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UNITS RELATED TO RADIATION EXPOSURE AND RADIOACTIVITY IN MASS MEDIA: THE FUKUSHIMA CASE STUDY IN EUROPE AND RUSSIA

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Using an analysis of the way European newspapers covered the Fukushima nuclear accident, this article explores how the mass media transmit information about radiation risks from experts to the general public. The study applied a media content analysis method on a total of 1340 articles from 12 leading newspapers in 6 countries: Belgium ($N = 260$), Italy ($N = 270$), Norway ($N = 133$), Russia ($N = 172$), Slovenia ($N = 190$) and Spain ($N = 315$). All articles analysed were selected as being directly or indirectly related to the Fukushima accident by containing the word 'nuclear' and/or 'Fukushima' and were published between the 11th March and the 11th May 2011. The data presented here focus specifically on a cross-cultural comparison of the way the media use quantitative units. Results suggest that although experts are accustomed to communicating about radiological risks in technical language, often using quantitative units to describe the risks, mass media do not tend to use these units in their reporting. Although the study found a large variation in the measurement units used in different countries, it appeared that journalists in all the analysed countries preferred to describe radioactivity by comparing different radiation exposures, rather than reporting the actual measured units. The paper concludes with some practical guidelines for sound public communication about radiation risks.

INTRODUCTION

The mass media play a progressively important role in contemporary crisis situations including nuclear or radiological accidents such as Fukushima (2011). Media studies now take it as granted that mass media are the most prominent information channels related to risk communication for the general public with certain power influencing radiological risk perception[1–4]. The media can create, shape and terminate a crisis in the way they report—or frame—an event[5–7]. The way emergency actors and media communicate about the radiological risk from a nuclear accident can directly and indirectly influence a public response to a nuclear event. Covello[8, p.511] stressed that: 'poor risk communication can fan emotions, undermine public trust, create stress, and exacerbate the existing crisis, while good risk communication can rally support, calm a nervous public, build trust, encourage cooperative behaviors, and potentially help save lives'.

Characteristics of radiological risks, such as unfamiliarity, catastrophic potential, low controllability, dread, possible influence on children and future generations, tampering with nature, etc.[9, 10], make this topic highly publishable and newsworthy for different mass media[11–13]. The Fukushima nuclear accident had all these characteristics. It led to a significant radiological contamination of the terrestrial and marine environment, and accident was given the highest possible ranking on the International Nuclear Event Scale[14, 15]. A series of countermeasures were taken at different moments in time in order to reduce the radiation risk for the population, ranging from evacuation and stable-iodine distribution, to decontamination of people and the environment. Some 160000 people were evacuated from their homes as a result of the nuclear accident and only in 2012 were allowed limited return. All these protective actions in alliance with radiological risks needed to be communicated to the affected population and to concerned public worldwide[16].

Communication about radiological risks can be quite challenging at least due to the three main reasons. First, the general public lacks knowledge about radioactivity and only rarely has acknowledged experiences with radiation exposure outside the medical field[17–19]. Second, a low level of knowledge about radiation concepts among lay population influences the ability to process the information and makes decision-making process challenging[20] and, finally, quantitative information about radiological risks may be meaningful only to people who have some aptitude with basic numerical concepts, a construct called numeracy[21, 22]. For example, research about the role of numeracy in understanding the

benefit of mammography screening by Schwartz *et al.*[21] found that both accuracy in applying risk reduction information and numeracy were poor among the patients. More than half of patients participating in the research had a low basic understanding of probability and had trouble converting between percentages and probability expressions. However, when communicating about radiological risks with the general population, experts and officials in communication often provide quantitative information related to ionising radiation, expressed with numerical data and units related to radiation exposure and radioactivity. For instance, press release during the Fukushima nuclear accident issued by Yukio Edano (Japan's chief government spokesman) on Sunday, 13 March 2011 at 11:00 a.m., 2011 reports:

> Monitoring of radiation levels on the spot is ongoing. At point MP4, where a reading of 1,015μSv was detected yesterday, a radiation level of 44.6μSv was recorded at 00:30 this morning, and a level of 36.7μSv at 6:00am. After the start of venting around 9:20, a reading of 76.9μSv was recorded at 9:20 and of 70.3μSv at 9:30.

The media acts as a bridge between experts, officials and the general population and has to 'translate' quantitative information into qualitative statements, including to explain to the population (readers) the scope of the danger and risk. This is a rather challenging task since most journalists, and even science correspondents need to cover several topics so they cannot build specialist expertise in only one area. As journalists expressed in the research by Železnik *et al.*

> 'They must balance diverse opinions provided by independent experts or by official spokespersons, who often are not prepared to provide immediate answers to questions of public concern (e.g., on the impact of accidental or normal emissions on public health, the environment, food safety, etc.) in understandable language.[23, p. 20–21]

However, there is only a limited amount of research on media reporting about radiological risks that is based on quantitative data. One example is that a media analysis related to Chernobyl accident was conducted by Rowe, Frewer and Sjöberg[24]. This was a cross-national study looking at how newspapers from Sweden and the UK characterised a variety of risks, focusing on the 2 months around the 10th anniversary of the Chernobyl accident. The authors found that media reports about hazards tended to be alarmist rather than reassuring and rarely used statistics to express degrees of risk. In the analysis of media reporting about the first commemoration of the Fukushima accident in nine Flemish newspapers, Perko *et al.* (2013) recognised a communication challenge related to the use of a different language to describe radiological risks used by the experts and the media. They found that only ~12 % of all articles published in analysed newspapers contained radiological units, the most often used measurement unit was the becquerel (38 % among the articles reporting measurement units) and only 8 % of the articles contained a qualitative comparison of the radiological risks with familiar radiological exposures, such as X-rays[25]. An additional content analysis by Turcanu *et al.*[26] related to the Fukushima accident was carried out in four Belgian newspapers (French and Dutch language) examining the media reporting in the first year after the accident. The articles were selected that specifically referred in the text to the radioactive contamination in the food chain or the related environmental contamination. Results showed that measurement units specific to radiation were reported in only 18 of the 110 articles (total in 4 newspapers) that addressed food chain issues related to radioactive contamination. When measurement units were mentioned, the majority of the information concerned activity concentrations, e.g. in food products or drinking water, and the most reported units were Bq kg^{-1} and Bq l^{-1}. These units are also widely used to assess the radioactive contamination in food and are specified in the legal (European) norms for maximal allowable quantities of radionuclides in food products. When risk comparisons were used, these mostly related to legal norms and, to a lesser extent to the natural radioactivity background.

Research on mass media reporting about radiological risks that focuses on quantitative data often lacks a systematic cross-cultural and cross-media comparison, as well as an in-depth analysis of how radiological risks are transferred to the general population via media. Studies also rarely link the results with practical guidelines, such as how to communicate radiological risks to general population.

With this in mind, the research reported in this paper is based on a large content analysis of media reporting about radiological units and risk comparisons in six countries Belgium, Italy, Norway, Slovenia, Spain and Russia after the Fukushima nuclear accident. The goal of the research was 3-fold: first, to identify, how mass media reported about radiological risks related to Fukushima; secondly, to identify the differences in media reporting about radiological quantitative and qualitative data in different countries; and lastly, to suggest how to improve public communication about radiological risks.

METHOD

The scientific method applied was a media content analysis. Several known books and articles exist to instruct in the methods of content analysis including selection of texts (newspapers) to be analysed[27, 28].

Each selected article from each newspaper was coded by two independent coders, all of them native speakers, trained for the coding and strictly following the code book developed for the analysis. In order to increase the validity of the authors' results, the databases independently produced by the two coders (containing coded articles for each newspaper) were checked and compared by a master coder. In case of a difference in the results by the two coders, a consensual assessment was made among the coders and a final master database was made.

The media content analysis of 12 leading newspapers was conducted in 6 countries: 'Le Soir' and 'De Standaard' in Belgium ($N = 260$); 'Corriere della Sera' and 'La Repubblica' in Italy ($N = 270$); 'Aftenposten' and 'Dagsavisen' in Norvay ($N = 133$); 'Komsomolskaya Pravda' and 'Izvestiya' in Russia (N=172); 'Večer' and 'Delo' in Slovenia ($N = 190$) and 'El País' and 'El Mundo' in Spain ($N = 315$). The articles coded ($N = 1340$) were directly or indirectly related to the Fukushima nuclear accident by containing word 'nuclear' and/or 'Fukushima' and were published between the 11th of March, 2011 and the 11th of May, 2011.

For analysis of the radiological risk-related information, quantitative and qualitative information in the media articles was coded. The quantitative information was the analysis of different possible measurement units corresponding to measurement of activities, activity concentration, ground depositions, dose rates or estimates of the dose received. The qualitative information analysed was a comparison of one radiological risk with other radiological risks, for instance with risks from medical purposes, with risks from flying or with natural radiation background. The coding was done using standard methods for content analysis[27–29] and detailed in the specific code book developed for the research.

Every article was coded by two independent coders for each language group (thus 14 coders). In case of disagreements, the third coder, master-coder decided the final code based on a discussion. The inter-coder reliability was calculated by Krippendorf's alpha[30], which is a statistical measure of the agreement achieved when coding a set of units of analysis in terms of the values of a variable. In order to achieve high inter-coder reliability, each coder received training on content analysis before she/he started the coding. Krippendorf's alpha for both variables: quantitative and qualitative information about radiological risks is >0.84.

RESULTS

The mass media reporting to general population about radiological risks using quantitative and qualitative information was assessed by first analysing the quantities used. Radiation-related quantities can be expressed using different measurements units. For the analysis reported here, the authors have used the following list of 18 different possible measurement units corresponding to measurement of activities, activity concentration, ground depositions, dose rates or estimates of the dose received: mSv (millisievert), mSv h^{-1} (millisievert per hour), μSv h^{-1} (microsievert per hour), nSv h^{-1} (nanosievert per hour), Sv (sievert), Sv h^{-1} (sievert per hour), Bq kg^{-1} (becquerel per kilogram), Bq g^{-1} (becquerel per gram), (becquerel per litre), kBq kg^{-1} (kilo becquerel per kilogram), MBq kg^{-1} (mega becquerel per kilogram), Bq m^{-2} (becquerel per square metre), Bq cm^{-2} (becquerel per square centimetre), kBq cm^{-2} (kilo becquerel per square centimetre), MBq m^{-2} (mega becquerel per square metre), MBq km^{-2} (mega becquerel per square kilometre), TBq km^{-2} (terra becquerel per square kilometre) and other measurement units related to radiation (e.g. air concentration in Bq m^{-3}).

Results show that radiation measurement units were not widely used in newspaper articles (Figure 1). Less than 16 % of all articles used radiation measurement units. When radiation measurement units were used, the most often used were millisievert for dose and millisievert per hour, microsievert per hour and other units for dose rate.

Measurements related to contamination of food or goods, not dose related, were barely used. One explanation could be that people are interested in how dangerous something is for them. Since dose-related units are directly related to the estimation of health effects, they are therefore relevant for people who want to

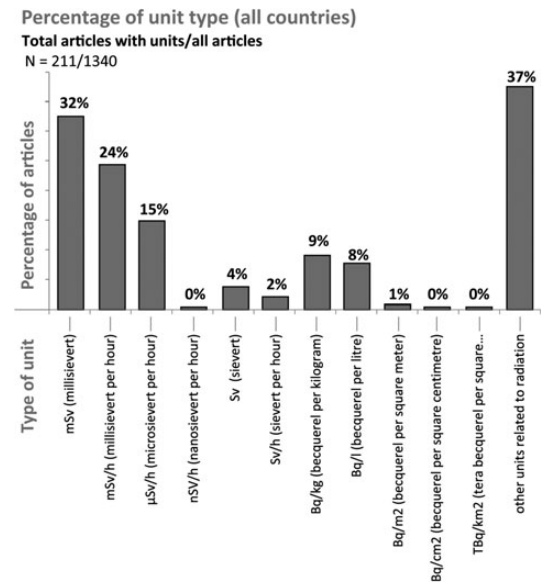

Figure 1. Units related to radiation exposure and radioactivity in press.

know what is dangerous for them. Besides, these units can be connected to legal limits or background exposures, providing journalists with a benchmark to frame their story with. In other words, millisievert could be a clearer unit from a communication point of view. Last, it seems that the media used a multitude of different units as no unit really stands out in comparison with others. Rather, it seems like several units were used interchangeably. Also, millisievert was highly used in all countries, but this was often not connected to a timescale. For instance: 'The clean-up workers on Japan NPP received less than 250 mSv, which the Japan government adopted as the maximum allowable dose'. (In: Izvestiya on 4th of April, 2011). Another example is: 'There are first victims already: 17 people received a radiation dose higher than 100 mSv'. (In: Komsomolskaya Pravda on 25th of March, 2011, p. 6).

Units reported were not the same in all countries however (Figure 2). For instance, Russia stands out on a high usage of other units. The reason is that due to historical reasons, Russian experts often use older-SI units (roentgen, rad, etc.). In addition, Italy is the only country where becquerel per square metre was used. Also, becquerel per kilogram was used in Italy, but not becquerel per litre. Therefore, there seem to have been a focus on contamination of land and food, but not on a contamination of water.

The qualitative formats of radiological risk communication was analysed by looking for the following comparisons: with risks from medical purposes (e.g. X-ray), with risks from flying, with natural radiation background (usually the word 'normal'), with professional (normal) exposure to radiation of workers at nuclear installations, with limits or norms (words such as 'limits', 'norms' and 'maximal allowed levels') and with a historic nuclear accident e.g. Chernobyl (NOT the atomic bombs at Hiroshima or Nagasaki) and with something else. In the comparison with historical accidents only comparison of radioactivity and not the accident in general were coded. For example, number of victims or size of evacuation would not belong to this category. The comparison of the rating given on the INES scale—Fukushima and other accidents—is included in this category.

Qualitative explanations of radiological measurements appeared in the media more regularly than quantitative explanations. It was observed that around one in four articles used comparisons when reporting about Fukushima. Spanish newspapers used

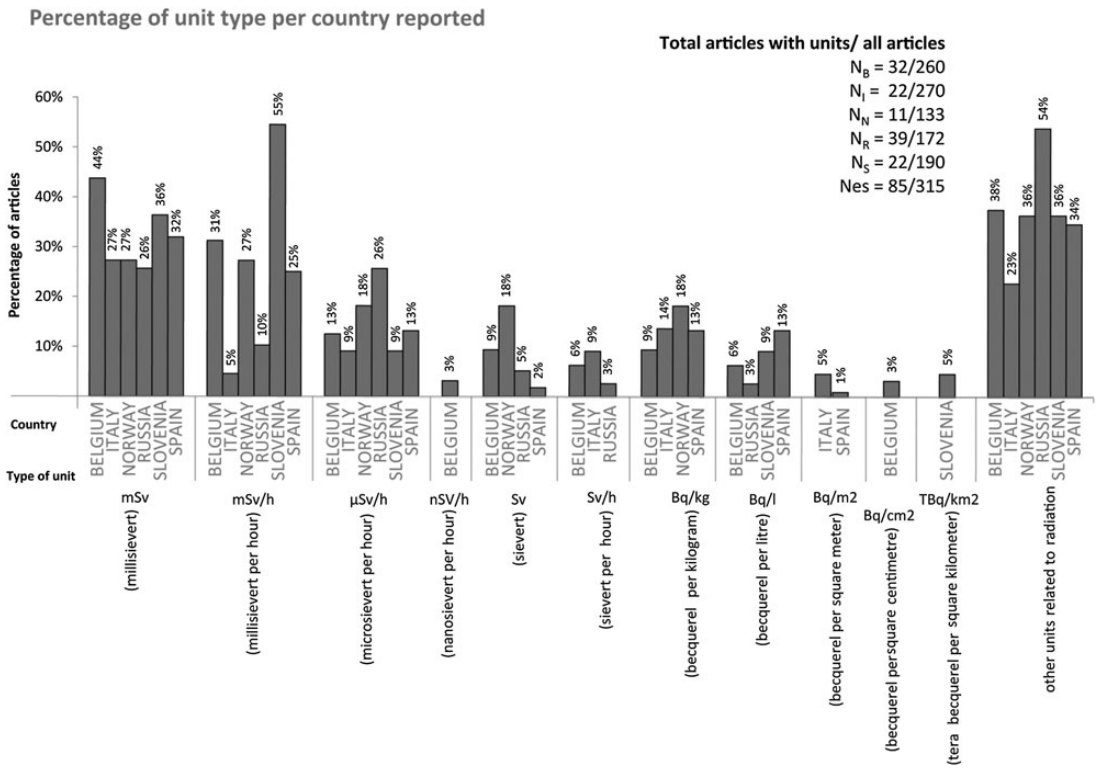

Figure 2. Units related to radiation exposure and radioactivity in press per country reported.

comparisons most often (36 %), followed by Russian newspapers (33 % of articles used comparisons). Norwegian newspapers were the least likely to use comparisons (14 %). Most comparisons were with legal norms (50 %), although these comparisons were less frequently used in Italy. Comparisons with historical accidents were also prominent (38 %), except in Russia and Slovenia. Slovenia stands out with a high use of comparisons with natural radiation background. For instance, in the article in Delo on 14th of March 2011 (p. 3) related to the accident, the author stated that 'radioactivity exceeded the natural background for 3000 times'. They continue with information that '1000 micro sievert in one hour is equal to the amount of radiation that person receives in one year; 0,1 micro sievert per hour is the radiation exposure in normal environment'. In the article related to radioactive water in Delo on 29th of March, 2011 (p. 28), a journalist used the following comparison: 'leakage of highly contaminated water exceeded the usual level by 100 000 times'. A newspaper in Slovenia even published an overview of natural background levels in the country (In: Delo on 7th of April 2011, p. 18).

Comparisons to workers' exposure to radiation at a nuclear installation were not present in Italy, as expected in non-nuclear power country. However, Russian and Belgian media differ in their use of this comparison, as it was used in Belgian newspapers (12 %), but not in Russian newspapers, whereas both countries have nuclear energy installations. This could be related to the fact that Russian newspapers often compared Fukushima with dangerous and non-dangerous levels of radiation, which is usually more understandable for members of the general public. Also, Italian, Norwegian and Belgian newspapers often compared Fukushima with historical nuclear accidents. In Italy, this could be linked to the nuclear energy debate being on-going around that time. In all countries, the comparisons with risks from medical purposes and risks if flying are barely used (comparison with risks if flying is only used in Russia in one article and Spain in two articles). This seems odd, as a debate is open in many countries and also in the European parliament on the radiation risks in the aviation industry. For instance, in Russian article published in Komsomolskaya Pravda on 26th of April, 2011 (p. 12–13): 'During my three-day stay near the fourth power unit sarcophagus I received 0.06 mSv, which was less than the dose received during a flight from Moscow to New York (0.3 mSv)'.

Russian media quite regularly used other comparison than those in the code book. An in-depth evaluation showed that the Russian media used comparisons with 'dangerous/safe levels' of radioactivity. For instance, in an article published in Komsomolskaya Pravda on 14th of March, 2011 (p. 5): 'Rad is a radiation measurement unit. Doses from 100 to 1000 rad cause radiation disease among people exposed to these doses during 1–3 days'. In an article published in the same newspaper on 15th of March 2011 (p. 6) 'The radiation level in the middle of the cloud trace (precipitations) - 700 rad/hour is accepted as dangerous' or in article in Komsomolskaya Pravda on 16th of March 2011 (p. 5): 'According to the officials on Tuesday the radiation level on NPP Fukushima were multiplied by more than twenty and amounted to 400000 μSv h^{-1} (400 mSv). Dose 500 μSv h^{-1} is considered safe'.

DISCUSSION AND CONCLUSIONS

Although the media reported about the nuclear accident, radiological risks and danger, <2 articles in 10 contained radiological measurement units. The exceptions are Spain and Russia with >2 articles out of 10 reporting radiological units. The most often used measurement unit was mSv. It is clear that, although experts are used to communicate about radiological risks in technical language, often using quantitative units to present risks, mass media do not tend to use these units in their reporting. The authors have also found that there was a very large variation in the measurement units used in different countries. However, journalists in all analysed countries prefer to report about radioactivity measures by comparing different exposures with radiation than reporting the measurement units itself. Approximately one article out of four used comparisons to explain the radiation exposures related to the Fukushima nuclear accident. The most used comparison was comparison with legal norms. Comparisons with historical accidents (e.g. Chernobyl) were also prominent. However, significant differences in the number of comparisons and types of comparisons used in the articles published in the analysed countries were observed. For a future work, it would be interesting to investigate why these differences occurred.

The findings of this media content research lead to certain suggestions for preparing sound communication for possible nuclear or radiological emergencies. In communication with mass media, expert should use comparisons with different exposures to radiation and not only the measurement units itself. The use of units should be connected to legal limits or background exposures, because these provide journalists with a benchmark to frame their story with. However, although advised by different communication guidelines, like for instance the IAEA document 'Communication with the Public in a Nuclear or Radiological Emergency'[16], it appears that the media are not interested in publishing comparisons of risk from a nuclear accident with risks from medical purposes and risks from flying or expert community have not offered such a comparison . Finally, it is important to be consistent with units (e.g. mSv h^{-1} or μSv h^{-1} and MBq m^{-2} or TBq km^{-2}) and understand that numeracy related to

risk and safety is meaningful only to a limited number of journalists and people.

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