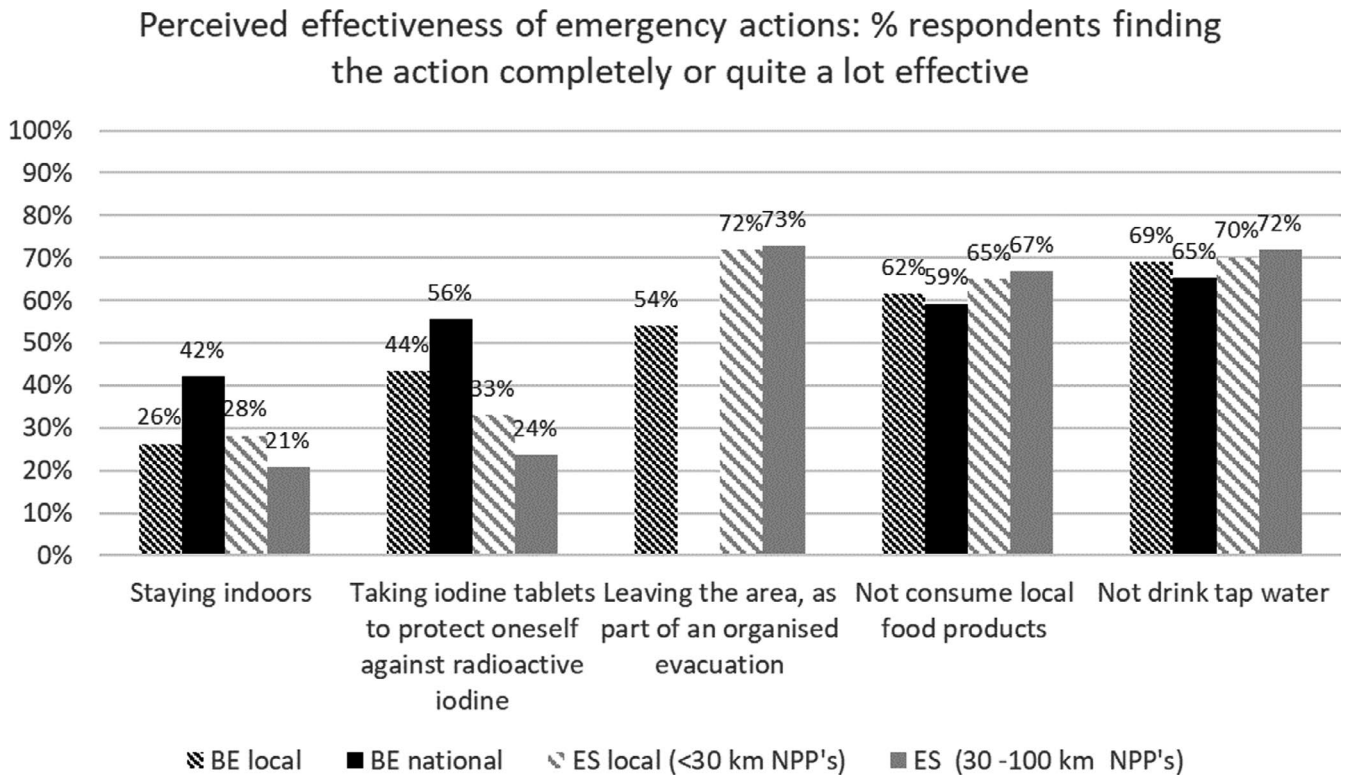

FIGURE 5 Perceived effectiveness of protective actions: % respondents who believe that action protects completely or quite a lot against harmful health effects due to a radioactive release in the air

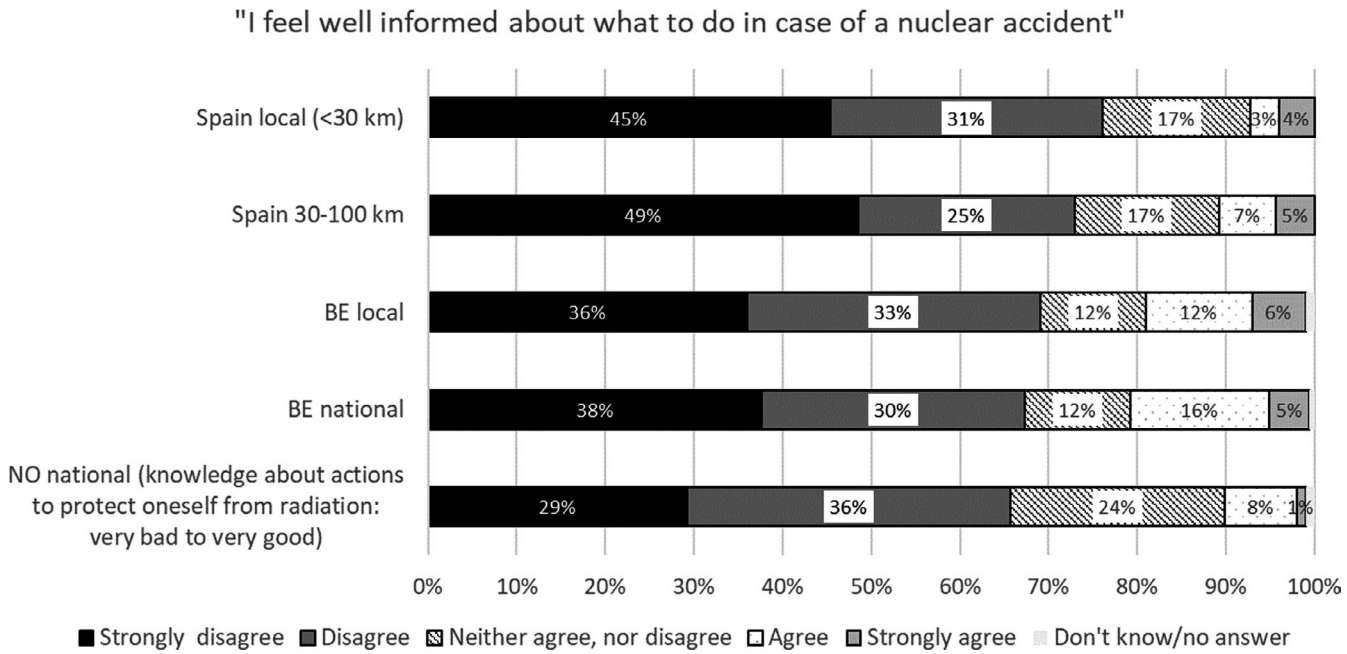

FIGURE 6 Self-assessed level of knowledge about protection in case of a nuclear accident. *In Norway, answers ranged from "very bad knowledge," through to "bad knowledge," "moderate knowledge," "good knowledge," "very good knowledge" and "unsure"

protective effectiveness of staying indoors (Spearman's rho = 0.32, p = <.001 in the local population; rho = 0.28, p < .001 in the general population). Correlations between taking an iodine tablet even when authorities say it is not necessary and the investigated independent variables were either very low or not statistically significant.

TABLE 3 Trust in communicators to provide correct and objective information about personal protection measures in the event of a nuclear accident (mean score on a scale from 1 to 6)

Mean trust score (*SD*)	BE national (*N* = 1,083)	BE local (*N* = 315)	ES (30–100 km) (*N* = 506)	ES (0–30 km) (*N* = 302)
Environmental organizations	3.9 (1.2) (*n* = 1,003*)	3.7 (1.4) (*n* = 310)	4.2 (1.4) (*n* = 492)	4.3 (1.3) (*n* = 293)
The media	3.1 (1.2)	3.1 (1.4)	3.8 (1.3) (*n* = 499)	3.8 (1.3) (*n* = 296)
Nuclear safety authority	4.4 (1.0) (*n* = 512)	4.0 (1.3) (*n* = 285)	4.3 (1.4) (*n* = 475)	4.3 (1.4) (*n* = 280)
Medical doctors	4.3 (1.0)	4.4 (1.1) (*n* = 314)	4.8 (1.1) (*n* = 501)	4.9 (1.0) (*n* = 297)
Rescue services (firemen, Civil Protection, policemen)	4.6 (1.0)	4.6 (1.1) (*n* = 314)	4.9[a] (1.1) (*n* = 501)	5.0[a] (1.0) (*n* = 297)
Research centre (SCK•CEN in BE, CIEMAT in ES)	4.5 (1.1) (*n* = 539)	4.1 (1.4) (*n* = 259)	4.5 (1.3) (*n* = 447)	4.6 (1.2) (*n* = 268)
Scientists from universities	4.5 (1.0)	4.2 (1.1) (*n* = 309)	4.7 (1.1) (*n* = 491)	4.6 (1.1) (*n* = 295)
The Red Cross	4.3 (1.1)	4.1 (1.2)	4.7 (1.2) (*n* = 499)	4.6 (1.1) (*n* = 297)
Federal Crisis Centre	4.5 (1.0) (*n* = 570)	4.3 (1.1) (*n* = 298)	4.5 (1.3) (*n* = 428)	4.5 (1.3) (*n* = 260)
Local authorities (mayors, governors)	3.5 (1.2)	3.4 (1.4) (*n* = 313)	3.5 (1.5) (*n* = 500)	3.7 (1.4) (*n* = 297)
Members of parliament, public representatives	2.9 (1.2)	2.5 (1.2) (*n* = 313)	2.6 (1.4) (*n* = 500)	2.8 (1.4) (*n* = 296)

[a]In Spain Rescue services did not include Civil Protection; for Civil Protection the mean trust was 4.7 (sample 30–100 km), respectively, 4.8 (sample 0–30 km).

*N = sample size; n = respondents who know the actor ($n = N$, unless otherwise mentioned).

4.6 | Associations between gender, age and education and self-assessed compliance with emergency actions

t tests and analysis of variance were conducted to gain additional insights into the potential role of socio-demographic variables, using a significance level $p < .01$. The answering category "I don't know" was treated as missing answer in Spain and Belgium. In the case of Norway, the answers were recoded with "not sure" treated as middle category.

t tests were carried out to identify statistically significant differences in self-assessed compliance with respect to gender. Men reported somewhat lower intended compliance than women for going/staying indoors among national and local populations in Belgium and the national population in Spain (Belgium national: $M = 5.24$, $SD = 1.27$ for male, and $M = 5.44$, $SD = 1.09$ for female, $t(1{,}019) = -2.76$, $p < .01$, Cohen's $d = -0.17$; Belgium local: $M = 4.91$, $SD = 1.62$ for male, and $M = 5.37$, $SD = 1.18$ for female, $t(310) = -2.90$, $p < .01$, Cohen's $d = -0.32$; Spain national: $M = 3.51$, $SD = 1.56$ for male, and $M = 3.95$, $SD = 1.48$ for female, $t(489) = -3.25$, $p = .001$, Cohen's $d = -0.29$). A similar effect was noticed with regard to avoiding the use of phone in the national sample in Belgium ($M = 3.72$, $SD = 1.83$ for male, and $M = 4.11$, $SD = 1.75$ for female, $t(1{,}050) = -3.56$, $p < .001$, Cohen's $d = -0.22$) and both national and local samples in Spain (Spain national: $M = 2.91$, $SD = 1.56$ for male, and $M = 3.49$, $SD = 1.58$ for female, $t(485) = -4.04$, $p < .001$, Cohen's $d = -0.36$; Spain local: $M = 3.63$, $SD = 1.55$ for male, and $M = 4.11$, $SD = 1.48$ for female, $t(297) = -2.75$, $p < .01$, Cohen's $d = -0.31$). No effects of gender were found in Norway at a significance level $p < .01$.

One-way analysis of variance (ANOVA, using Welch test in case of heterogeneous data with unequal group sizes) was carried out to investigate differences in self-assessed compliance depending on the education level or the age category. Tukey or Games–Howell post hoc tests were applied depending on whether the homogeneity of variances was satisfied or not.

This analysis for the Belgian national sample revealed statistically significant differences (at $p < .01$ level) in self-assessed compliance depending on the education level for leaving children at school ($F(2, 294) = 10.85$, $p < .001$, $\eta^2 = 0.07$) and refraining from consuming local

TABLE 4 Correlations (Spearman's rho) between self-assessed compliance and independent variables

	Nucl. risk perception	Social. norm	Difficulty of action	Effectiveness of action	Feeling informed	Trust in nuclear safety authority	
Staying indoors	ns	0.27**	−0.18**	0.27**	ns	ns	BE national
	ns	0.39**	−0.24**	0.36**	ns	ns	ES (30–100 kmNPP's)
	ns	0.23**	−0.22**	0.21**	ns	ns	BE local (<20 km)
	−0.17**	0.49**	−0.51**	0.50**	ns	0.37**	ES (0–30 km NPP's)
Avoiding use of phone	0.13**	0.41**	−0.44**		ns	ns	BE national
	0.13**	0.49**	−0.31**		ns	ns	ES (30–100 km NPP's)
	ns	0.33**	−0.44**		ns	0.21**	BE local (<20 km)
	ns	0.38**	−0.42**		ns	0.25**	ES (0–30 km NPP's)
Leaving children at school	−0.18**	0.52**	−0.55**	0.14**	ns	ns	BE national
	ns	0.46**	−0.35**	0.24*[b]	ns	ns	ES (30–100 km NPP's)
	ns	0.48**	−0.73**	0.31**	ns	0.32**	BE local (<20 km)
	ns	0.49**	−0.63**	0.31**	0.41**	ns	ES (0–30 km NPP's)
Taking an iodine tablet	ns	0.43**		0.32**	ns	ns	BE national
	ns	0.61**		0.39**	ns	ns	ES (30–100 km NPP's)
	ns	0.27**	−0.18**	0.21**	ns	ns	BE local (<20 km)
	ns	0.56**	−0.24**	0.34**	ns	0.25**	ES (0–30 km NPP's)
Give iodine to children	ns	0.52**		0.26**	ns	ns	BE national
							ES (30–100 km NPP's)
	ns	0.35**	−0.29**	ns	ns	ns	BE local (<20 km)
							ES (0–30 km NPP's)
Not consume local food	ns	0.42**	−0.29**	0.31**	ns	ns	BE national
	ns	0.39**	−0.17**	0.32**	ns	ns	ES (30–100 km NPP's)
	ns	0.37**	−0.28**	ns	ns	ns	BE local (<20 km)
	ns	0.40**	−0.43**	0.41**	−0.17**	0.19**	ES (0–30 km NPP's)
Not drink tap water	ns	0.36**	−0.26**	0.32**	ns	ns	BE national
	ns	0.51**	−0.30**	0.35**	ns	ns	ES (30–100 km NPP's)
	ns	0.30**	−0.26**	ns	ns	ns	BE local (<20 km)
	ns	0.42**	−0.46**	0.42**	−0.21**	ns	ES (0–30 km NPP's)
Leave area few days	ns						BE national
	ns	0.34**	−0.40**	0.34**	ns	ns	ES (30–100 km NPP's)
	ns	0.30**	−0.30**	0.21**	ns	ns	BE local (<20 km)
	ns	0.33**	−0.34**	0.37**	−0.22**	ns	ES (0–30 km NPP's)

Note: Grey shaded cells = question not asked.

[a]Correlation between compliance with taking an iodine tablet and difficulty of finding/taking an iodine tablet.

[b]Correlation between compliance with leaving children at school and perceived effectiveness of staying indoors.

**$p < .01$; ns, correlation is not statistically significant ($p \geq .01$).

food products ($F(2, 596) = 5.68$, $p = .004$, $\eta^2 = 0.01$). Compliance with leaving children at school among respondents with highest education ($M = 3.90$, $SD = 1.81$) was higher than among respondents with middle ($M = 3.00$, $SD = 1.94$, $p < .001$) or lowest education level ($M = 2.70$, $SD = 1.93$, $p < .001$). Concerning refraining from local food consumption, respondents with highest education level

TABLE 5 Correlations (Spearman's rho) between risk attitudes and other variables

Correlation	Sample	Nuclear risk perception	Trust in nuclear safety authority	Feeling informed	Effectiveness of protective action	Difficulty of protective actions
Continue using local products if authorities say that radioactivity levels do not pose any health risks	BE local	−0.21**	ns	ns	ns (not consume local products)	0.15** (not consume local products)
	BE national	ns	ns	ns	−0.20** (not consume local products)	0.16** (not consume local products)
Respect the request to not leave the area, if advised to stay indoors	BE local	ns	ns	ns	0.32** (staying indoors)	−0.22** (staying indoors one day)
					−0.24** (leaving area)	0.19**(leaving area)
	BE national	ns	0.16**	ns	0.28** (staying indoors)	−0.18** (staying indoors)
Take iodine tablets even if authorities say it is not necessary	BE local	ns	ns	ns	ns	−0.16** (find and take tablets)
	BE national	ns	ns	ns	0.16** (take tablets)	

**$p < .01$; ns, correlation is not statistically significant ($p \geq .01$).

reported somewhat higher compliance ($M = 5.29$, $SD = 1.31$) than those with lowest education level ($M = 4.87$, $SD = 1.67$, $p = .002$). In the local Belgian population, there were no statistically significant differences in compliance with respect to the education level at the $p < .01$ level. Among the Spanish respondents living farther than 30 km from a nuclear installation, compliance differed with respect to the education level for refraining from consumption of local food ($F(2, 474) = 6.15$, $p = .002$, $\eta^2 = 0.03$) and tap water ($F(2, 152) = 7.08$, $p = .001$, $\eta^2 = 0.03$). Respondents with highest education level seemed more likely to comply with avoiding local food products ($M = 4.27$, $SD = 1.75$) than respondents with lowest education level ($M = 3.44$, $SD = 1.86$, $p = .004$), and they also expressed somewhat more willingness to comply with refraining from drinking tap water ($M = 4.86$, $SD = 1.61$ for highest education) than those with middle education level ($M = 4.35$, $SD = 1.88$, $p = .003$) or lowest education level ($M = 3.97$, $SD = 2.15$, $p = .01$). In the Spanish local sample, compliance differed with the education level only with respect to leaving children at school ($F(2, 49) = 16.34$, $p < .001$, $\eta^2 = 0.09$): compliance was lower among respondents with lowest education ($M = 1.30$, $SD = 0.48$) compared to the middle education level ($M = 2.48$, $SD = 1.61$, $p < .001$) and the highest education level ($M = 2.82$, $SD = 1.51$, $p < .001$). In Norway, the education level was associated with differences in compliance with taking an iodine tablet ($F(2, 377) = 4.52$, $\eta^2 = 0.02$, $p = .01$): respondents with lower education level expressed a lower level of compliance ($M = 3.41$, $SD = 1.43$) than those with highest education level ($M = 4.21$, $SD = 1.12$, $p = .01$).

The evidence with respect to age was inconsistent at a significance level $p < .01$. In the Belgian general population, compliance is generally lower among younger respondents (18–29) for staying indoors compared to all other age groups ($F(3, 499) = 8.71$, $p < .001$, $\eta^2 = 0.03$) and for taking stable iodine compared to 60+ ($F(3, 508) = 4.66$, $p = .003$, $\eta^2 = 0.01$). However, the latter measure targets mainly respondents younger than 40. Noteworthy is that respondents aged 18–29 years expressed less compliance with going/staying indoors ($M = 4.90$, $SD = 1.46$) than those aged 30–44 years ($M = 5.34$, $SD = 1.15$, $p = .006$), 45–59 years ($M = 5.39$, $SD = 1.15$, $p = .001$) and 60+ ($M = 5.54$, $SD = 1.01$, $p < .001$). In the Belgian local population, there were differences for leaving the area in the context of an organized evacuation ($F(3, 160) = 9.14$, $p < .001$, $\eta^2 = 0.07$), with respondents aged 60 + expressing lower compliance ($M = 4.95$, $SD = 1.20$) than those aged 18–29 years ($M = 5.58$, $SD = 0.77$, $p = .004$) and those aged 30–44 years ($M = 5.79$, $SD = 0.64$, $p < .001$).

Among the Spanish respondents, no effects of age were observed at a significance level $p < .01$ either in the national or in the local Spanish population.

In Norway, lowest compliance was found for the age group <30 years for staying indoors ($F(3, 527) = 6.95$, $p < .001$, $\eta^2 = 0.03$), following dietary advice ($F(3, 529) = 11.52$, $p < .001$, $\eta^2 = 0.04$), taking iodine tablets ($t(377) = -4.63$, $p < .001$, Cohen's $d = -0.46$) and giving iodine tablets to children ($F(3, 34) = 6.67$, $p = .001$, $\eta^2 = 0.1$). Specifically, those aged 18–29 years expressed lower intended compliance for staying indoors ($M = 4.36$, $SD = 0.93$) than the age groups 45–59 years ($M = 4.62$, $SD = 0.71$, $p = .005$) and older than 60 years ($M = 4.56$, $SD = 0.76$, $p < .001$). For dietary advice, respondents younger than 30 years expressed lower compliance ($M = 4.14$, $SD = 1.03$) than all the other three age groups ($M = 4.43$, $SD = 0.87$, $p = .007$ for 30–44; $M = 4.59$, $SD = 0.75$, $p < .001$ for 45–59; $M = 5.59$, $SD = 0.80$, $p < .001$ for 60+). For giving iodine tablets to children, respondents younger than 30 reported lower intended compliance ($M = 3.60$, $SD = 1.28$) than those in the age categories 30–44 years ($M = 4.46$, $SD = 0.89$, $p = .001$) and 45–59 years ($M = 4.53$, $SD = 0.75$, $p < .001$). Finally, self-assessed compliance with taking an iodine tablet was lower among respondents in the age category 18–29 years ($M = 3.88$, $SD = 1.24$) than among those in the age category 30–44 years ($M = 4.41$, $SD = 0.99$, $p < .001$). Additionally, the percentage of respondents who felt unsure about giving iodine tablets to children was markedly higher in the youngest age category in both the Norwegian (24%) and Belgian national samples (21%).

With respect to risk attitudes among Belgian respondents, some differences in compliance with the advice to not leave the area when advised to stay indoors were revealed with respect to gender in both national ($t(1, 003) = -4.21$, $p < .001$, Cohen's $d = -0.26$) and local ($t(300) = -3.26$, $p = .001$, Cohen's $d = -0.36$) population samples, education level (only local: $F(2, 181) = 8.38$, $p < .001$, $\eta^2 = 0.04$) and age in both national ($F(3, 49) = 14.29$, $p < .001$, $\eta^2 = 0.03$) and local samples ($F(3, 150) = 10.12$, $p < .001$, $\eta^2 = 0.08$). Men seem less willing to comply with this advice compared to women (national: $M = 4.80$, $SD = 1.37$ for male, $M = 5.13$, $SD = 1.14$ for female; local: $M = 4.42$, $SD = 1.67$ for male, $M = 4.98$, S = 1.36 for female); respondents with highest education level ($M = 4.44$, $SD = 1.52$, $p < .001$) and those with middle education level ($M = 4.62$, $SD = 1.63$, $p = .007$) would comply less than those with lowest education level ($M = 5.29$, $SD = 1.31$); and age categories 18–29 years ($M = 4.19$, $SD = 1.49$, $p < .001$) and 30–44 years ($M = 4.27$, $SD = 1.72$, $p < .001$) in the local population would comply less than respondents in the 60+ age category ($M = 5.28$, $SD = 1.23$), while in the national population respondents from all three lower age categories 18–29 years ($M = 4.4.68$, $SD = 1.40$, $p < .001$), 30–44 years ($M = 4.86$, $SD = 1.28$, $p < .001$) and 45–50 ($M = 4.87$, $SD = 1.37$, $p < .001$) would comply less than those aged 60 or older ($M = 5.30$, $SD = 1.02$). In addition, among respondents living within 20 km from a nuclear installation in Belgium, the willingness to consume the local food products if authorities say these products do not pose any risks also changes with the age category ($F(3, 159) = 6.88$, $p < .0.001$, $\eta^2 = 0.05$), namely it is higher in the age category 18–29 years ($M = 3.60$, $SD = 1.61$, $p < .001$) and 60+ ($M = 3.27$, $SD = 1.84$, $p = .007$) than among those in the age category 30–44 years ($M = 2.43$, $SD = 1.52$).

4.7 | Potentially explanatory factors for self-assessed compliance with emergency actions

To gain additional insights into potentially explanatory factors for self-assessed compliance among local populations on Belgium and Spain, regression analyses (general linear models using SPSS v.25) were conducted. Perceived social norm, perceived difficulty and effectiveness of action, perception of personal risk from a nuclear accident, trust in nuclear safety authorities as communicator in an emergency and self-assessed knowledge about protective actions were entered as independent variables when significantly correlated ($p < .01$) with self-assessed compliance. Socio-demographic variables gender, age category and education level were also included in all models. The models containing the aforementioned variables are presented in Annex 3 and 4. Parameter estimates with robust standard errors are given whenever heteroscedasticity was detected (Breusch–Pagan test).

The results of the regression models confirm that, overall, perceived social norm, perceived effectiveness and perceived difficulty come out consistently as statistically significant predictors. Socio-demographics were not significant as predictors (at a significance level $p < .01$) (see Annex 3 and 4). Future research should explore interactions between socio-demographic variables and the other independent variables, for instance perceived social norm.

Trust in nuclear safety authorities was a significant predictor only for compliance with staying indoors and avoiding the use of phone (higher trust, higher compliance).

Self-assessed knowledge was a significant predictor for a number of actions, but its influence varied. For instance, among Spanish local respondents higher self-assessed knowledge about how to protect oneself in case of an accident was associated to higher compliance with leaving children in school, but less willingness to leave the affected area for a few days or refrain from consuming local food or tap water.

Risk perception was used as independent variable only in one model, namely compliance with staying indoors among Spanish local population, due to the low significance value of its correlation with the dependent variable ($p > .01$). In that case, it was negatively related to compliance with staying indoors (higher risk perception, lower compliance).

A more detailed example is provided in Table 6 for "leaving children at school" as dependent variable. It can be noticed that the socio-demographics are not significant at a level $p < .01$ even when entered as the only variables in the model (Model 1). Trust in nuclear safety authorities has a direct effect in Model 2, but does not come out as a significant predictor in Model 3. This may be either due to the reduction in the number of respondents or to the fact that, after accounting for the effect of the perceived social norm and perceived difficulty, trust does not add anything additional to the model. Model 3 explains 50% of the variance in the data, showing that lower perceived difficulty and higher perceived compliance of others are associated with higher compliance with leaving children at school.

5 | DISCUSSION

This study summarizes results of empirical investigations in Belgium, Spain and Norway concerning potential compliance with protective actions in case of a nuclear accident, self-assessed knowledge about protective actions and trust in various communicators.

Results suggest that most respondents expect to comply with emergency actions, except for leaving children at school and avoiding the use of phone. In case of the latter, <50% of respondents in Belgium and Spain say this is likely to happen. This supports previous research from Taylor et al. (2011) indicating that a radiological or nuclear incident is likely to result in a high demand on phone services: 92% of respondents in this study said it was very or extremely likely that they would call family members, and 76% would call emergency services. This is recognized as a widespread phenomenon also in other emergencies (Dalovisio, 2006; Nagami, Nakajima, Juzoji, Igarashi, & Tanaka, 2006).

Highest levels of compliance were expressed in Norway and lowest in Spain, with Belgium in between. In Spain, self-assessed compliance was markedly higher among respondents living <30 km

away from a nuclear installation, compared to those living farther away. The differences between the two populations were, however, not consistent and much smaller in Belgium. More research is needed to reveal the factors underlying these differences, given the ongoing international efforts to harmonize emergency response in Europe.

Giving an iodine tablet to children was highly correlated with taking a tablet oneself and was a strong predictor for self-assessed compliance. This converges with findings from a retrospective study in the Fukushima prefecture, showing that a significantly higher percentage of children took stable iodine if their parents also did so, in comparison with children whose parents did not take stable iodine (Nishikawa et al., 2019). In the aforementioned study, the most common reason for not giving children iodine tablets was parental concern about safety.

Three actions are generally considered as both easy to undertake and effective to protect against the nuclear risk associated with an emergency situation: dietary restrictions, leaving the area and avoiding drinking tap water. Staying indoors is perceived, on average, as relatively easy, but less effective. Taking an iodine tablet is considered as not very easy and only moderately effective.

Communication and participation have been recognized as key factors influencing the effectiveness of emergency response (Renn, 2005, pp. 16). Lemyre et al. (2009) also note that failing to communicate risks and uncertainties in the preparedness phase is an element of vulnerability in the preparedness plans and may lead to sub-optimal decisions (Helsloot & Ruitenberg, 2004). In our study, self-assessed knowledge about protective actions was revealed as rather low in all three countries, regardless of the nuclear energy status of the country or the previous experience with radiological events. This confirms previous studies (Malešič et al., 2015; Verbeeck et al., 2017) and is a matter of concern, particularly given that self-assessed knowledge can be even lower than actual knowledge (Verbeeck et al., 2017). At the same time, the reason for low self-assessed knowledge could be that citizens believe they require specialist knowledge about the protective actions for radiological accidents, while the actual protective measures are relatively simple. Future research should further explore this aspect. Nevertheless, opening emergency exercises to broader publics than

TABLE 6 Regression models for self-assessed compliance with leaving children at school staying indoors among Belgian local population

	Leave children at school					
Depend. variable	**Model 1: socio-demographic variables**		**Model 2: socio-demographic variables and trust**		**Model 3: all variables**	
Indep. variables	***B* (Sig)**	***SE*, CI**	***B* (Sig)**	***SE*, CI**	***B* (Sig)**	***SE*, CI**
Intercept	2.56 ($p = .003$)	0.83, (0.92, 4.21)	0.29 ($p = .8$)	1.10, (−1.01, 2.49)	4.63 ($p = .007$)	1.67, (1.30, 7.97)
Gender Male	0.104 ($p = .8$)	0.46, (−0.81, 1.020)	0.22 ($p = .6$)	0.46, (−0.69, 1.14)	−0.052 ($p = .9$)	0.39, (−0.82, 0.72)
Education Lower	−1.47 ($p = .03$)	0.65, (−2.76, −0.19)	−1.34 ($p = .04$)	0.50, (−2.62, −0.061)	−0.27 ($p = .6$)	0.54, (−1.35, 0.82)
Higher sec.	−0.33 ($p = .5$)	0.50, (−1.33, 0.66)	−0.29 ($p = .6$)	0.50, (−1.28, 0.70)	0.27 ($p = .5$)	0.5, (−0.55, 1.089)
Age categ. 60+	a	a	a	a	a	a
45–59	1.11 ($p = .2$)	0.79, (−0.45, 2.68)	1.27 ($p = .12$)	0.80, (−0.32, 2.86)	0.76 ($p = .2$)	0.62, (−0.49, 2.007)
30–44	1.11 ($p = .1$)	0.60, (−0.32, 2.56)	1.23 ($p = .1$)	0.75, (−0.26, 2.72)	1.18 ($p = .04$)	0.58, (0.031, 2.34)
Perceived social norm	NA		NA		**0.303 ($p = .009$)**	**0.11, (0.079, 0.53)**
Perceived difficulty	NA		NA		**−1.078 ($p < .001$)**	**0.24, (−1.55, −0.60)**
Perceived effectiveness (of staying indoors)	NA		NA		0.059 ($p = .8$)	0.201, (−0.34, 0.46)
Trust in authorities	NA		**0.51 ($p = .003$)**	**0.16, (0.18, 0.84)**	0.21 ($p = .2$)	0.16, (−0.11, 0.54)
Adj.R^2 (N)	**0.05 ($N = 90$)**		**0.15 ($N = 82$)**		**0.50 ($N = 75$)**	

Note: Reference categories: female, higher post-secondary education, age category 18–29 years. Grey shaded cells with bold letters indicate statistically predictors with significance $p < .01$. Maximal variance inflation factors (VIF): 1.72 (no specific issues with multi-colinearity). Breusch–Pagan test for heteroscedasticity: $p > .05$ (variance of the errors does not depend on the values of the independent variables).

Abbreviations: CI, 95% confidence interval; NA, not included; *SE*, standard error.

[a]Category excluded because it contained only one case.

the governmental emergency actors, the use of new communication tools and stimulating continuous community engagement might facilitate better knowledge of protective actions, particularly among local residents.

A number of studies in other fields highlighted perceived consequences of a hazard as a positive predictor for preparedness intention (Sun & Xue, 2020) or adoption of self-protective actions (Cheng, Wei, Marinova, & Guo, 2017; Duan, Jiang, Deng, Zhang, & Wang, 2020). In our study, risk perception of a nuclear accident was generally uncorrelated with self-assessed compliance with emergency actions (Hypothesis 1a could not be validated), except in a few instances. Risk perception was positively correlated with intention to avoid using the phone among general publics in Belgium and Spain. Opposite to this, respondents with higher risk perception might be less likely to leave children at school in Belgium (general population) or stay indoors in Spain (local population). Among the local population in Belgium, higher risk perception is also associated with the intention to avoid consumption of local food products (Hypothesis 1b), but was not associated with self-evacuation when advised to stay indoors (at a significance level $p < .01$). Thus, we could not confirm Johnson and Zeigler's results (1983) in a study of three hypothetical nuclear accident scenarios.

In Belgium and Spain, perceived social norm, perceived difficulty and effectiveness of actions, self-assessed knowledge of protective actions and trust in nuclear safety authorities have been studied in connection with behavioural expectations concerning protective actions. As expected, self-assessed compliance increases with higher perception of other residents' compliance and perceived effectiveness of protective action, but decreases with perceived difficulty (Hypotheses 2, 3 and 4 confirmed). Emergency managers should therefore take into consideration that some residents living in areas adjacent to those where evacuation is implemented will also evacuate, although the per cent of the population doing so will likely decline with distance from the evacuation zone boundary. This has been also suggested in several other studies for different types of emergencies (Lindell, Murray-Tuite, Wolshon, & Baker, 2019; Zeigler, Brunn, & Johnson, 1981, pp. 74–76). At the same time, leaving the area when advised to remain indoors was associated (for both general and local publics) with a balance of perceived effectiveness and difficulty of the two actions in favour of self-evacuation. In the empirical study of Kohzaki et al. (2015), residents of the Fukushima prefecture (living outside of the mandatory evacuation zone) who did not consider evacuation also highlighted the difficulties of practical or economic nature, rather than their feeling safe in their environment, as their main motivation. That study showed the opposite for residents living outside Fukushima: those who decided not to evacuate did so mostly because they felt safe in their environment.

The strength of association between self-assessed compliance and its most important correlates (perceived social norm, effectiveness and difficulty) varied across countries and across actions. For leaving children at school and avoiding the use of phone, the perceived difficulty of the action was the strongest correlate to intended behaviour. For taking an iodine tablet, perceived social norm had a stronger correlation with behavioural expectation, compared to perceived difficulty and effectiveness of the action.

The correlation between self-assessed knowledge and behavioural expectations was in many cases not statistically significant. Thinking one knows more about protective actions is therefore in general not a guarantee of compliance with the advice from authorities in an emergency situation. Compliance with leaving children at school, as an exception, was, however, positively correlated with self-assessed knowledge about what to do in case of a nuclear accident in the Spanish local population. Opposite to this, higher self-assessed knowledge was associated with lower self-assessed compliance with refraining from drinking tap water or consuming local food and leaving the affected area for few days among the Spanish local population (Hypothesis 5 rejected).

The experience from the Fukushima accident showed that in the aftermath of the accident, there was widespread distrust towards government, safety regulators and nuclear industry (Figueroa, 2013; Kohzaki et al., 2015; Yasumura & Abe, 2017), while family doctors and radiation protection experts were seen as more reliable sources of information (Kohzaki et al., 2015; Tateno & Yokoyama, 2013). Our study confirms that rescue services, national crisis centres, research centres, scientists from universities and medical doctors enjoy highest trust, while politicians have lowest levels of trust. Kohzaki et al. (2015) observed that trust in radiation protection experts was higher among respondents living outside the Fukushima prefecture, compared to those living in this prefecture, whereas trust in medical doctors as a reliable or very reliable source of information was higher within Fukushima than outside this area. The former result was also confirmed in Belgium, where the local population expressed markedly more scepticism towards scientists from universities and research centres and nuclear safety authorities, than the general population. Local authorities have lower trust than other actors in Belgium and Spain, but in Norway they are revealed as the preferred information source during an emergency, followed by the nuclear safety authority. It should be noted that patterns of stakeholder ratings can vary by stakeholder characteristic (expertise, trustworthiness and protection responsibility), stakeholder and hazard. For example, Arlikatti et al. (2007) reported that US West Coast respondents rated all levels of government and news media roughly equal in perceived expertise and trustworthiness for earthquakes. Similarly, Wei et al. (2018) found that Chinese respondents rated all stakeholders (physicians, health departments, elected officials, news, media, Internet and peers) roughly equal in perceived expertise and trustworthiness for influenza. However, Wei et al. (2018) found that Texas respondents rated physicians and health departments much higher in perceived expertise and trustworthiness than elected officials, news media and the Internet for influenza. Lindell and Perry (1992) reported that respondents had different patterns of ratings of perceived expertise for radiological, chemical and volcano hazards.

Higher trust in the nuclear safety authorities as emergency communicator is associated with higher self-assessed compliance mostly among the local populations and particularly in Spain (Hypothesis 6

partially confirmed). Respondents in the local populations with higher trust seemed somewhat more inclined to comply with staying indoors (Spain), avoiding the use of phone (both Belgium and Spain), taking an iodine tablet (Spain), leaving children at school (Belgium) and respecting dietary restrictions (Spain). In this respect, our results confirm Lasker (2004), Morss et al. (2016) and Mahdavian, Wiens, Platt, and Schultmann (2020), suggesting that people with low trust in authorities may be less willing to immediately follow advice from the nuclear safety authorities in an emergency situation. However, except for the first two actions, the effect of trust in nuclear safety authorities on compliance with actions was not statistically significant when added as predictor together with perceived norm, perceived difficulty and perceived effectiveness (as shown by models in Annex 3 and 4 for the local populations).

In general, in the few cases when variations in self-assessed compliance with protective actions among population groups with different socio-demographic characteristics were statistically significant, these variations were generally small. This converges with reviews of research on hurricane evacuation that have shown that demographic variables have small and inconsistent effects on compliance with protective actions (Baker, 1991; Huang et al., 2016). Moreover, regression models carried out for the local populations suggest there may be interaction effects between socio-demographic variables and the other independent variables.

Concerning the influence of gender, women reported higher compliance for staying indoors and avoiding the use of phone (Spain and Belgium). Men seemed also more inclined to leave the area when advised to stay indoors (Belgium). Overall, results show a similar role of gender among the local population, which is more likely to be affected by an accident, and other publics.

The education level had similar influence among the local compared to the general population (Hypothesis 8 not confirmed). Furthermore, in the few cases when it has an effect, compliance is generally lowest for the respondents with primary or lower education level in all three countries.

There were only very few associations between age and compliance with emergency actions and the effects of age are not always in the same direction. Younger respondents seem less willing to comply with going/staying indoors, in the Belgian general population. Younger age categories in the Belgian local population are also less inclined to respect the advice to not leave the area when advised to shelter, compared to those aged 60 or older. By contrast, respondents aged 18–44 years in the Belgian local population are somewhat more willing to comply with leaving the area in the context of an organized evacuation, compared to those older than 60 years. In Norway, the lowest reported degree of compliance among the general public was also for the age group <30 years, that is the generation that has not experienced the Chernobyl accident, with the largest difference to other age groups reported for giving iodine tablets to children. Future research should explore more in depth how young adults would respond to a nuclear emergency, particularly in the local populations.

The Belgian results also suggest that significant parts of respondents in both the local and general populations may be reluctant to consume local food products with residual radioactivity. Moreover, a large fraction of respondents may take an iodine tablet contrary to the advice from authorities. This converges with findings from previous research in the context of emergency preparedness, as well as lessons learned from the Fukushima and Chernobyl accidents (Crépey et al., 2013; Drottz-Sjöberg & Sjoberg, 1990; Orita et al., 2015; Turcanu, Carlé, Hardeman, Bombaerts, & Van Aeken, 2007).

6 | LIMITATIONS OF THE STUDY

Our study used different data collection methods. However, the samples used are representative for the target populations with respect to gender, age and education.

Furthermore, the measurement of the perceived ease of carrying out an action in our research is likely a combination between resource- and value-related judgement. Qualitative research could provide insights into which of the two aspects is most strongly associated with the compliance with official advice. The cross-sectional nature of the study design is a limitation that could be addressed in future research by conducting longitudinal studies.

7 | CONCLUSIONS

Understanding peoples' concerns, motivations, beliefs and value judgements underlying individual decision-making in an emergency situation is crucial to improving the governance of nuclear incidents and accidents. Increasing societal capacities to respond to and recover from such events, therefore, requires addressing societal concerns arising in various cultural contexts and joint reflection on how related vulnerabilities may bear on the effectiveness of emergency management.

This paper highlighted various ways in which nuclear emergency management might exhibit vulnerabilities in terms of public response. Each recommended action may trigger a particular response, due, for instance, to its perceived effectiveness. Future research should address in detail the perceived risks and benefits associated with the different actions.

Moreover, the effect of social media on the compliance with protective actions in nuclear emergencies, particularly among the younger generations, deserves more attention.

Our findings substantiate the need for broader engagement in emergency planning and response in order to account for these aspects in current nuclear emergency plans. These results can inspire emergency actors and publics to enhance societal resilience through acknowledgment of vulnerabilities and co-construction of strategies to respond effectively in the event of an emergency.

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ANNEX 1

SELF-ASSESSED COMPLIANCE WITH EMERGENCY PROTECTIVE ACTIONS

		Stay/go indoors	Avoid use of phone (land, mobile)	Leave children at school (16 years old or younger) (*N* = 97)	Take iodine tablet	Give iodine to children (16 years old or younger (*N* = 97)	Not consume local food products	Leave affected area for few days	Not drink tap water
Belgium—local (0–20 km)	Definitely not	5.7%	14%	38.1%	4.1%	3%	4.8%	2.5%	4.8%
	Probably not	4.1%	16.2%	10.3%	2.5%	1%	3.5%	4.1%	1.9%
	Maybe not	2.9%	8.9%	2%	1.3%	0%	2.9%	0.6%	1%
	Maybe yes	5.7%	10.5%	5.1%	5.7%	5.1%	3.8%	7.6%	2.2%
	Probably yes	20.6%	20.3%	14.4%	13.3%	16.5%	14%	15.2%	8.6%
	Definitely yes	60%	29.2%	23.7%	70.5%	70.1%	70.8%	68.9%	81%
	Don't know/no answer	1%	1%	6.1%	2.5%	4.1%	0.3%	1%	0.6%

ANNEXE 1 (Continued)

		Stay/go indoors	**Avoid use of phone (land, mobile)**	**Leave children at school (*N* = 299)**	**Take iodine tablet**	**Give iodine to your children (*N* = 299)**	**Not consume local food products**		**Not drink tap water**
Belgium—national	Definitely not	3%	13.2%	26.4%	5.3%	4.3%	5%		5%
	Probably not	2.8%	16%	16.7%	3.7%	4.7%	5.1%		4%
	Maybe not	1.6%	9.6%	9.7%	3.1%	2.7%	2.7%		2%
	Maybe yes	6.2%	12.6%	7.7%	8.8%	9.4%	5.2%		5%
	Probably yes	21.6%	21.1%	18.7%	20.7%	21.4%	20.6%		15%
	Definitely yes	64.4%	26.3%	20.1%	56.2%	53.8%	60.8%		69%
	Don't know/ no answer	0.5%	1.13%	0.7%	2.2%	3.7%	0.6%		0%
		Stay indoors or go indoors	**Avoid the use of phone (landline and mobile)**	**Leave the children at school (12 years old or younger) (*N* = 88)**	**Take an iodine tablet**		**Not consume local food products**	**Leave the affected area for few days**	**Not drink tap water**
Spain—0–30 km	Definitely not	7%	8.0%	38.7%	6%		5.6%	2%	5.6%
	Probably not	7.9%	11.9%	18.2%	5.6%		5%	3%	2.3%
	Maybe not	9.6%	19.5%	17%	6.9%		5.6%	4.3%	3%
	Maybe yes	18.9%	17.5%	10.2%	19.9%		15.6%	13.2%	6.6%
	Probably yes	26.8%	25.5%	11.4%	20.9%		20.5%	27.8%	14.3%
	Definitely yes	29.1%	16.6%	3.4%	31.1%		46%	48.4%	66.2%
	Don't know/no answer	0.7%	1%	1.1%	9.6%		1.7%	1.3%	2%
		Stay/go indoors	**Avoid use of phone (land, mobile)**	**Leave the children at school (*N* = 123)**	**Take iodine tablet**		**Not consume local food products**	**Leave the affected area for few days**	**Not drink tap water**
Spain—30–100 km	Definitely not	9.1%	17.4%	47.2%	13.8%		13%	7.5%	13.4%
	Probably not	17.6%	22.5%	24.4%	11.3%		9.9%	10.9%	5.3%
	Maybe not	12.6%	13.2%	7.3%	9.9%		12.6%	7.3%	6.5%
	Maybe yes	23.1%	19.2%	13%	20%		15.8%	16.6%	10.1%
	Probably yes	22.5%	15.6%	4.1%	16.4%		16.8%	21.9%	14.8%
	Definitely yes	12.5%	8.3%	1.6%	12%		26.1%	32%	46%
	Don't know/ no answer	2.6%	3.8%	2.4%	16.6%		5.8%	3.8%	3.9%
		Stay indoors up to 2 days			**Take iodine (younger than 40 years) (*N* = 381)**	**Give iodine to children (18 years old or younger) (*N* = 341)**	**Follow dietary advice given by authorities**		
Norway—national	Definitely not	1%			4%	3%	2%		
	No, probably not	2%			10%	4%	5%		
	Yes, probably	28%			28%	29%	29%		
	Yes, definitely	66%			51%	59%	62%		
	Not sure	2%			7%	6%	2%		

ANNEX 2
CORRELATIONS (SPEARMAN'S RHO) BETWEEN SELF-ASSESSED COMPLIANCE FOR DIFFERENT ACTIONS

	1	2	3	4	5	6	7	8	
1. Staying indoors	1	0.21**	0.29**	0.28**	0.18**	0.25**	0.21**		BE national
	1	0.42**	ns	0.29**		0.24**	ns	ns	ES (30–100 km NPP's)
	1	0.21**	0.33**	0.27**	0.33**	0.28**	0.25**	ns	BE local (<20 km)
	1	0.59**	0.39**	0.31**		0.31**	0.25**	ns	ES (0–30 km NPP's)
2. Avoid the use of phone		1	0.30**	0.16**	ns	0.18**	0.18**		BE national
		1	ns	0.29**		0.26**	ns	0.19**	ES (30–100 km NPP's)
		1	0.33**	0.24**	ns	ns	0.17**	ns	BE local (<20 km)
		1	0.36**	0.29**		0.35**	0.25**	0.21**	ES (0–30 km NPP's)
3. Leave children at school			1	0.15**	ns	0.17**	ns		BE national
			1	ns		ns	ns	ns	ES (30–100 km NPP's)
			1	0.33**	ns	ns	ns	ns	BE local (<20 km)
			1	ns		ns	ns	ns	ES (0–30 km NPP's)
4. Taking an iodine tablet				1	0.84**	0.37**	0.28**		BE national
				1		0.43**	0.32**	0.40**	ES (30–100 km NPP's)
				1	0.81**	0.32**	0.26**	0.19**	BE local (<20 km)
				1		0.57**	0.41**	0.42**	ES (0–30 km NPP's)
5. Give iodine to children					1	0.42**	0.36**		BE national
									ES (30–100 km NPP's)
					1	ns	ns	0.34**	BE local (<20 km)
									ES (0–30 km NPP's)
6. Not consume local food						1	0.56**		BE national
						1	0.54**	ns	ES (30–100 km NPP's)
						1	0.41**	0.33**	BE local (<20 km)
						1	0.66**	0.54**	ES (0–30 km NPP's)
7. Not drink tap water							1		BE national
							1	0.49**	ES (30–100 km NPP's)
							1	0.42**	BE local (<20 km)
							1	0.58**	ES (0–30 km NPP's)
8. Leave area few days									BE national
								1	ES (30–100 km NPP's)
								1	BE local (<20 km)
								1	ES (0–30 km NPP's)

** $p < .01$; ns, correlation is not statistically significant ($p \geq .01$); grey shaded cells = question not asked.

ANNEX 3

REGRESSION MODELS OF SELF-ASSESSED COMPLIANCE WITH EMERGENCY ACTIONS AMONG THE BELGIAN LOCAL POPULATION

Depend. variable	Stay indoors[a]		Avoid the use of phone		Leave children at school[d]		Take iodine[a]		Give iodine to children[a]	
Indep. variables	***B* (Sig)**	**Rob.*SE* CI**	***B* (Sig)**	***SE*, CI**	***B* (Sig)**	***SE*, CI**	***B* (Sig)**	**Rob.*SE*, CI**	**B (Sig)**	**Rob.*SE*, CI.**
Intercept	3.53 ($p < .001$)	0.54, (2.46, 4.59)	3.71 $p < .001$	9.57, (2.58, 4.84)	4.63 $p = .007$	1.67, (1.30, 7.97)	2.44 $p = .001$	0.73, (1.00, 3.88)	1.09 $p = .2$	0.77, (−0.45, 2.63)
Gender Male	−0.22 $p = .2$	0.16, (−0.52, 0.087)	−0.14 $p = .5$	0.19, (−0.51, 0.24)	−0.052 $p = .9$	0.39, (−0.82, 0.72)	0.26 $p = .07$	0.14, (−0.018, 0.53)	−0.13 $p = .5$	0.2, (−0.53, 0.26)
Education Lower	0.15 $p = .5$	0.21, (−0.26, 0.57)	−0.004 $p = .9$	0.27, (−0.53, 0.53)	−0.27 $p = .6$	0.54, (−1.35, 0.82)	−0.33 $p = .1$	0.21, (−0.75, 0.082)	−0.104 $p = .6$	0.19, (−0.48, 0.27)
Higher sec.	0.27 $p = .1$	0.18, (−0.089, 0.62)	−0.24 $p = .3$	0.21, (−0.65, 0.18)	0.27 $p = .5$	0.5, (−0.55, 1.089)	−0.34 $p = .03$	0.15, (−0.64, −0.041)	0.12 $p = .5$	0.18, (−0.24, 0.47)
Age categ. 60+	0.29 $p = .2$	0.23, (−0.17, 0.75)	−0.41 $p = .15$	0.29, (−0.98, 0.15)	c		0.32 $p = .1$	0.206, (−0.087, 0.72)	c	
45–59	0.21 $p = .4$	0.26 (−0.29, 0.72)	−0.57 $p = .05$	0.29, (−1.14, 0.000)	0.76 $p = .2$	0.62, (−0.49, 2.007)	−0.007 $p = .9$	0.21, (−0.42, 0.406)	−0.56 $p = .1$	0.35, (−1.25, 0.13)
30–44	0.19 $p = .4$	0.25, (−0.306, 0.69)	**0.043 $p = .9$**	**0.29, (−0.53, 0.62)**	1.18 $p = .04$	0.58, (0.031, 2.34)	0.17 $p = .4$	0.2, (−0.22, 0.56)	−0.36 $p = .3$	0.31, (−0.99, 0.27)
Perceived social norm	**0.29 $p < .001$**	**0.077, (0.14, 0.44)**	**0.38 $p < .001$**	**0.060, (0.27, 0.50)**	**0.303 $p = .009$**	**0.11, (0.079, 0.53)**	**0.39 $p < .001$**	**0.102, (0.19, 0.59)**	0.21 $p = .02$	0.09, (−0.028, 0.39)
Perceived difficulty	**−0.33 $p < .001$**	**0.091, (−0.508, −0.15)**	**−0.52 $p < .001$**	**0.077, (−0.68, −0.37)**	**−1.078 $p < .001$**	**0.24, (−1.55,−0.60)**	−0.010 $p = .8$	0.057, (−0.12, 0.102)	−0.031[d] $p = .7$	0.088 (−0.207, 0.14)
Perceived effectiveness	**0.27 $p < .001$**	**0.072, (0.12, 0.41)**	NA		0.059[b] $p = .8$	0.201, (−0.34, 0.46)	**0.21 $p = .01$**	**0.084, (0.043, 0.37)**	0.2 $p = .04$	0.093 (0.013, 0.38)
Trust in authorities	NA		**0.22 $p = .003$**	**0.72, (0.077, 0.36)**	0.21 $p = .2$	0.16, (−0.11, 0.54)	0.074 $p = .2$	0.061, (−0.045, 0.19)	NA	
Risk percept.	NA		NA		NA		NA		NA	
Feel informed	NA		NA		NA		NA		NA	
Take iod.. tablets self	NA		NA		NA		NA		**0.58 $p = .001$**	**0.16, (0.26, 0.904)**
Adj.R^2 (*N*)	**0.22 (*N* = 274)**		**0.37 (*N* = 248)**		**0.50 (*N* = 75)**		**0.18 (*N* = 241)**		**0.67 (*N* = 77)**	

Note: Reference categories: female, higher post-secondary education, age category 18–29 years.Abbreviations: CI, 95% Confidence Interval; NA, Not included; Rob.*SE*, (robust)standard error.Bold values correspond to a significance value lower than 0.01.[a] Parameter estimates with robust standard errors (HC3 method). [b] Perceived effectiveness of staying indoors. [c] Category excluded because it contained only one case. [d] Multi-colinearity tests resulted in variance inflation factors (VIF) lower than 1.7, which shows limited multi-colinearity. Perceived difficulty of finding and taking an iodine tablet.

(Continued)

ANNEXE 3 (Continued)

Depend. variable	Leave area few days[a]		Refrain from local food[a]		Refrain from tap water[a]	
Indep. variables	***B* (Sig)**	**Rob.*SE*, CI**	***B* (Sig)**	**Rob.*SE*, CI**	***B* (Sig)**	**Rob.*SE*, CI**
Intercept	4.44 $p < .001$	0.53, (3.39, 5.48)	3.2 $p < .001$	0.62, (1.98, 4.42)	3.92 $p < .001$	0.61, (2.73, 5.11)
Gender Male	0.040 $p = .8$	0.13, (−0.22, 0.31)	−0.103 $p = .5$	0.14, (−0.42, 0.21)	−0.12 $p = .4$	0.14, (−0.39, 0.15)
Education Lower	−0.33 $p = .06$	0.17, (−0.67, 0.018)	0.049 $p = .8$	0.23, (−0.41, 0.51)	−0.103 $p = .6$	0.2, (−0.49, 0.28)
Higher sec.	−0.35 $p = .02$	0.17, (−0.64,−0.06)	0.031 $p = .8$	0.16, (−0.30, 0.36)	−0.14 $p = .4$	0.15, (−0.44, 0.16)
Age categ. 60+	−0.38 $p = .04$	0.18, (−0.73,−0.02)	0.062 $p = .8$	0.25, (−0.43, 0.55)	−0.129 $p = .5$	0.19, (−0.49, 0.24)
45–59	−0.13 $p = .5$	0.19, (−0.50, 0.24)	0.26 $p = .3$	0.25, (−0.23, 0.75)	−0.16 $p = .4$	0.19, (−0.53, 0.21)
30–44	0.26 $p = .08$	0.14, (−0.07, 0.54)	0.16 $p = .50$	0.26, (−0.35, 0.66)	−0.18 ($p = .3$)	0.18, (−0.53, 0.17)
Perceived social norm	**0.27 $p < .001$**	**0.071, (0.13, 0.41)**	**0.44 $p < .001$**	**0.096, (0.25, 0.63)**	**0.44 $p < .001$**	**0.101, (−0.24, 0.64)**
Perceived difficulty	**−0.15 $p = .01$**	**0.061, (−0.27, −0.03)**	−0.18 $p = .1$	0.12, (−0.43, 0.057)	**−0.21 $p = .01$**	**0.082, (−0.37, −0.049)**
Perceived effectiveness	0.094 $p = .1$	0.06, (−0.028, 0.21)	0.054 $p = .4$	0.062, (−0.06, 0.17)	NA	
Trust in authorities	NA		NA		NA	
Risk percept.	NA		NA		NA	
Feel. informed	NA		NA		NA	
Take iod. tablets self	NA		NA		NA	
Adj.R^2 (*N*)	**0.18 (*N* = 284)**		**0.15 (*N* = 281)**		**0.17 (*N* = 289)**	

Note: Reference categories: female, higher post-secondary education, age category 18–29 years.Abbreviations: CI, 95% Confidence Interval; NA, Not included; Rob.*SE*, (robust)standard error.[a] Parameter estimates with robust standard errors (HC3 method). [b] Perceived effectiveness of staying indoors. [c] Multi-colinearity tests resulted in variance inflation factors (VIF) lower than 1.7, which shows limited multi-colinearity. Category excluded because it contained only one case.

ANNEX 4

REGRESSION MODELS OF SELF-ASSESSED COMPLIANCE WITH EMERGENCY ACTIONS AMONG THE SPANISH LOCAL POPULATION

Depend. variable	Stay indoors		Avoid using phone		Leave children at school[a]		Take iodine[a]	
Indep. variables	***B* (Sig)**	***SE*, CI**	***B* (Sig)**	***SE*, CI**	***B* (Sig)**	**Rob.*SE*, CI**	***B* (Sig)**	**Rob.*SE*, CI**
Intercept	1.11 $p = .01$	0.44, (0.25, 1.97)	1.20 $p = .002$	0.39, (0.43, 1.97)	−0.075 $p = .9$	0.61, (−1.29, 1.14)	1.18 $p = .005$	0.41, (0.37, 2.00)
Gender Male	0.019 $p = .9$	0.15, (−0.28, 0.32)	−0.19 $p = .3$	0.18, (−0.54, 0.16)	−0.063 $p = .8$	0.29, (−0.63, 0.51)	0.37 $p = .02$	0.16, (0.048, 0.69)
Education Lower	0.073 $p = .5$	0.26, (−0.45, 0.59)	−0.095 $p = .8$	0.30, (−0.69, 0.50)	−0.65 $p = .2$	0.45, (−1.53, 0.24)	−0.18 $p = .6$	0.32, (−0.801, 0.45)

(Continued)

ANNEXE 4 (Continued)

Depend. variable	Stay indoors		Avoid using phone		Leave children at school[a]		Take iodine[a]	
Indep. variables	***B* (Sig)**	***SE*, CI**	***B* (Sig)**	***SE*, CI**	***B* (Sig)**	**Rob.*SE*, CI**	***B* (Sig)**	**Rob.*SE*, CI**
Higher sec.	−0.17 $p = .3$	0.15, (−0.47, 0.13)	−0.25 $p = .2$	0.18, (−0.59, 0.098)	−0.23 $p = .4$	0.28, (−0.79, 0.33)	−0.15 $p = .4$	0.16, (−0.46, 0.17)
Age categ. 60+	−0.55 $p = .09$	0.32, (−1.19, 0.095)	−0.51 $p = .2$	0.38, (−1.26, 0.24)	c	c	−0.68 $p = .09$	0.398, (−1.46, 0.108)
45–59	−0.20 $p = .3$	0.21, (−0.62, 0.21)	−0.39 $p = .1$	0.25, (−0.87, 0.092)	0.21 $p = .7$	0.53, (−0.85, 1.27)	−0.28 $p = .3$	0.2, (−0.78, 0.22)
30–44	0.024 $p = .9$	0.18, (−0.34, 0.38)	−0.22 $p = .3$	0.21, (−0.64, 0.195)	−0.011 $p = .9$	0.48, (−0.96, 0.94)	−0.33 $p = .2$	0.23, (−0.78, 0.13)
Perceived social norm	**0.18 $p = .004$**	**0.062, (0.058, 0.303)**	**0.30 $p < .001$**	**0.063, (0.19, 0.42)**	**0.43 $p = .007$**	**0.15, (0.12, 0.74)**	**0.55 $p < .001$**	**0.11, (0.34, 0.77)**
Perceived difficulty	**−0.42 $p < .001$**	**0.069, (0.28, 0.56)**	**−0.44 $p < .001$**	**0.073, (0.29, 0.58)**	−0.46 $p = .02$	0.19, (0.078, 0.84)	−0.10 $p = .2$	0.084, (−0.066, 0.27)
Perceived effectiveness	**0.31 $p < .001$**	**0.077, (0.16, 0.46)**	NA		0.040[b] $p = .8$	0.14, (−0.25, 0.33)	0.17 $p = .1$	0.11, (−0.047, 0.38)
Trust in authorities	**0.18 $p = .003$**	**0.060, (0.064, 0.30)**	**0.202 $p = .002$**	**0.063, (0.077, 0.33)**	NA		0.12 $p = .11$	0.072, (−0.026, 0.26)
Risk percept. accident	−0.101 $p = .05$	0.051, (−0.20, −0.001)	NA		NA		NA	
Feeling informed	NA		NA		0.27 ($p = .04$)	0.13, (0.017, 0.52)	NA	
Adj.R^2 (N)	**0.45 ($N = 251$)**		**0.30 ($N = 257$)**		**0.54 ($N = 77$)**		**0.40 ($N = 218$)**	

Note: Reference categories: female, higher post-secondary education, age category 18–29 years.Abbreviations: CI, 95% Confidence Interval; NA, Not included; Rob.*SE*, (robust)standard error.Bold values correspond to a significance value lower than 0.01.[a] Parameter estimates with robust standard errors (HC3 method). [b] Perceived effectiveness of staying indoors. [c] Multi-colinearity tests resulted in variance inflation factors (VIF) lower than 1.7, which shows limited multi-colinearity. Category excluded because it contained only one case.

Depend. variable	Leave area few days[a]		Refrain from local food[a]		Refrain from tap water[a]	
Indep. variables	***B* (Sig)**	**Rob.*SE*, CI**	***B* (Sig)**	**Rob.*SE*, CI**	***B* (Sig)**	**Rob.*SE*, CI**
Intercept	2.68 $p < .001$	0.46, (1.77, 3.59)	1.17 $p = .1$	0.47, (0.24, 2.101)	1.17 $p = .002$	0.54, (0.62, 2.77)
Gender Male	−0.076 $p = .6$	0.14, (−0.34, 0.19)	0.26 $p = .1$	0.16, (−0.061, 0.58)	−0.24 $p = .2$	0.18, (−0.59, 0.11)
Education Lower	0.049 $p = .9$	0.33, (−0.59, 0.69)	−0.209 $p = .5$	0.29, (−0.79, 0.37)	0.029 $p = .9$	0.27, (−0.49, 0.55)
Higher sec.	−0.13 $p = .3$	0.12, (−0.36, 0.11)	−0.17 $p = .3$	0.17, (−0.503, 0.15)	−0.34 $p = .03$	0.15, (−0.64, −0.041)
Age categ. 60+	−0.58 $p = .09$	0.34, (−1.25, 0.097)	−0.86 $p = .06$	0.45, (−1.74, 0.024)	−0.013 $p = .9$	0.31, (−0.62, −0.59)
45–59	−0.34 $p = .04$	0.17, (−0.67, −0.008)	0.025 $p = .9$	0.24, (−0.46, 0.51)	−0.031 $p = .9$	0.23, (−0.48, 0.42)
30–44	−0.19 $p = .2$	0.15, (−0.49, 0.096)	−0.050 $p = .8$	0.23, (−0.50, 0.401)	−0.019 $p = .9$	0.21, (−0.43, 0.39)

(Continues)

ANNEXE 4 (Continued)

Depend. variable	Leave area few days[a]		Refrain from local food[a]		Refrain from tap water[a]	
Indep. variables	***B* (Sig)**	**Rob.*SE*, CI**	***B* (Sig)**	**Rob.*SE*, CI**	***B* (Sig)**	**Rob.*SE*, CI**
Perceived social norm	**0.22 $p = .001$**	**0.068, (0.089, 0.36)**	**0.29 $p = .004$**	**0.098, (0.094, 0.48)**	**0.23 $p = .006$**	**0.084, (0.066, 0.40)**
Perceived difficulty	**−0.25 $p = .001$**	**0.075, (0.104, 0.4)**	**−0.37 $p = .001$**	**0.11, (0.15, 0.59)**	**−0.35 $p = .001$**	**0.101, (0.15, 0.55)**
Perceived effectiveness	**0.302 $p = .001$**	**0.094, (0.12, 0.49)**	**0.28 $p = .009$**	**0.106, (0.071, 0.49)**	**0.34 $p = .002$**	**0.108, (0.12, 0.55)**
Trust in authorities	NA		0.077 $p = .3$	0.074, (−0.07, 0.22)	0.061 $p = .4$	0.069, (−0.075, 0.20)
Risk percept. accident	NA		NA		NA	
Feeling informed	**−0.23 $p = .002$**	**0.074, (−0.37, −0.09)**	−0.16 $p = .03$	0.072, (−0.30, −0.018)	−0.16 $p = .05$	0.084, (−0.33, 0.001)
Adj.R^2 (*N*)	**0.29 ($N = 273$)**		**0.34 ($N = 251$)**		**0.34 ($N = 254$)**	

Note: Reference categories: female, higher post-secondary education, age category 18–29 years.Abbreviations: CI, 95% confidence Interval; NA, Not included; Rob.*SE*, (robust)standard error.[a] Parameter estimates with robust standard errors (HC3 method). [b] Multi-colinearity tests resulted in variance inflation factors (VIF) lower than 1.7, which shows limited multi-colinearity. Perceived effectiveness of staying indoors.