 DOI: 10.1111/risa.12618

Information Sources as Explanatory Variables for the Belgian Health-Related Risk Perception of the Fukushima Nuclear Accident

Bart Vyncke,[1,*] Tanja Perko,[2] and Baldwin Van Gorp[1]

The media play an important role in risk communication, providing information about accidents, both nearby and far away. Each media source has its own presentation style, which could influence how the audience perceives the presented risk. This study investigates the explanatory power of 12 information sources (traditional media, new media, social media, and interpersonal communication) for the perceived risk posed by radiation released from the damaged Fukushima nuclear power plant on respondents' own health and that of the population in general. The analysis controlled for attitude toward nuclear energy, gender, education, satisfaction with the media coverage, and duration of attention paid to the coverage. The study uses a large empirical data set from a public opinion survey, which is representative for the Belgian population with respect to six sociodemographic variables. Results show that three information sources are significant regressors of perceived health-related risk of the nuclear accident: television, interpersonal communication, and the category of miscellaneous online sources. More favorable attitudes toward nuclear power, longer attention to the coverage, and higher satisfaction with the provided information lead to lower risk perception. Taken together, the results suggest that the media can indeed have a modest influence on how the audience perceives a risk.

KEY WORDS: Fukushima nuclear accident; new media; risk perception; social media; traditional media

1. INTRODUCTION

Fortunately, major nuclear accidents do not occur often. Unfortunately, this means that research regarding how the public perceives the risk of actual nuclear accidents, and how these perceptions are shaped, is also comparatively rare. Although risk is essentially all about probabilities,[1] people rarely use statistical methods when making judgments about risks in daily life.[2] *Risk perception*—also called *risk judgment*[3,4]—signifies the phenomenon that people take into account various other factors when assessing risks.[4,5] These factors are often qualitative in nature.[1,5,6] As a result, people can worry a lot about comparatively minor or very unlikely risks, while ignoring things that really threaten them. Major events, such as the 2011 Fukushima nuclear accident, can quickly make people aware of the prominence of a risk, and can make them more afraid even though the probabilities have not changed.

The media play an important role in risk communication.[5,7–9] They provide the public with information about what happened. However, by doing so, they may also influence their audience. This can happen on purpose (with biased articles), but also unknowingly. Kasperson *et al.*[5] pointed to

[1]KU Leuven, Institute for Media Studies, Leuven, Belgium.
[2]Belgian Nuclear Research Centre SCK•CEN, Society and Policy Support, Mol, Belgium.
[*]Address correspondence to Bart Vyncke, KU Leuven, Institute for Media Studies, Parkstraat 45 – bus 3603, 3000 Leuven, Belgium; tel: +32-16-37-25-84; bart.vyncke@soc.kuleuven.be.

the possibility that each transmitter of information will change the original message by intensifying, weakening, and/or filtering parts of it. As such, media are not just neutral intermediaries: they will change the information in the process, and this might influence the recipients of their messages. It is plausible that the unique characteristics of different media sources (regardless of content) may lead to different effects on their audience as well—which was already articulated in the much-quoted catchphrase "the medium is the message."[10]

The Fukushima nuclear accident offered a unique opportunity to study the effects that different media sources can have on the risk perception of actual nuclear accidents. Previous research on this topic is rare, often uses convenience samples, and generally studies only a limited number of media sources. This study, however, included 11 media sources (including traditional media, new media, and social media) and interpersonal communication, using a large sample that was representative for the Belgian population.

This study investigated whether media use during the Fukushima nuclear accident in 2011 had explanatory power for the long-term risk perception in 2013, several years after the accident. More specifically, it explored the risk that respondents thought the radiation released from the damaged Japanese plant would have on their own health and on that of the general population. For example, the audience might believe that the radiation from Fukushima could increase the number of cancers in Belgium, even though research on the airborne fallout of Fukushima found that there was no concern for public health due to airborne activity levels in Europe.[11]

Belgium is an interesting case, notwithstanding the large distance between the country and Fukushima. Nuclear energy has been on the Belgian public agenda for a while: in 2003, Belgium decided to phase out nuclear energy, but at the time of the accident it still had seven operational reactors. In the following years, the Belgian government has been looking to prolong the lifespan of three nuclear power plants with 10 years, instead of decommissioning them in 2015 as originally planned.[12,13] The Belgian public is also divided, with 27% in favor of nuclear energy, and 32% opposing it. Thirty-eight percent is neither in favor nor opposed to nuclear energy.[14] Clearly, Belgium has a mixed relationship with nuclear energy, which makes it an interesting case study. Furthermore, the distance from the site of the nuclear accident provides the opportunity to compare the media use and effects of the indirectly affected Belgian population with available data from the directly affected population.[15]

2. LITERATURE REVIEW

2.1. Media Sources: Fostering Our Actual and Imagined Fears?

As the mass media are by definition capable of reaching a large number of people simultaneously,[16] it is not surprising that they play an important role in risk communication.[5,7–9] Each media source has distinctive characteristics that might affect risk perception, such as their perceived trustworthiness, their level of interactivity, linearity, etc. In other words, the same message, delivered through different sources, could affect risk perception in different ways as a result of the unique characteristics of the source. If that is the case, risk communicators do not only have to focus on *what* they are saying, but also on *how* they are spreading their message.

Previous studies have provided some support for the hypothesis that media sources can have an influence on risk perception. Coleman[4] studied the influence of four media sources (newspapers, magazines, books, and television) on risk perception in New York State. She found that media sources have a limited influence on both personal and voluntary societal risk. Interpersonal communication had significant influence on involuntary societal risk.

Research conducted in Japan regarding the Fukushima nuclear accident found that there were pronounced differences in the fears people had, depending on the kind of media they used as their source of information.[15] Those who listened to rumors were more fearful of the possible effects of radiation on their health. Readers of regional newspapers were more worried about the prospects for the future, whereas those who read the national newspapers were less worried. Respondents who listened to radio news were more fearful of social disruption breaking out in the aftermath of the accident. Neither television nor Internet use showed any significant correlations with either of these concerns. It is important to note, however, that these particular results are inherently linked to the Japanese context: for example, it is known that Japanese national newspapers tend to avoid controversies in order to protect the consensus and the harmony of Japanese society.[17] Furthermore, the directly affected

Japanese respondents could have "decoded" the coverage in a different way than the Belgians, as different audiences interpret media messages in a different way, in accordance with local context or culture.[18–20]

> **RQ1:** Which information sources that were used by the Belgian population to get informed during the 2011 Fukushima nuclear accident have statistically significant explanatory power for the long-term health-related risk perception in Belgium?

2.1.1. Traditional Media: Newspapers, Television, and Radio

Both in times of crisis and in regular circumstances, an important role of newspapers is to provide the public with greater detail than what the other, "faster" media are able to. This was also true in the case of the Fukushima nuclear accident. Newspapers and their associated websites often used infographics, multimedia, and explanatory articles written by experts to inform their audience.[21] The use of infographics and other kinds of visuals could influence the readers. If an article is accompanied by a visual, the audience is significantly more likely to read it, and to read it with more attention. If the image shows impending danger or damage caused by a threat, the audience recalls more information from the text.[22] In covering the Fukushima story, newspapers also provided ample opinion pieces by different stakeholders,[23] providing their audience a broader context and different perspectives on the disaster. However, research has shown that newspapers could increase personal risk perception for those who are highly dependent on newspapers for health information.[24]

Research on a large sample of Belgians showed that television news is both the most used source of information in Belgium, and the most trusted.[25] In 2011, Belgians still largely relied on their own channels and those of their neighboring countries. In Flanders, "Other TV-channels (non-Dutch)" only had a market share of 6.5%; in Wallonia, "Other TV-channels (non-French)" had a market share of 6.1%.[26] Television news differs from newspaper news in different respects that can be important for crisis communication. Frewer *et al.*[27] state that although readers of newspapers have the choice not to read a certain article if it does not capture their interest, television viewers do not have the same freedom: if a topic is featured in television news, the audience cannot help but watch it. Henning and Vorderer[28] suggest that this "linearity" would also make it more difficult for the viewers to think autonomously, because they cannot pause the broadcast to ponder upon the content. Third, because of time constraints, television is not able to give the same extensive background and context that newspapers provide.[21] Television tells the public a hazard exists, but gives little background information beyond that.[27, p. 20] Finally, the effects of the moving images on television could be more outspoken than those of the static images in print. According to Reeves and Nass,[29] the audience pays even more attention to a moving image than to a still one and attributes more importance to vivid information. Furthermore, they demonstrated that some types of movement (such as images "coming closer") could make viewers feel threatened. Aust and Zillmann[30] found that television reports featuring upset victims cause the public to rate the presented risk as more dangerous to both themselves and people in general.

After television, radio was the second most used and second most trusted media source in Belgium. Furthermore, over 75% of Belgians state they would consult radio as a news source in case of a nuclear accident.[25] Similar to television, radio news is linear, preventing the listeners from choosing what news to pay attention to. However, it misses the visuals that make television more engaging.

2.1.2. The Internet: New and Social Media

The Internet gave rise to both great opportunities and problems for risk communication: it all but nullified the gate-keeping function of the traditional media, and gives unconventional experts a platform to distribute understandable information to the public, which can interact with these experts and among themselves.[21,31] The International Atomic Energy Agency[32] advised public information officers that in the case of a nuclear emergency, risk communication is most likely to succeed when communication is a two-way process. As the possibility of interaction and two-way communication is a main feature of social media,[33] it is reasonable to assume that social media would be highly effective in managing risk perception. However, the Internet also helps the spread of misinformation because of the very rapid news cycle it demands—with little room for fact checking—and by giving a voice to people who may not have the necessary knowledge to

accurately discuss complex issues. In addition, once information, correct or false, goes viral, few bother to check its accuracy.[21,31] Given these potential problems, it is perhaps not surprising that the public is wary when it comes to Internet sources such as social media, judging them to be significantly less credible than other media sources.[33,34] This perception might not match reality when considering the case of Fukushima. Worldwide, Tweets that were tagged with #fukushima often cited highly reliable sources.[34]

YouTube is the third most accessed site on the Internet, according to Alexa.com (October 1, 2014). As such, it could play a major role in risk communication as well. However, research suggests that a majority of YouTube clips can be classified as "entertainment," with only a small amount of videos in the categories of "News & Politics," "Education," and "Science & Technology."[35] Similarly, the share of college students that had watched at least some comedy-format news shows was somewhat larger than the share of people that had watched at least some traditional news shows on YouTube. The sharing rate was also higher for "comedy" news than for traditional news.[36] However, other research[37] has shown that even entertainment programs can increase risk perception. As of yet, it is still unclear how YouTube clips will influence risk perception.

2.1.3. Interpersonal Communication

Although the different media sources have transformed the way in which risks are communicated, interpersonal communication still plays an important role in the diffusion of high-impact stories: people will likely continue to talk with each other about important news events. Although information received from interpersonal communication might not be as detailed as information from the mass media, people still seem to attribute greater trustworthiness to information they heard from others, compared to information from a media source.[38]

There has been little research on the influence of interpersonal communication on risk perception.[39] However, the existing literature shows that it could have an influence on both personal risk[24] and societal risk.[4,39] For example, Binder *et al.*[39] found that interpersonal discussion increased the risk perception of a biological research facility: opponents or people neutral to the facility had higher risk perception when they had talked about the facility "often." Furthermore, the interlocutor also had a role in shaping risk perception: people who had last talked with an opponent experienced higher risk.

2.2. Duration of Attention Paid to the News

Wåhlberg and Sjöberg[3] point to the availability heuristic as a theory often used in explaining risk perception: the easier one can recall a certain event happening, the more probable one will judge the likelihood of that event happening again. Extensive media coverage is one way in which events could become easier to recall,[40] which would lead to people overestimating the probability of that kind of event.[1,9] The fact that the Fukushima nuclear accident was compared to the Chernobyl nuclear accident in both the United States[41] and the European Union[42] can remind the public that there have been multiple large-scale nuclear accidents in the past. As a result, the consideration that a major accident is possible would become more "accessible" to the public, increasing their estimation of the risk. This would especially be the case for people who paid attention to the news for a long period of time because they will have heard a larger number of references to both major nuclear accidents.

> **H1:** People who followed the news about the Fukushima nuclear accident for a longer period of time have a statistically significantly higher risk perception than people who followed it for a shorter amount of time.

2.3. Satisfaction with Media Coverage

The role of the media in risk communication is—first and foremost—to provide the public with information. The Chernobyl nuclear accident demonstrates that a lack of information during a crisis situation creates uncertainty, which in turn exacerbates existing fear and stress.[43,44]

Even if information is available and accessible, the public may still not find it satisfactory. For example, during the Fukushima nuclear accident, the provided information did not suit the needs of parents in Japan, which led them to experience higher anxiety.[45]

Even if the population is not directly affected by the nuclear accident, satisfactory media coverage would probably prevent respondents from experiencing unnecessary uncertainty, anxiety, and stress, which would lower their perceived risk.

H2: Those who indicate higher levels of satisfaction with the media coverage about the Fukushima nuclear accident have a statistically significantly lower risk perception of it, compared to people who are less satisfied.

2.4. Context Variables

Based on existing literature, attitudes toward nuclear energy in general,[46–48] gender,[45,49–51] and education[2,4,52,53] can also have an influence on risk perception, so these variables were added to the analyses in order to test the influence of media sources in the wider context of risk perception.

H3: When controlling for the media-related independent variables, attitudes toward nuclear energy, education, and gender will have statistically significant explanatory power for long-term health-related risk perception.

3. METHODOLOGY

This study was conducted using empirical data from the SCK•CEN Barometer 2013,[14] the fifth edition of a regular public opinion survey regarding nuclear energy, commissioned by the Belgian Nuclear Research Center (SCK•CEN). A company specialized in opinion research conducted computer-assisted personal interviews in all 10 Belgian provinces, between August 15 and September 12, 2013. The Fukushima nuclear accident was still featured in the news when the fieldwork was conducted, with 196 articles featuring "Fukushima" published in all Belgian newspapers (search conducted on February 26, 2014, using academic.gopress.be).

To gather representative data, a list of all Belgian municipalities was first divided into a total of 44 strata. For each of these, an address was randomly selected. The data were then gathered using a random walk method, selecting each *n*th household.[14] All interviews took place in the respondent's home, and lasted for an average of 35 minutes. The questionnaire gauged respondents' attitude toward and knowledge about nuclear energy, and trust in and knowledge about several actors in the nuclear field. Finally, a section was devoted to the Fukushima nuclear accident, with questions regarding perception of the accident, solidarity with the victims, media use, and attitude toward contaminated foods and goods. Most questions had respondents answering using a Likert scale, with an option to not answer. Within most question sets, there was randomization of the question order to combat order effects.

A total of 1,002 respondents were interviewed face-to-face, in Dutch or French. After a weighing procedure, the sample was representative of the adult Belgian population with respect to gender, age, region, size of locality, education, professional activity, and the size of household. All results reported in this article made use of the weighed sample.

Of the total sample, 64 respondents (6.4%) were not aware of the nuclear accident that happened in Fukushima. This group contained more women, $\chi^2(1; N = 1002) = 11.37$, $p = 0.001$, and was more likely to have no degree or only to have finished elementary school, $\chi^2(8, N = 999) = 54.23$, $p < 0.001$. They were more likely to live in Flanders, $\chi^2(2, N = 1002) = 21.65$, $p < 0.001$, and to have less members in their household ($M = 2.46$, $SD = 1.34$) compared to those who were aware of the accident ($M = 2.82$, $SD = 1.35$), $t(1000) = 2.09$, $p = 0.037$. There were no significant differences with respect to age, $t(68.662) = 0.779$, $p = 0.439$, the level of urbanization of their municipality of residence, $\chi^2(3, N = 1002) = 1.76$, $p = 0.623$, or their income levels, $\chi^2(2; N = 1002) = 3.66$, $p = 0.160$. Because these respondents were not asked any further questions regarding their media use during the coverage of the Fukushima nuclear accident, they were not taken into account in this study. This left a total of 938 valid respondents for analysis.

3.1. Operationalization

The designation of an *information source as important* was operationalized as a dichotomous variable. Respondents were presented with a list and they could indicate one or more information sources that had been important in informing them about the nuclear accident. Those who selected "Internet" as one of their initial choices were then presented with another list with the various Internet sources, from which they could select multiple answers. Again, these variables were operationalized as dichotomous variables.

For the dependent variable, *risk perception* of the Fukushima nuclear accident, a scale was constructed using principal component analysis with oblimin with Kaiser normalization. The analysis revealed three factors. The first factor was labeled "health-related risk perception," and consisted of three questions (Table I). It explained 18.00% of the

Table I. Factor Loadings

Indicator	Health-Related Risk Perception	Risk in Japan	Worse than Official Accounts
How do you evaluate the risk to your health in the near or far future due to the radiation from the Fukushima accident?	**0.89**	−0.06	0.17
How do you perceive the risk to your health in the near or far future due to the radioactivity in food or other products from Japan?	**0.81**	0.07	0.21
Due to the Fukushima accident, the number of cancers in Belgium will increase.	**0.77**	0.13	0.04
In certain areas of Japan there are serious problems with radioactive contamination.	−0.01	**0.86**	0.12
Children in Japan will have serious health problems due to the nuclear accident.	0.26	**0.78**	0.20
A nuclear accident as serious as the Fukushima one will never happen in Belgium.	−0.12	−0.19	**−0.73**
The problems of the population in Fukushima are mainly due to the earthquake and tsunami, not the radioactivity.	0.00	−0.18	**−0.58**
The radioactive deposition in Belgium due to the Fukushima accident was far less important than that from the Chernobyl accident.	0.35	−0.28	**0.48**
The Belgian government agencies have always told the truth during the Fukushima accident.	−0.15	0.01	**−0.77**
Scientific reports of international organizations tell the truth about the situation in Fukushima.	−0.15	−0.05	**−0.77**

Note: Principal component analysis with oblimin with Kaiser normalization. Loadings greater than 0.4 are indicated in boldface.

variance, and it had good internal consistency (Cronbach's alpha = 0.794). The second factor explained 14.30% of the variance, and consisted of two items, both of which focused on Japan. As a result, this factor was labeled "perception of risk in Japan." This factor had a lower internal consistency (Cronbach's alpha = 0.650). The focus of the third factor was less clear. As it consisted of various statements that doubted the official account, and feared that a major accident could also happen in Belgium, the factor was labeled "Fear that the accident was worse than the official accounts presented." It explained 27.94% of the variance, and had a Cronbach's alpha of 0.683 when the negatively loaded items were reverse coded. The questions regarding risk perception were based on similar questions in previous editions of the SCK Barometer,[25,54] but were adapted so they referred to the Fukushima nuclear accident. The topics they dealt with may have been present in Belgian news, but probably only in a limited amount. Only 15% of articles about the nuclear accident that were published in two Belgian newspapers (*De Standaard* and *Le Soir*) in the first two months after the accident, had Belgium as the country of concern.[23]

The factor regarding *health-related risk perception* was chosen since it had good internal consistency and focused on the own health of the respondents themselves and that of Belgians in general. It accounted for 70.95% of the variance of the included items. The item regarding cancer was measured from 1 ("strongly disagree") to 5 ("strongly agree"), but the two others were measured from 1 ("no risk at all") to 6 ("very high risk"). As the items used different scales, internal reliability was measured using the factor scores. Each component in the scale of health-related risk perception had a factor loading of 0.77 or higher (see Table I). A low score on the scale signified a low risk perception of the Fukushima nuclear accident.

Satisfaction of respondents with the information they got from the media was measured using a single question: "In general, how satisfied were you with the information you got about the (Fukushima) accident?" How long respondents followed the news about the nuclear accident (*duration of*

Table II. Descriptive Statistics of the Variables Measured by Likert Scales

	Likert Scale Range	*M (SD)*	*N*
Satisfaction with media coverage	1 (Very unsatisfied) 5 (Very satisfied)	3.31 (0.92)	923
Duration of attention	1 (Did not follow at all) 6 (Still following)	3.73 (1.57)	931
Attitude toward nuclear power	1 (Totally in favor) 5 (Totally against)	3.12 (0.97)	922

attention), was also measured using a single question: "How long did you pay attention to news about the Fukushima accident?" The *attitude toward nuclear power* was measured using the answers to "What is your opinion on nuclear energy?" Table II gives a more detailed overview of these variables, including the Likert-scale ranges and descriptive statistics.

3.2. Analysis Procedures

The explanatory power of the information sources for the long-term health-related risk perception was calculated using two linear regression analyses. The first analysis was limited to the broad categories of information sources (i.e., television, radio, newspapers, Internet, and interpersonal communication—hereinafter referred to as "primary information sources"). As the Fukushima nuclear accident was the first major nuclear accident in the Internet age,[21,45] a second analysis focused on the different information sources on the Internet. This second analysis was not combined with the first because only 280 respondents answered the contingency question, compared with 938 responses for the primary information sources. Combining the two analyses would therefore result in significantly lower statistical power.

Satisfaction with the coverage and duration of attention were included in both analyses, as were attitude toward nuclear energy, gender, and education. The sample contained slightly more women (50.2%) than men. Education was recoded to have three levels. The lowest level of education consisted of respondents with no degree, an elementary level degree, or a lower secondary degree (27.9% of the sample). The intermediate level (40.7%) consisted of people with a higher secondary level degree, whereas respondents in the high level (31.4%) held a higher education degree, either from a university or nonuniversity higher education.

Table III. Percentage of Respondents that Indicated the Primary Information Sources as Having Been Important for Them (Multiple Answers Possible)

	Percentage
Television	93.4
Radio	49.6
Newspapers	48.5
Internet	29.8
Interpersonal communication	16.2
$N = 938$	

Note: Measured as a percentage of all valid respondents; nonexclusive options.

Table IV. Percentage of Internet Users that Indicated the Online Information Sources as Having Been Important for Them (Multiple Answers Possible)

	Percentage of Internet Users
Online newspapers	84.0
TV and radio station websites	49.9
(Non-)governmental agencies websites	27.6
Facebook	26.4
Blogs	10.2
Others (e.g., YouTube)	8.9
Twitter	3.3
$N = 280$	

Note: Measured as a percentage of all Internet users; nonexclusive options.

4. RESULTS

4.1. Media as Important Information Sources

The media played an important role in informing the Belgian public about the nuclear accident in Fukushima. Which information sources were most widely named as important is shown in Tables III and IV. The existence of a multimedia society is also apparent from the results: 66.6% of respondents indicated more than one important source of information about the accident. On average, people

indicated 2.38 important information sources ($SD = 1.21$) in their search for information about the accident. However, 25.04% of the total sample indicated that television was their only important source of information.

Similar results appear for the online media sources: 63.9% of Internet users named more than one important online information source, with an average of 2.10 ($SD = 1.07$). However, the distribution is skewed: none of the respondents answered that all seven response options had been important to them, and only 10.2% of the audience had used more than three.

4.2. Influencing Factors of Long-Term Health-Related Nuclear Risk Perception

The relationship between the information sources and risk perception was analyzed using a linear regression analysis, $R^2 = 0.173$, $F(11,816) = 15.54$, $p < 0.001$ (see Table V for results). The dependent variable was the factor scale of the risk perception of the Fukushima nuclear accident. The independent variables were all entered in the analysis at the same time, and there were no problems with multicollinearity.

The factor score could not be calculated for 90 cases. As a result, these could not be included in the analysis. Compared to the cases for which the factor score could be calculated, these missing cases did not differ significantly in their attitude toward nuclear energy, $\chi^2(4, N = 924) = 4.98$, $p = 0.290$; education level, $\chi^2(2, N = 940) = 0.80$, $p = 0.670$); duration of attention paid to the coverage, $\chi^2(5, N = 931) = 4.88$, $p = 0.431$; or satisfaction with the coverage, $\chi^2(4, N = 922) = 4.81$, $p = 0.308$. There was, however, a significant difference in gender, $\chi^2(1, N = 938) = 4.73$, $p = 0.030$): the group for which the factor score could not be calculated contained significantly more women than expected.

Out of the five primary information sources studied, only two turned out to be significant regressors of the risk perception of the Fukushima nuclear accident: having used television ($\beta = 0.083$, $p = 0.018$) or interpersonal communication ($\beta = 0.117$, $p < 0.001$) as an important source of information in 2011 led to higher risk perception in 2013.

With the exception of gender, all other variables included in the analysis were significant regressors. The duration of attention paid to the media coverage was significant, but in the opposite direction than H1 predicted ($\beta = -0.073$, $p = 0.029$): respondents who paid attention to the news about Fukushima for a longer period of time had a lower risk perception. As predicted by H2, higher satisfaction with the media coverage was associated with lower risk perception ($\beta = -0.118$, $p < 0.001$). Attitude toward nuclear energy was the most influential regressor ($\beta = 0.291$, $p < 0.001$): people who have a positive attitude toward nuclear power had a lower risk perception. Education had the second highest regression coefficient ($\beta = -0.135$, $p < 0.001$): people with a higher level of education did have lower risk perception, compared to those with a lower level of education. This provides limited support for H3, with two out of three context variables being significant regressors.

An additional regression analysis was run for the different Internet sources, $R^2 = 0.211$, $F(12,244) = 5.46$, $p < 0.001$ (see Table VI for results). Once again, all variables were entered at the same time and there were no problems with multicollinearity.

Only one Internet source had significant explanatory power. "Other sources, such as YouTube" had a highly significant negative β-coefficient (-0.186, $p = 0.002$). Attitude toward nuclear energy turned out to be the strongest regressor ($\beta = 0.229$, $p < 0.001$), followed by satisfaction with media coverage ($\beta = -0.204$, $p = 0.001$), providing support for H2. Gender became a significant regressor online: women had a significantly higher risk perception than men ($\beta = 0.151, p = 0.01$). Again, H3 received limited support, with two out of the three context variables being significant. Both educational level and duration of attention lost their explanatory power, but educational level did approach significance ($\beta = -0.114$, $p = 0.058$).

5. DISCUSSION

This study set out to investigate the explanatory power of 12 information sources on the Belgian long-term risk perception of the Fukushima nuclear accident, about 2.5 years after it occurred, and aimed to contribute to the understanding of the relationship between media and risk perception in several different ways. First, because a representative data set was used, the results would be perceived as more easily generalized. Second, this study considered the effects on perceived risk of an *actual* nuclear accident, rather than a hypothetical one. Finally, a whole range of information sources was included in the analyses, instead of focusing on just a couple. This is especially important because the media

Table V. Explanatory Power of Primary Information Sources for Risk Perception

Model: Risk Perception of the 2011 Fukushima Nuclear Accident			
Explanatory Variable	*B* (*SE*)	*β*	*p*
Gender	0.110 (0.064)	0.055	
Attitude toward nuclear energy	0.299 (0.034)	0.291	***
Education	−0.176 (0.044)	−0.135	***
Duration of attention paid to media coverage	−0.047 (0.022)	−0.073	*
Satisfaction with media coverage	−0.127 (0.035)	−0.118	***
Media source: Television	0.353 (0.149)	0.083	*
Media source: Radio	0.049 (0.068)	0.024	
Media source: Newspapers	−0.103 (0.070)	−0.052	
Media source: Internet	−0.036 (0.074)	−0.017	
Interpersonal communication	0.310 (0.088)	0.117	***
None of the above	0.546 (0.377)	0.050	
Constant	−0.485 (0.271)		
$N = 828$			
Adjusted $R^2 = 0.162$			

Note: Linear regression analysis; dependent variable: factor scores of risk perception of the 2011 Fukushima nuclear accident. All variables were entered in the same block. *B*, unstandardized *β* coefficient; *β*, standardized *β* coefficient.
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$.

Table VI. Explanatory Power of Online Information Sources for Risk Perception

Model: Risk Perception of the 2011 Fukushima Nuclear Accident			
Explanatory Variable	*B* (*SE*)	*β*	*p*
Gender	0.292 (0.113)	0.151	**
Attitude toward nuclear energy	0.226 (0.059)	0.229	***
Education	−0.156 (0.082)	−0.114	
Duration of attention paid to media coverage	−0.064 (0.040)	−0.100	
Satisfaction with media coverage	−0.211 (0.061)	−0.204	***
Media source: Online newspapers	0.107 (0.160)	0.040	
Media source: TV and radio station websites	−0.041 (0.116)	−0.021	
Media source: (Non-)governmental agencies websites	0.202 (0.131)	0.094	
Social medium: Twitter	0.112 (0.328)	0.021	
Social medium: Facebook	0.092 (0.136)	0.042	
Social medium: Blogs	−0.206 (0.195)	−0.066	
Media source: Others (e.g., YouTube)	−0.647 (0.208)	−0.186	**
Constant	0.039 (0.417)		
$N = 257$			
Adjusted $R^2 = 0.173$			

Note: Linear regression analysis; dependent variable: factor scores of risk perception of the 2011 Fukushima nuclear accident. All variables were entered in the same block. *B*, unstandardized *β* coefficient; *β*, standardized *β* coefficient.
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$.

landscape has changed dramatically since the inception of research on risk perception.

Television clearly has become an ubiquitous medium, with as many as 93.4% of the valid respondents in this study identifying television as an important medium for informing themselves about the nuclear accident. Television use in Belgium was significantly related to higher risk perception, but this relationship was by no means very strong. The literature explained the relationship between the use of television and higher risk perception in different ways, with some studies linking it to the availability heuristic[27] and others to the visuals and the structure of television news.[4] Alternatively, the explanation could lie in the distinctive characteristics of the respondents who did not identify television

as a major source of information. For example, students with a high need for cognition watch less television.[28] People with a high need for cognition will also be more motivated to process the information systematically,[55] and thus to base their opinion on factual information. This will possibly make them less dependent on heuristics, similar to what the effect of education is assumed to be.[9]

Another major development is the rise of the Internet. The Fukushima nuclear accident was the first major accident in the Internet age, which has changed the risk communication paradigm completely:[21,45] audiences have access to a whole range of alternative sources of information, and risk communicators and news outlets are faced with new challenges and possibilities to reach their audience.[21,31,32] Even though a great deal of research has been conducted on Twitter use during and after the Fukushima nuclear accident,[33,34] the studied population did not use Twitter as an important information source at that time. Perhaps the rather low usage was due to the audience not perceiving social media as being as credible as newspapers,[33] for instance.

The category of miscellaneous online sources had a significant negative relationship with risk perception, possibly offering an opportunity for risk communicators. Although the category is vague, it is quite likely that YouTube was the most important component, given its prominence online. Although entertainment can increase risk perception,[37] this does not seem to be the case with YouTube, perhaps because YouTube clips differ greatly from traditional videos.[35] Unfortunately, this study can only indicate the possible importance of YouTube.

The other two traditional media, printed newspapers and radio, failed to reach significance as regressors of risk perception in Belgium. The lack of effect of newspapers on risk perception is perhaps attributable to the balanced reporting on the subject. Media content analyses of the Belgian press revealed that a majority of newspaper articles were neutral toward nuclear energy. This was the case both for the first two months after the accident[23] and a year after the accident.[42]

Sugimoto *et al.*[15] found that radio was an important regressor for fear of social disruption in Japan, but this result was not replicated in this study. In contrast to Japan, radio is not the central risk communicating medium in Belgium,[25] which could explain the lack of effect. Alternatively, the difference could also be due to the audience,[18–20] as the Belgian respondents were not directly affected by the nuclear accident, whereas the respondents of Sugimoto *et al.* all lived fairly close to the Fukushima nuclear power plant. A third possible explanation could be the lack of visuals when compared to television. Even though radio news is similar to television news with respect to its linearity and structure, visuals are one major aspect in which it differs.

Finally, interpersonal communication was also a significant regressor of risk perception when used as an important source of information. As the dependent variable *risk perception* was made up of both personal and societal risk judgment, this result is in line with previous research, which had found that interpersonal communication has significant influence on both personal risk[24] and societal risk.[4,39]

In response to the first research question, the results show that three information sources have significant explanatory power for long-term health-related risk perception in Belgium when they were used as important sources of information: television, interpersonal communication, and miscellaneous Internet sources. Even so, their βs were small when compared to some of the other variables entered in the analysis, such as attitudes toward nuclear power. However, combined with the significant explanatory power of satisfaction with the media coverage, it is evident that the media indeed play a role in explaining risk perception.

5.1. Other Regressors of Perceived Risk

Although the result was only statistically significant in one regression analysis, the results regarding duration of attention show that people who paid attention to the news for a longer period of time had a lower risk perception of the accident. This is in contrast to what the first hypothesis predicted. Wåhlberg and Sjöberg[3] suggested a possible explanation: if the amount of media coverage decreases, so does risk perception because the risk loses its accessibility in the minds of the audience members. Cantone *et al.*[23] noted that there was a significant decrease in the number of articles published regarding Fukushima, even in the first nine weeks after the accident. Just two Belgian newspapers published over 180 articles in the month following the accident,[23] although at the time of the data gathering (August 15, 2013–September 12, 2013), all Belgian newspapers together published 196 articles related to Fukushima. Although this is still a fair amount, it does indicate a decrease in coverage.

People who did not find the information satisfactory were more likely to have a higher risk perception of the accident, in accordance with the second hypothesis. However, from the current data it is not clear if this higher risk perception is because of a lack of (accessible) information,[43,44] because the provided information did not suit the needs of the Belgian population,[45] or because of another reason.

The third hypothesis received limited support, with only attitude toward nuclear energy being a significant regressor in both analyses. Gender and education each reached significance in only one analysis.

Attitude toward nuclear power was the most powerful regressor of risk perception of the Fukushima nuclear accident. Proponents of nuclear energy perceived the risk of the accident to be lower, whereas opponents deemed it to be higher. This result lends support to the hypothesis that proponents and opponents are likely to interpret a nuclear accident differently, in such a way as to fit with their previous held beliefs and attitudes.[46–48]

Education was the second most influential regressor for risk perception in the first regression analysis and it approached significance in the second. Education did seem to explain risk perception: people with a higher level of education had a lower risk perception of the Fukushima nuclear accident, compared to those with a lower level of education. This result supports the findings of Whitfield *et al.*[2] The concrete dynamic behind this finding is unknown, however, as the literature offered many different explanations.[9,38,52,56]

Gender was not a significant regressor of risk perception for the primary information sources, whereas the literature suggested it could be. Possibly, the gender difference in risk perception of a nuclear accident only appears in areas close to the site of the accident. Even when considering fear of nuclear power technology in general or of a hypothetical nuclear accident, Brody[49] noted that the gender difference is more outspoken for the local items, compared to the general items. Research after both the Chernobyl[50] and the Fukushima nuclear accidents[45] provides support for this hypothesis in the case of actual nuclear accidents. Perhaps Belgium is located too far away from Fukushima to have outspoken gender differences in the general population.

In the analysis regarding online sources, women perceived the risk to be significantly higher than men. The study of Drottz-Sjöberg and Sjöberg[50] offers an explanation. The authors found that young men were the least risk aversive group. In this study, the group that used the Internet as an important information source was indeed significantly younger (year of birth: $M = 1972.75$, $SD = 14.93$) than the group that did not ($M = 1961.61$, $SD = 17.30$), $t(603.474) = -9.956$, $p < 0.001$. Perhaps the difference is a result of the significantly lower risk perception of the younger males that use the Internet.

5.2. Limitations and Future Research

Although the data set used in this study was representative of the adult Belgian population, it still had some limitations. First, because not all factors could be controlled for, the results of the regression analyses cannot be interpreted as conclusive indications of causality. As the media use of 2011 explained the risk perception in 2013, these correlational data can nevertheless provide some time ordering. A longitudinal study would have provided more definitive clues on causality, but because of the unpredictability of nuclear accidents, it is very difficult to gather a representative data set of this size before and after the accident. Second, the data did not reveal how much exposure a respondent had to the sources in absolute terms, or the specific newspapers, television channels, or radio stations they had used. Furthermore, it is possible that it was the content in itself, or the amount of coverage, that altered risk perception, instead of the source as such. Perhaps television simply devoted more attention to the nuclear accident, or used different words to describe it. Future research should look into the differences and similarities of the coverage between different sources, both qualitatively and quantitatively. Furthermore, it could be considered problematic that the data were gathered over two years after the accident. For example, Tateno and Yokoyama[45] thought that changes in perceptions would have disappeared if they conducted their study more than a year after the accident. However, this study still yielded several significant results, indicating that the effects on risk perceptions are quite resistant to change. Finally, although a large-scale survey can offer a general outlook on the effects on the audience, it cannot show how different audiences interpret the same event from the same source.[19] More qualitative forms of research are needed to investigate this issue.

In future studies, YouTube should be a separate option in questions regarding media usage, seeing as it is the third most accessed website worldwide.

Although YouTube is probably the major component of "miscellaneous online sources," which significantly decreased the risk perception of the Fukushima nuclear accident, its influence can never be truly known if it is not studied as a separated category.

6. CONCLUSION

The results of this study demonstrated that information sources have modest but statistically significant explanatory power for the long-term health-related risk perception in Belgium, a country that is dependent on nuclear energy production, yet whose citizens are divided on their support for the energy source. The significance of some information sources as regressors for risk perception is remarkable since the analysis controlled for five variables, most of which were also (highly) significant regressors.

The attitude toward nuclear energy was the strongest regressor of perceived risk, with people favorable toward nuclear power perceiving less risk from the accident. People with higher education also had lower risk perception, as did people who were satisfied with the media coverage. The information sources will not cause people with low risk perception to suddenly experience high risk. In this sense, the source of information is indeed not a major factor in determining risk perception.

However, the other significant regressors are all rather stable variables: attitudes toward nuclear power are difficult to change, and evidence suggests that even after a nuclear accident, attitudes quickly bounce back to preaccident levels.[47] Raising the educational level of a population is certainly possible, but it requires time and effort. The same is true for satisfaction with the media coverage: although it is perfectly possible for journalists and risk communicators to improve their messages to better suit the needs of their audience, this will not happen overnight.

In comparison, which media sources are important for an individual is more volatile. Of course, practical limitations prevent everyone from having access to *all* media sources. However, as the results demonstrated, most people already have more than one important source of information. Depending on which medium gets the most weight in a person's media mix, their risk perception might change. Although this change would be subtle at best, it is still remarkable that such a minor difference can indeed significantly influence risk perception.

DISCLOSURE

All three authors agree that this article has not been submitted to or published in any other journal and no parts of the article are duplicated. The authors have no financial interest or benefit from the direct application of their research.

REFERENCES

1. Eiser J. Communication and interpretation of risk. British Medical Bulletin, 1998; 54(4):779–790.
2. Whitfield SC, Rosa EA, Dan A, Dietz T. The future of nuclear power: Value orientations and risk perception. Risk Analysis, 2009; 29(3):425–437. doi: 10.1111/j.1539-6924.2008.01155.x
3. Wåhlberg AAF, Sjöberg L. Risk perception and the media. Journal of Risk Research, 2000; 3(1):31–50. doi: 10.1080/136698700376699
4. Coleman CL. The influence of mass media and interpersonal communication on societal and personal risk judgments. Communication Research, 1993; 20(4):611–628.
5. Kasperson RE, Renn O, Slovic P, Brown HS, Emel J, Goble R, Kasperson JX, Ratick S. The social amplification of risk: A conceptual framework. Risk Analysis, 1988; 8(2):177–187.
6. Van der Pligt J, Midden CJH. Chernobyl: Four years later: Attitudes, risk management and communication. Journal of Environmental Psychology, 1990; 10(2):91–99.
7. Perko T, Valuch J, Nagy A, Lammers P, Mays C. Overview of mass and new media treatment of ionizing radiation topics: The case of Fukushima, 2013. Available at: http://eagle.sckcen.be/en/deliverables, Accessed November 22, 2013.
8. Yamamura E. Experience of technological and natural disasters and their impact on the perceived risk of nuclear accidents after the Fukushima nuclear disaster in Japan 2011: A cross-country analysis. Journal of Socio-Economics, 2012; 41(4):360–363.
9. Yim MS, Vaganov PA. Effects of education on nuclear risk perception and attitude: Theory. Progress in Nuclear Energy, 2003; 42(2):221–235.
10. McLuhan M. Understanding Media: The Extensions of Man. New York: Mentor, 1964.
11. Masson O, Baeza A, Bieringer J, Brudecki K, Bucci S, Cappai M, Pálsson SE. Tracking of airborne radionuclides from the damaged Fukushima Dai-ichi nuclear reactors by European networks. Environmental Science & Technology, 2011; 45(18):7670–7677.
12. Belgian Chamber of Representatives. [Draft bill regarding changing the law of 31 January 2003, regarding the nuclear phase-out for industrial electricity production, and regarding changing the law of 11 April 2003 regarding the facilities installed for the dismantling of the nuclear power plants and for the management of fuels that were radiated in these nuclear power plants], 2013. DOC. 53K3087. Available at: http://www.dekamer.be, Accessed October 9, 2015.
13. Belgian Chamber of Representatives. [Draft bill regarding changing the law of 31 January 2003, regarding the gradual nuclear phase-out for industrial electricity production, for the purpose of ensuring the security of energy supplies], 2015. DOC. 54K0967. Available at: http://www.dekamer.be, Accessed October 9, 2015.
14. Turcanu C, Perko T. The SCK•CEN barometer 2013. Perceptions and attitudes towards nuclear technologies in the Belgian population. Mol (BE): SCK•CEN, SCK•CEN-BLG-1097, January 2014.
15. Sugimoto A, Nomura S, Tsubokura M, Matsumura T, Muto K, Sato M, Gilmour S. The relationship between media consumption and health-related anxieties after the

Fukushima Daiichi nuclear disaster. PLoS ONE, 2013; 8(8):1–7. doi:10.1371/journal.pone.0065331
16. Wimmer RD, Dominick JR.Mass Media Research: An Introduction, 8th ed. Belmont, CA: Thomson Wadsworth, 2006.
17. Adriaensens E, Vanoverbeke D. Op zoek naar het nieuwe Japan: De Japanse politiek na 1945. Roeselare, BE: Globe, 2004.
18. Jensen KB. Media reception: Qualitative traditions. Pp. 156–170 in Jensen KB (ed). A Handbook of Media and Communication Research: Qualitative and Quantitative Methodologies. London: Routledge, 2002.
19. Kitzinger J. Audience and readership research. Pp. 167–182 in Downing JDH, McQuail D, Schlesinger P, Wartella E (eds). The SAGE Handbook of Media Studies. Thousand Oaks, CA: Sage Publications, Inc., 2004.
20. Morley D. Unanswered questions in audience research. Communication Review, 2006; 9(2):101–121.
21. Friedman SM. Three Mile Island, Chernobyl, and Fukushima: An analysis of traditional and new media coverage of nuclear accidents and radiation. Bulletin of the Atomic Scientists, 2011; 67(5):55–65.
22. Zillmann D, Knobloch S, Yu H. Effects of photographs on the selective reading of news reports. Media Psychology, 2001; 3(4):301–324.
23. Cantone MC, Perko T, Turcanu C, Prezelj I, Tavola F, Sturloni G, Geenen C, Mamane N, Van Rooy L, Marin L, Špeh K, Bizjak T. Content analysis of the media reporting on the Fukushima nuclear accident in three European countries. Paper presented at the 13th International Congress of the International Radiation Protection Association, May 13–18, 2012, Glasgow, UK.
24. Morton TA, Duck JM. Communication and health beliefs mass and interpersonal influences on perceptions of risk to self and others. Communication Research, 2001; 28(5):602–626.
25. Perko T, Turcanu C, Schröder J, Carlé B. Risk perception of the Belgian population: Results of the public opinion study in 2009. Mol (BE): SCK•CEN, SCK•CEN-BLG-1070, February 2010.
26. Centrum voor Informatie over de Media. CIM TV: Marktaandelen 2011. Available at: www.cim.be/nl/televisie/openbare-resultaten, Accessed October 22, 2015.
27. Frewer LJ, Rowe G, Sjöberg L. The 10th Anniversary of the Chernobyl Accident: The Impact of Media Reporting of Risk on Public Risk Perception in Five European Countries. Reading, UK: Institute of Food Research, 1998.
28. Henning B, Vorderer P. Psychological escapism: Predicting the amount of television viewing by need for cognition. Journal of Communication, 2001; 51(1):100–120.
29. Reeves B, Clifford N. The Media Equation: How People Treat Computers, Television, and New Media Like Real People and Places. Cambridge, UK: Cambridge University Press, 1998.
30. Aust CF, Zillmann D. Effects of victim exemplification in television news on viewer perception of social issues. Journalism & Mass Communication Quarterly, 1996; 73(4):787–803.
31. Pierpoint L. Fukushima, Facebook and feeds: Informing the public in a digital era. Electricity Journal, 2011; 24(6):53–58.
32. International Atomic Energy Agency. Communication with the Public in a Nuclear or Radiological Emergency. Vienna, AT: International Atomic Energy Agency, 2012.
33. Utz S, Schultz F, Glocka S. Crisis communication online: How medium, crisis type and emotions affected public reactions in the Fukushima Daiichi nuclear disaster. Public Relations Review, 2013; 39(1):40–46.
34. Thomson R, Ito N, Suda H, Lin F, Liu Y, Hayasaka R, Isochi R, Wang Z. Trusting tweets: The Fukushima disaster and information source credibility on Twitter. Paper presented at the 9th International ISCRAM Conference, Vancouver, Canada, 2012.
35. Cheng X, Liu J, Dale C. Understanding the characteristics of Internet short video sharing: A YouTube-based measurement study. IEEE Transactions on Multimedia, 2013; 15(5):1184–1194.
36. Hanson G, Haridakis P. YouTube users watching and sharing the news: A uses and gratifications approach. Journal of Electronic Publishing, 2008; 11(3). doi: 10.3998/3336451.0011.305
37. Leiserowitz AA. Day after tomorrow: Study of climate change risk perception. Environment: Science and Policy for Sustainable Development, 2004; 46(9):22–39.
38. Price V, Zaller J. Who gets the news? Alternative measures of news reception and their implications for research. Public Opinion Quarterly, 1993; 57(2):133–164.
39. Binder AR, Scheufele DA, Brossard D, Gunther AC. Interpersonal amplification of risk? Citizen discussions and their impact on perceptions of risks and benefits of a biological research facility. Risk Analysis, 2011; 31(2):324–334. doi: 10.1111/j.1539-6924.2010.01516.x
40. Verplanken B. Beliefs, attitudes, and intentions toward nuclear energy before and after Chernobyl in a longitudinal within-subjects design. Environment and Behavior, 1989; 21(4):371–392.
41. Katchanovski I. Fukushima vs. Chernobyl: Coverage of the nuclear disasters by American and Canadian media. Paper presented at the Annual Meeting of the American Political Science Association, New Orleans, LA, USA, 2012.
42. Perko T, Turcanu C. Reporting on Fukushima. Nuclear Engineering International, 2013; 58(704):38–40.
43. Manoj BS, Baker AH. Communication challenges in emergency response. Communications of the ACM, 2007; 50(3):51–53.
44. Rahu M. Health effects of the Chernobyl accident: Fears, rumours and the truth. European Journal of Cancer, 2003; 39(3):295–299.
45. Tateno S, Yokoyama HM. Public anxiety, trust, and the role of mediators in communicating risk of exposure to low dose radiation after the Fukushima Daiichi nuclear plant explosion. Journal of Science Communication, 2013; 12(2):1–22.
46. Katsuya T. Public response to the Tokai nuclear accident. Risk Analysis, 2001; 21(6):1039–1046.
47. Siegrist M, Visschers VHM. Acceptance of nuclear power: The Fukushima effect. Energy Policy, 2013; 59:112–119.
48. Sjöberg L. Factors in risk perception. Risk Analysis, 2000; 20(1):1–12.
49. Brody CJ. Differences by sex in support for nuclear power. Social Forces, 1984; 63(1):209–228.
50. Drottz-Sjöberg BM, Sjöberg L. Risk perception and worries after the Chernobyl accident. Journal of Environmental Psychology, 1990; 10(2):135–149.
51. Gustafson PE. Gender differences in risk perception: Theoretical and methodological perspectives. Risk Analysis, 1998; 18(6):805–811.
52. Renn O. Public responses to the Chernobyl accident. Journal of Environmental Psychology, 1990; 10(2):151–167.
53. Weisenfeld U, Ott I. Academic discipline and risk perception of technologies: An empirical study. Research Policy, 2011; 40(3):487–499.
54. Van Aeken K, Turcanu C, Bombaerts G, Carlé B, Hardeman F. Risk perception of the Belgian population. Results of the public opinion survey in 2006. Mol (BE): SCK•CEN, SCK•CEN-BLG-1038, January 2007.
55. Petty RE, Cacioppo JT. The Elaboration Likelihood Model of Persuasion. New York: Springer, 1986.
56. Renn O. Risk Governance: Coping with Uncertainty in a Complex World. London: Earthscan, 2008.