

The role of the media in the amplification of a contested health risk: Rubber granulate on sport fields

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This study aims to increase insights into the potential role of the media in the amplification and attenuation of modern risks in society, by studying the dynamics and contents of the newspaper coverage about the potential health risk posed by rubber granulate in the Netherlands. We thematically analysed 153 national newspaper articles about the risks posed by rubber granulate between September 2016 and February 2017. Our results suggest that newspaper coverage might have contributed to heightened public risk perceptions by presenting the negligible health risk as uncertain, focusing on controversy between authorities and experts, describing responses such as concerns, commotion, and adopted risk mitigation measures by members of the public, and by providing insufficient contextualization on whether hazardous substances in rubber granulate pose a threat to health. The risks posed by rubber granulate is one of the many modern risks that has become subject to heated and mediated public discussions. Our results provide in-depth insights into important content elements in media coverage during such discussions and the impact of these elements on public perceptions. Public health institutes and other authorities might be able to mitigate the amplification of risks through media coverage by means of appropriate preparedness and response.

KEY WORDS: crumb rubber; media; modern risks; newspapers; risk communication; risk perception; rubber granulate

1. INTRODUCTION

1.1. Public Discussions About Modern Risks

Public discussions about so called modern risks are frequently seen in contemporary societies (Beck, 1992; Blankestijn, Munnichs, & van Drooge, 2014). Modern risks are health risks posed by modern solutions, technologies or products. Examples of such risks are risks posed by biotechnology (Nisbet & Huge, 2006; Savadori et al., 2004; Thomson & Dininni, 2005), electromagnetic fields (Blankestijn et al., 2014; Claassen, Bostrom, & Timmermans, 2016), underground storage of carbon dioxide (Blankestijn et al., 2014; Boyd et al., 2013; Oltra, Sala, Solà, Di Masso, & Rowe, 2010), and food additives (Bearth, Cousin, & Siegrist, 2014; Shim

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et al., 2011). Modern risks are man-made, often not visible to the human eye (e.g., hazardous substances in a product), and relatively new and unknown to those exposed and in science. These features partly explain why modern risks often trigger concerns and discussion (Slovic, Fischhoff, & Lichtenstein, 1986). For many of these risks, there are considerable gaps between risk perceptions of the general public and risk assessments by experts (Bearth et al., 2014; Claassen et al., 2016; Oltra et al., 2010; Savadori et al., 2004). While experts and policymakers might consider the benefits to outweigh the risks, perceived high risks and therewith low support among the public is likely to hamper the implementation or durability of such solutions, technologies, or products.

In many public discussions about modern risks, the media¹ have a central role (Blankestijn et al., 2014). The media are often the first to share new risk information with the larger public and keep them up-to-date with new developments. Journalists consider being a societal “watchdog” as one of their important roles (Klemm, Das, & Hartmann, 2019). As watchdogs, journalists critically examine actions by authorities and industries and report on potential wrong doings, such as, for example, prioritizing economic interests above health interests in the development of new technologies, products, or processes. The role of the media as agenda-setter and disseminator of risk information has also been emphasized in the Social Amplification of Risk Framework (Binder, Cacciatore, Scheufele, & Brossard, 2014; Kasperson et al., 1988). This framework describes how risk information is spread through societies via so called amplifier stations, which adopt, interpret, and translate this information before disseminating it further. The media are considered one of the most important amplifier stations in this process (Binder et al., 2014; Kasperson et al., 1988). The translated and disseminated risk information leads to various perceptions of and responses to these risks in society. If new risk information leads to heightened risk perceptions this is called social amplification of risks; if new risk information leads to lowered risk perceptions this is called social attenuation of risks.

Various studies support the social amplification of risk framework by showing a positive association between the number of media messages on a risk

topic and perceived risks (Combs & Slovic, 1979; Frewer, Miles, & Marsh, 2002; Hong, Kim, & Xiong, 2019; Renn, Burns, Kasperson, Kasperson, & Slovic, 1992; Zhao, Rosoff, & John, 2019). One possible explanation for this association is that a large amount of media attention on a given topic may increase the availability of risk information in the receiver’s mind, which, in turn, may cause an increase in risk perception (Tversky & Kahneman, 1973). The social amplification of risk framework also emphasizes that amplifier stations alter risk information by interpreting and translating it before disseminating it further, which may also affect public risk perceptions.

1.2. Media Coverage and Cereptions of Risk

Media are often accused of arousing public fear by means of sensationalized reporting about risks. Sensationalistic reporting has been described as including “content features or formal features of messages that have the capability to provoke attention and arousal responses in viewers” (Kleemans & Hendriks Vettehen, 2009, p.229). Sensationalism can be in the choice of topics on the one hand—topics such as crises and violence are seen as inherently sensationalistic (Slattery, Doremus, & Marcus, 2001)—and the presentation of these topics on the other hand. Previous studies suggested that the media more often describe risks as serious and substantial, and less often provide more reassuring descriptions of these risks (despite whether experts perceive these risks as considerable or negligible) (Klemm, Das, & Hartmann, 2016; Rowe, Frewer, & Sjoberg, 2000; Ueda et al., 2015; Vasterman & Ruigrok, 2013). However, it has also been argued that media usually adopt risk information provided by authorities or experts without over sensationalizing this information (Dunwoody & Peters, 1992; McCarthy, Brennan, De Boer, & Ritson, 2008; Vasterman & Ruigrok, 2013; Wahlberg & Sjoberg, 2000).

One important content element frequently applied in news reporting about risks and other topics is the representation of conflict or controversy between various sources (Schultz, 2007), for example in media coverage of climate change (Antilla, 2005) and vaccinations (Clarke, 2008). The presentation of controversy likely increases perceived uncertainty about the risk, and perceived uncertainty is associated with a higher perception of risks (Miles & Frewer, 2003). In addition, controversy about risks in media coverage can decrease trust in those sources that indicate that a risk is low (Markon & Lemyre, 2013).

¹With media, we refer to the traditional media communicating news to the public, such as news outlets on the radio and television, and newspapers. Our study does not incorporate social media, such as Facebook and Twitter.

Another important feature in media coverage is the presentation of affective responses, such as concerns or anxiety, expressed by members of the public, also called “vox pop” in journalism studies (Hendriks Vettehen, Nuijten, & Beentjes, 2005; Vettehen, Nuijten, & Peeters, 2008). Sandman, Miller, Johnson, and Weinstein (1993) showed that messages in which members of the public address concerns or fear increased perceived risks in the receivers more strongly than messages without such a description (Sandman et al., 1993). More recent work found that the so-called emotional tonality (e.g., using words such as “disastrous” instead of “serious”) and content features evoking affective responses such as fear or concerns in written news increases perceived severity of risks in readers (Klemm, Hartmann, & Das, 2019).

Finally, it has been emphasized that while media tend to adopt information from authorities and experts in their news items, these items often lack essential contextual information and explanations of technical terms used (Freimuth, Greenberg, DeWitt, & Romano, 1984; Wahlberg & Sjoberg, 2000). For example, media might provide information about hazardous substances released by a chemical plant, without reporting on critical exposure levels necessary for negative health effects. By leaving the interpretation of this risk information up to the reader, media messages can have a potentially amplifying or attenuating effect on perceived risks (Freimuth et al., 1984; Wahlberg & Sjoberg, 2000).

1.3. The Perceived Risks Posed by Practicing Sports on Fields with Rubber Granulate

The present study examines media coverage of a modern risk in the Netherlands, namely the potential health risk posed by practicing sports on synthetic turf fields with rubber granulate infill. This infill makes these fields more similar in use to fields with natural grass. In October 2016, rubber granulate became a well-known topic in the Netherlands, after a television broadcast raised questions about the potential health risks posed by practicing sports on fields with rubber granulate (Bosma, 2016) (see Fig. 1 for a description of the broadcast). Following this broadcast, the National Institute for Public Health and the Environment (RIVM) stated, in line with the conclusions from earlier research (Health Protection Scotland, 2017; New York State Department of Environmental Conservation & New York State Department of Health, 2009; Norwegian Institute of Public Health & Radium Hospital Norway,

2006): “Based on the information studied, the RIVM does not expect that the application of rubber granulate on synthetic turf will lead to health risks. There is at present no reason to stop exercising sports on these fields.” (National Institute for Public Health and the Environment (RIVM), 2016b). Despite this reassuring risk appraisal, the broadcast led to extensive media coverage, and national and regional authorities responsible for public health received questions by concerned owners and (parents of) users of synthetic sports fields. In response to these concerns, the minister of Health Welfare and Sports (HWS) asked the RIVM to conduct new research to provide clarity about the health risks posed by rubber granulate. The results of this research published on 20 December 2016 confirmed the RIVM’s initial risk appraisal, and stated that practicing sports on fields with rubber granulate is safe (National Institute for Public Health and the Environment (RIVM), 2016a).

Our earlier study on this topic (de Vries et al., 2019) showed that public perceptions of the risk posed by rubber granulate changed in a relatively short period. Shortly before the publication of the RIVM report in December 2016, the risk posed by rubber granulate was generally perceived as a considerable health threat to children. The data from the follow-up survey, conducted shortly after the publication of the RIVM report, indicated a consistent decline in the public’s perceived risk posed by rubber granulate (de Vries et al., 2019).

1.4. Research Aim

The present study aims to increase insights into the role of the media in the amplification and attenuation of modern risks in society, by studying the dynamics and contents of the newspaper coverage about the potential health risk posed by rubber granulate in the Netherlands. This case study provides a unique example of a heated public discussion about a risk previously unknown to the public, and (from a scientific point-of view) negligible health risk. In addition, the availability of risk perception survey data, enables us to compare three important perspectives in risk discussions, namely scientific risk appraisals, the presentation of these risks in the media, and public perceptions of these risks. In our analysis of the newspaper coverage, we focus on four important content elements of possible influence on public perceptions of risks, namely (a) how the risk posed by rubber granulate was appraised, (b) whether the articles represented conflict or controversy about the

The news broadcast named “Dangerous game” took approximately 37 minutes. In these 37 minutes the spectator, among other things, ...

- Was told that rubber granulate contains hazardous substances, including carcinogenic substances, but that it is unknown what granulates from different producers exactly contain;
- Was informed about a badly smelling synthetic field with rubber granulate in the Netherlands, which led to health complaints among people living close to the field;
- Was introduced to a father in the United Kingdom who had worked for the Nation Health Services and now associates the diagnosed Leukemia in his son with his son’s frequent exposure to rubber granulate as a soccer keeper;
- Was informed about an American keeper trainer who keeps record of young soccer players who practiced on fields with rubber granulate and are diagnosed with lymph node cancer;
- Was told that current research does not answer the question if exposure to rubber granulate is a threat to health;
- Was told that all Dutch authorities base their confidence of the safety of rubber granulate on a limited study, supervised by the National Institute for Public Health and the Environment (RIVM), with only seven research participants;
- Was informed about the different EU regulatory standards for hazardous substances and got to know that rubber granulate is allowed to contain many more hazardous substance then for example children’s toys.

Fig 1. A Description of the Broadcast “Dangerous game” of the Television Programme Zembla (Bosma, 2016).

risk between different authorities and experts, (c) to what extent articles displayed responses to the risk by members of the public, and (d) to what extent contextualized information about the risk was provided.

2. METHODS

2.1. Data Retrieval and Selection

Full text articles were retrieved from nine Dutch national newspapers via the search operator from Lexis Nexis (Lexis Nexis, n.d.). The search terms used for the data retrieval included various Dutch synonyms for rubber granulate and sport fields of artificial turf. Articles were collected over the period September 2016 (a month before the news broadcast about rubber granulate) to February 2017 (a month after the publication of the RIVM report) and the search resulted in a total of 260 articles. Article ti-

tles and abstracts were checked for relevance, and in case of ambiguity, full texts were read. Articles were excluded from the analyses in case the risk posed by rubber granulate was not discussed or only mentioned as a side note. This resulted in 153 articles eligible for coding and further analyses.

2.2. Thematic Content Analysis

An explorative analysis of a random subsample (10%) of the articles resulted in the development of a preliminary codebook for thematic content analysis. Codes were assigned to each recurrent topic or theme that could conceptually be associated with perceived risks of the reader. Consequently, all articles eligible for the analysis were thematically coded in the analysis programme Atlas.ti by one of the authors (MdV).

All text fragments in the articles corresponding to one of codes in the codebook were coded. The text

fragments varied from a sentence to a paragraph's length (e.g., for the code "RIVM quoted," the text fragment coded was equal to the length of the quote by the RIVM). New inductive codes were added to the codebook throughout the analysis through an iterative coding process.

After coding all articles with a detailed code book, the most relevant codes were selected based on theoretical considerations and code occurrence. These selected codes can be grouped in four themes, namely: risk appraisals, controversy between authorities, public responses, and contextualization of risk. These themes and the corresponding codes are discussed in the paragraphs below.

A subsample of the articles (10%) was independently coded by a second coder (intern at the research project). Interrater reliability was assessed per code by means of the Kappa's coefficient.

Following this coding process, the coding data from Atlas.ti were put into a numeric data set with the articles as records and the codes as binary variables (present or absent in the articles). The coded text fragments were thus aggregated per article, which made it possible to present code frequencies in totals and per week.

2.2.1. Risk Appraisals

Three types of risk appraisals were coded to understand how the magnitude of the risk posed by rubber granulate was described in the newspaper articles: a high risk appraisal (the text implies that the risk posed by rubber granulate is high or that it is unwise or unsafe to practice sports on fields with rubber granulate), a low risk appraisal (the text implies that the risk posed by rubber granulate is low or that it is no problem or safe to practice sports on fields with rubber granulate), and an uncertain/unknown risk appraisal (the text implies that it is unknown or uncertain how serious the risk posed by rubber granulate is). Each of these risk appraisals could be present or absent in a single article, and one article could contain multiple risk appraisals.

2.2.2. Controversy between Authorities and Experts

Different authorities and experts were frequently cited or paraphrased as a source throughout the newspaper articles: the minister of HWS, the RIVM, the Dutch soccer association (KNVB), the branch organizations representing the producers of

rubber granulate, and other scientists not employed at one of the previous mentioned organizations.

Each text fragment in which one of the above-mentioned authorities and experts was cited or paraphrased (from now on referred to as "quoted") was given an authority-specific code. Consequently, each quote by an authority was given an additional code indicating whether the quote would fit into one of the previously mentioned risk appraisals.

2.2.3. Public Responses

Responses of the public were coded in two different ways: We coded quotes from members of the public and we coded general references to public responses with regard to the risk posed by rubber granulate.

Two groups of citizens were frequently quoted in the newspaper coverage, namely persons affiliated to a sport club with fields with rubber granulate infill (from now on referred to as "sport clubs"), and parents with a child who practiced sports on a fields with rubber granulate infill (from now on referred to as "parents"). We coded all text fragments in which a sport club or parent was quoted and we consequently analyzed the content of each quote/paraphrase with four types of recurrent responses: (a) concerns (the club/parent expressed concerns about the possible health risks posed by rubber granulate/is unsure about the safety of practicing sports on fields with rubber granulate), (b) no concerns (the club/parent expressed not to be concerned about the possible health risks posed by rubber/to trust the judgement from authorities regarding these risks), (c) measures adopted (the club/parent expressed to have adopted measures to mitigate the risks posed by rubber granulate), (d) measures rejected (the club/parent expressed not to have taken measures to mitigate the risks posed by rubber granulate).

Aside from the quotes from sport clubs and parents, there was a notable recurrence of more general references to public responses in the newspaper coverage. These were mostly general descriptions of public responses from the writer of the article. We coded all text fragments that literally mentioned concerns and commotion (or synonyms of these words), and all references to measures adopted/rejected.²

²We did not code quotes from sport clubs or parents to prevent overlap with the codes for quotes from members of the public.

Table I. Article characteristics; the newspaper, the month of publication, the page in newspaper, the word count, and the type of article

Characteristic	Number (%) of Articles (<i>N</i> = 153)
Newspaper	
. Volkskrant	25 (16%)
. Telegraaf	37 (24%)
. Algemeen Dagblad	32 (21%)
. NRC Handelsblad	15 (10%)
. Nederlands Dagblad	11 (7%)
. Reformatorisch Dagblad	3 (2%)
. Trouw	16 (10%)
. Metro	11 (7%)
. Financieel Dagblad	3 (2%)
Month of Publication	
. September 2016	0 (0%)
. October 2016	85 (56%)
. November 2016	19 (12%)
. December 2016	45 (29%)
. January 2017	4 (3%)
Page Number: Median (range)	11 (1–44)
Word Count: Median (range)	329 (26–1382)
Type of Article	
. News article	96 (63%)
. Interview	11 (7%)
. Letter to the editor	26 (17%)
. Opinion piece	16 (11%)
. Other	4 (3%)

2.2.4. Contextualization of Risk

To study to what extent newspaper articles provided contextualized information about the risk posed by rubber granulate, (technical) elements of risk were coded throughout the articles in line with previous work on perceptions of the risk posed by rubber granulate (described more elaborately in de Vries *et al.*, 2019). These elements included all references to (hazardous) substances in rubber granulate, exposure to (substances in) rubber granulate, possible health effects due (to exposure to substances in) rubber granulate, and the probability of these health effects to occur.

3. RESULTS

3.1. Data Description

In the period September 2016 to February 2017, 153 articles in nine national newspapers discussed the risk posed by rubber granulate. An overview of article characteristics is shown in Table I. The interrater reliability was good with a mean Kappa's coefficient of 0.86 (range: 0.64–1.00). The following sec-

tion (3.2) discusses the main subjects covered in each period, and reflects on the themes *risk appraisals* (Fig. 3(a)) and *controversy between authorities and experts* (Figs. 3(b) and (c)). Consequently, we will discuss *citizens' responses* to the risks posed by rubber granulate (Section 3.3, Table II) and the *contextualization of risk* (Section 3.4, Table III) across the entire period of newspaper coverage.

3.2. Dynamics in Risk Appraisals and Controversy between Authorities and Experts

There were three peaks in the amount of newspaper articles over time: one large peak at the start of the newspaper coverage (week 41), and two smaller peaks in week 48 and week 51 (see Fig. 2). Based on these peaks, we can divide the media in three periods (week 40–47, 89 articles; week 48–49, 26 articles; and week 50–4, 38 articles) as illustrated in Fig. 2.

3.2.1. The First Period of Newspaper Coverage

The newspaper articles that led to the first peak in coverage were published directly after the television broadcast about the potential health risk posed

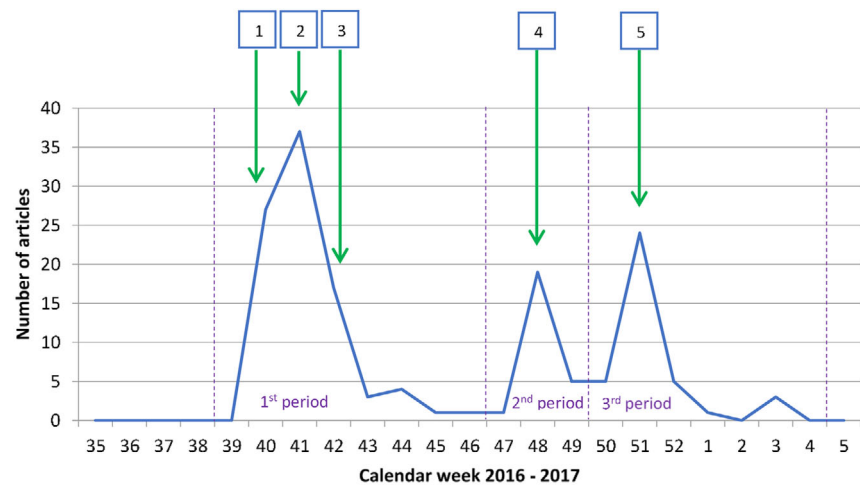


Fig 2. Number of Newspaper Articles per Calendar Week (September 2016–February 2017).

Key topics covered in the newspaper articles:

- 1 Week 40: The airing of the television programme Zembla, about the potential health risks posed by rubber granulate, and the first response to the alleged risk by the authorities.
- 2 Week 41: Responses to the risk by parents and soccer clubs, (financial) consequences of the rubber granulate discussion and an announcement by well-known national soccer club to replace its fields with rubber granulate for an alternative.
- 3 Week 42: An announcement by the branch organization of rubber granulate, which offered a test of rubber granulate to the owners of fields with rubber granulate.
- 4 Week 48: The results from the tests of rubber granulate offered by the branch organization, followed by a discussion about which European standards for hazardous substances rubber granulate should adhere to.
- 5 Week 51: The results from the research from the National Institute for Public Health and the Environment (RIVM) on the risk posed by rubber granulate.

by rubber granulate. In these first weeks following the broadcast, articles repeated elements from that particular broadcast (see Fig. 1) and reported on the responses by various authorities. In addition, articles mentioned that the RIVM would perform a new research to study the potential health risks of practicing sports on fields with rubber granulate, and that the institute “advised to take a shower after sporting on these fields.”³ In the third week of the first period

of coverage, articles communicated that the branch organizations of rubber granulate producers offered concerned owners of fields with rubber granulate a test of their rubber granulate.

In this first period, the risk posed by rubber granulate was mostly appraised as an uncertain health risk (see Fig. 3a), although many articles depicted both an uncertain and a low risk appraisal. This combination of risk appraisals in single articles re-

³This was not an official advice from the RIVM, but was mentioned in the Q&A on their website in the following words: [Q] “What can I do to minimize exposure?; [A] Exposure can be

avoided by not playing with rubber granulate (use it for sports) and by showering and putting on clean clothing after practicing sports.”

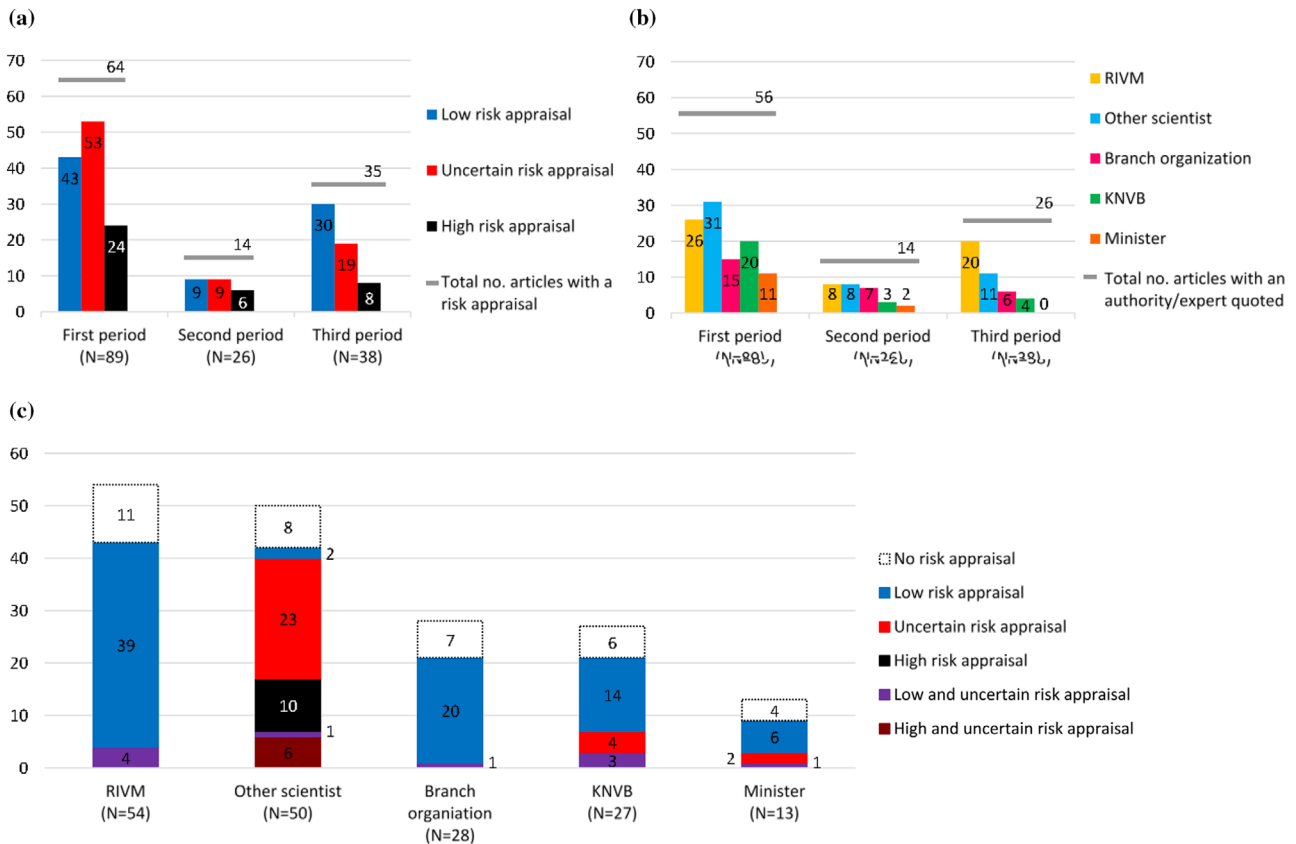


Fig 3. The Number of Articles Per Period in the Newspaper Coverage with a Low, an Uncertain and a High Risk Appraisal (a); The Number of Articles Per Period in the Newspaper Coverage with One of the Experts/Authorities Quoted (3b)*; and the Risk Appraisals Corresponding to the Quotes from experts/authorities in the Entire Period of Newspaper Coverage (c)*. Note: The authorities and experts shown are: the minister of Health Welfare and Sports (*Minister*), the National Institute for Public Health and the Environment (*RIVM*), the Dutch soccer association (*KNVB*), the branch organizations representing the producers of rubber granulate (*Branch organizations*) and other scientists that were not employed at one of the previous mentioned organizations (*Other scientist*).

sulted largely from the conflicting content of the quotes provided from various authorities. Often, articles quoted multiple authorities and experts (see Fig. 3(b)), and in many articles these citations or paraphrases were given a format such as “X says [...], however Y disagrees because [...].” The minister of HWS (quoted in 13/153 articles, 8%), the KNVB (27/153, 18%), and the RIVM (54/153, 35%) most frequently provided low risk appraisals when quoted (see Fig. 3(c)). Quotes from scientists from another institution (i.e., a toxicologist employed at a university and other [largely undefined] experts who had been interviewed in the television broadcast), who were quoted in 50 of the 153 articles (33%), represented more frequently an uncertain or high-risk appraisal. The following text fragment from calendar week 40 illustrates this:

Should I still allow my child to play soccer? According to the KNVB, who takes the commotion seriously, but does not yet assume that the fields are unsafe, you can. [Name toxicologist] says the opposite. “As long as there is no clarity, maybe you should choose not to play on these fields, as a precaution. No matter how annoying that is.”⁴

Scientists from other institutions were the most prominent of all experts and authorities in first period of news coverage, followed by the RIVM (see Fig. 3b).

⁴Van der Wal, C. (2016, October 7). *Can we play soccer safely* (In Dutch: Kunnen we wel veilig voetballen?). *Algemeen Dagblad*, p. 13.

3.2.2. *The Second Period of Newspaper Coverage*

In the second period of the newspaper coverage, many articles reported on the results from the tests of rubber granulate by the branch organizations, who concluded that even while rubber granulate contains hazardous substances, the concentrations were acceptable according to European standards. In the newspaper articles that followed, a discussion unfolded between the branch organizations and scientists from other institutions, of whom one toxicologist was frequently quoted. This discussion concerned which European standard the substances in rubber granulate should adhere to. According to the branch organizations, the European standard for mixtures would suffice and therefore it should be concluded that rubber granulate is safe. According to the other scientist(s), rubber granulate should adhere to the standard for consumer products, resulting in the opposite conclusion about the safety of rubber granulate.

In this second period, the number of articles with a low-risk appraisal was equal to the number of articles with an uncertain risk appraisal (see Fig. 3(a)). The RIVM and the other scientists were, with an equal number of articles, the most frequently quoted authority/expert in this second period, followed by the branch organizations (see Fig. 3(b)). The following text fragment is illustrative of the news coverage in this week:

The rubber granules from old car tires contain carcinogenic substances such as benzene, toluene and polycyclic aromatic hydrocarbons (PAHs). According to the branch organization of the tire industry, the rubber granulate on Dutch artificial grass pitches more than sufficiently meet the European standards. The branch organization [name organization] relies on the measurements on fifty artificial grass pitches. The fields are safe, they told municipalities and sports boards this week. Toxicologist [name toxicologist] of [name university] draws the opposite conclusion. The rubber granules contain 1 to 10 milligrams carcinogenic substances per kilogram. For a few types of PAHs, the concentration exceeds the standard that applies to consumer products. That (standard) is more than a thousand times lower than the standard that applies to technical mixtures, on which the [name branch organization] bases itself.⁵

⁵Vermolen, S. (2016, November 28). Research on rubber in artificial turf leads to opposite conclusions (In Dutch: Onderzoek naar rubber in kunstgras leidt tot tegengestelde conclusies). *NRC Handelsblad*, p. 6.

3.2.3. *The Third Period of Newspaper Coverage*

At the end of 2016 most articles reported on the conclusions following the research from the RIVM. The RIVM concluded that rubber granulate does indeed contain hazardous substances, but that these are barely released from the granulate. Therefore, the institute concluded that the risk for health is practically negligible and that it is safe to practice sports on fields with rubber granulate. The RIVM advised to adjust the current European standard for hazardous substances in rubber granulate (the standard for mixtures), to those standards set for consumer products. Most of the articles described the conclusions from the RIVM report quite literally, some addressed doubts regarding these conclusions or mentioned continuing concerns among owners and users of artificial turf fields.

In this last period of the newspaper coverage, we observed considerably more low risk appraisals and fewer high-risk appraisals (see Fig. 3(a)), and the RIVM was quoted in a majority of the articles (see Fig. 3(b)). The following text fragment is an example of the news coverage about the RIVM research in this week:

Practicing sports on artificial grass pitches with rubber granulate is safe. That is the conclusion of the research by the National Institute for Public Health and the Environment (RIVM) last Tuesday. The harmful substances, that raised turmoil earlier this year, are present in the granules, but are only released in very small quantities. As a result, the harmful effect on health is 'practically negligible'.⁶

3.3. Public Responses

Table II provides an overview of quotes by members of the public (i.e., persons associated to a sport club with fields with rubber granulate and parents of children who practiced sports on fields with rubber granulate) and general references to public responses to the risk posed by rubber granulate (mostly provided by the author of an article) observed throughout the newspaper coverage. In approximately one-fourth of the articles in the newspaper coverage, a (person associated to a) sport club was quoted, and in approximately one-sixth of the articles a parent was quoted. The most common response in the quotes from sport clubs was that the club had

⁶Unknown author. (2016, December 21). RIVM: Artificial grass not dangerous after all (In Dutch: RIVM: kunstgras toch niet gevaarlijk). *Financieel Dagblad*, p. 9.

Table II. Overview of sport clubs and parents cited/paraphrased, and general references to public responses

	Code Description	Illustrative Text Fragments Corresponding to the Codes	Number (%) of Articles Coded (<i>N</i> = 153)
Sport clubs cited or paraphrased	A sport club is cited or paraphrased	(see text fragments below)	37 (24%)
	A sport club's citation/paraphrase (total = 37 articles) indicates that the club ...- is concerned about the risk	<i>Youth coach [name coach] did not have a good feeling about it already for some time. Those shredded old car tires on the synthetic turf pitch could never be good. [...]</i> ¹	11 (7%)
	- is unconcerned about the risk	<i>The RIVM says that practicing sports on synthetic turf poses no health risk " says chairman [name chairman] from [name soccer club]. " They are knowledgeable about these things.</i>	11 (7%)
	- has adopted risk mitigation measures	<i>[...] We have chosen to exchange the fields because there are better alternatives available. If you are presented with an alternative that is guaranteed to contain no carcinogenic substances, then you choose it, right?</i> ³	16 (10%)
	- has rejected risk mitigation measures	<i>The [city] [name soccer club] will continue to play on synthetic turf, says chairman [name chairman]. "We adhere to the advice of the RIVM. In addition: December 10 the winter break will start for youth teams. Thus, there are only two more games left to play."</i> ⁴	9 (6%)
Parents cited or paraphrased	A parent is cited or paraphrased	(see text fragments below)	22 (14%)
	A parent's citation/paraphrase (total = 22 articles) indicates that the parent ...- is concerned about the risk	<i>Then the Zembla broadcast aired. I was shocked and researched the internet myself. I read about an American soccer coach who had tracked down nearly two hundred soccer players who had developed leukemia or lymphoma. I explained to my children that it might be bad for their health to keep playing on these fields. I just didn't want to risk waiting for the research. If my child got something, I would never forgive myself.</i> ⁵	14 (9%)
	- is unconcerned about the risk	<i>You hear so many stories about things that are carcinogenic. At a certain point you no longer know what you can and cannot do, "says mother [name mother]. Father [name father] fully agrees." First they say that fruit is healthy, then there is too much sugar in it. What to believe? I let my child play on this field without any concerns.</i> ⁶	7 (5%)
	- has adopted risk mitigation measures	<i>Football mother [name mother] found this choice a devilish dilemma. "You also don't want to be seen as an overprotective mother. But nobody knows how dangerous it is. [...]</i> After the broadcast, I immediately sent an e-mail to the school and stated that my daughter is not on that field for the time being. ⁷	5 (3%)
	- has rejected risk mitigation measures	<i>And the parents? Of course they are shocked by the reports about artificial turf, but what are they supposed to do? Take their children off the field? "Who would I help with that?," father [name father] wonders aloud.</i> ⁸	2 (1%)

(Continued)

Table II. (Continued)

	Code Description	Illustrative Text Fragments Corresponding to the Codes	Number (%) of Articles Coded (N = 153)
General references to public responses	A reference to one of the following public responses:- commotion	<i>Even after last weekend, the commotion about the alleged toxicity of shredded car tires in synthetic turf has not yet subsided.</i> ⁸	55 (36%)
	- concerns	<i>The broadcast caused concern among clubs, parents and athletes.</i> ⁹	47 (31%)
	- adopted risk mitigation measures	<i>Some associations have banned the use of synthetic turf until further notice and have been forced to move to (real) grass at the neighbors. Other associations only let their youngest soccer players train and play on natural grass as a precaution.</i> ¹⁰	61 (40%)
	- rejected risk mitigation measures	<i>Many clubs have continued to play on their artificial turf.</i> ¹¹	25 (16%)

¹Fontein, J. Are they or are they not allowed on artificial grass? (In Dutch: Mogen ze wel of niet het kunstgras op?) (2016, October 8). De Volkskrant, p. 3.

²Unknown author. Help, my son plays soccer on 'dangerous' artificial turf (In Dutch: Help, mijn zoon speelt op 'gevaarlijk' kunstgras) (2016, October 6). Metro, P. 7.

³Unknown author. Ajax replaces artificial turf (In Dutch: Ajax vervangt kunstgrasvelden) (2016, October 14). De Volkskrant, p.8.

⁴Unknown author. Clubs level headed concerning new research artificial turf (In Dutch: Clubs nuchter onder nieuw onderzoek kunstgras) (2016, November 29). Algemeen Dagblad, p. 15.

⁵Schoonhoven, S. Artificial grass: save or not? (In Dutch: Kunstgras: veilig of niet?) (2016, November 29). De Telegraaf, p. 8.

⁶Van Gaalen, E. Keepers and F-players not on artificial turf (in Dutch: Keepers en F'jes niet op kunstgrasveld) (2016, October 8). Algemeen Dagblad, p. 5.

⁷Wageman, S. (2016, October 9). Parents shiver for artificial turf (In Dutch: Ouders bibberen voor kunstgras). Telegraaf, p. 2.

⁸Van der Kaaij, M. Replacing field is expensive (In Dutch: Vervangen veld is kostbare zaak) (2016, October 11). Trouw, p. 10

⁹Unknown author. The tire industry calls fuss incomprehensible (In Dutch; Bandenbranche noemt ophef onbegrijpelijk) (2016, October 21). NRC Handelsblad, p. 3.

¹⁰Misérus, M. Suction of granules at the penalty spot (In Dutch: Korrels zuigen bij de penaltystip) (2016, November 3). De Volkskrant, p. 3.

¹¹Dekker, M. So back to artificial turf? SC Erica is not so sure yet (In Dutch: Dus toch maar weer op kunstgras? SC Erica weet t nog niet zo zeker) (2016, December 21). NRC Handelsblad, p. 4.

adopted measures to mitigate the risks posed by rubber granulate. In the quotes from parents, the most common response was that the parent had concerns about the risks posed by rubber granulate (see Table II).

Most of the general references to public responses (i.e., references to commotion, concerns, measures adopted, and measures rejected) were observed more frequently than the quotes from sport clubs or parents (see Table II). More than a third of the articles mentioned commotion and/or concerns about the risks posed by rubber granulate. Four out of 10 articles mentioned that measures had been adopted by sport clubs, parents, or others to mitigate the risk posed by rubber granulate, while less than two out of 10 articles mentioned that others had rejected risk mitigation measures.

3.4. Contextualization of the Risk

The proportions and percentages of articles discussing the risk elements (hazardous) substances in rubber granulate, exposure to rubber granulate, potential health effect, and probability of health effects, as well as illustrative text fragments, are shown in Table III. Substances in rubber granulate were explicitly mentioned in a majority of the newspaper articles. Most articles referred to substances in general terms and with the adjectives "hazardous" or "carcinogenic." A number of articles mentioned specific types of substances in rubber granulate, such as polycyclic aromatic hydrocarbons (PAHs). Those articles that did not specifically mention substances, did often refer to "carcinogenic rubber" or "carcinogenic granulate." Notably, the word "carcinogenic" was mentioned in more articles than substances in rubber granulate were.

Table III. Number and percentages of articles coded with a reference to one of the following risk elements throughout the newspaper coverage: substances in rubber granulate, exposure to (substances in) rubber granulate, potential health effects due to (exposure to substances in) rubber granulate, and the probability of occurrence of these health effects

Code description	Illustrative text fragments corresponding to the codes	Number (%) of articles coded (N = 153)
References to substances in rubber granulate	- "The granules contain substances that are proven carcinogenic." ¹ - "These [rubber granulates] contain various harmful chemicals, including PAHs (polycyclic aromatic hydrocarbons), nitrosamines and plasticizers." ²	90 (59%)
- Mentioning of the word 'carcinogenic'*	- "Many thousands of soccer players in the Netherlands want clarity about whether or not soccer on rubber granulate is carcinogenic." ³	94 (61%)
References to exposure to (substances in) rubber granulate	- "That means footballers dive, slide and fall on fields with rubber granules full of toxic substances such as zinc, lead, benzene and also PAHs, chemicals that can cause cancer." ⁴ - "[...] the National Institute for Public Health and the Environment (RIVM) has never properly investigated whether carcinogens in this so-called rubber granulate can end up in the body of athletes." ⁵	68 (44%)
References to potential health effects due to (exposure to) rubber granulate	- "Minister [name] wants it to be re-examined whether the rubber granules can harm health." ⁶ - "I read about an American football coach who had tracked down nearly two hundred football players with leukemia or lymph node cancer." ³	77 (50%)
References to the probability of health effects due to (exposure to) rubber granulate	- "Researchers are clear. It is very dangerous for the players. However, replacement is expensive, so the young athlete still plays on it. With a high risk of cancer." ⁷ - "Altogether, with these exposure levels for PAHs (polycyclic aromatic hydrocarbons, carcinogens), about one in a million people who are field players throughout their lives could actually get cancer." ⁸	6 (4%)
- Mentioning of the word 'risk'**	- "The RIVM does not see any health risks of the rubber granules in artificial grass." ⁹ - "I think we can quickly tell whether there are risks based on the analyses." ¹⁰ - "The National Institute for Public Health and the Environment (RIVM) will present additional research into the possible risks of these artificial grass pitches in December." ¹¹ - "The municipality will immediately stop building sports fields with rubber granules. [...] The health risks are considered too high." ¹²	78 (51%)

*Those articles that did not specifically mention substances, did often refer to 'carcinogenic rubber' or 'carcinogenic granulate'.

**The word 'risk' can, but does not necessarily, indicate a probability of a harmful effect due to the exposure to a hazard. The use of this word was not coded as 'probability of health effects'.

¹Unknown author. Journalism Zembla (In Dutch: Journalistiek Zembla) (2016, October 5). NRC Handelsblad, p. 14.

²Fontein, J. Are they or are they not allowed on artificial grass? (In Dutch: Mogen ze wel of niet het kunstgras op?) (2016, October 8). *De Volkskrant*, p. 3.

³Schoonhoven, S. Artificial grass: save or not? (In Dutch: Kunstgras: veilig of niet?) (2016, November 29). *De Telegraaf*, p. 8.

⁴Van der Wal, C. Can we play soccer safely (In Dutch: Kunnen we wel veilig voetballen?) (2016, October 7). *Algemeen Dagblad*, p. 13.

⁵Unknown author. Ajax replaces gets artificial turf fields replaced (In Dutch: Ajax laat kunstgrasvelden vervangen) (2016, October 14). *De Telegraaf*, p. 5.

⁶Ajax replaces artificial turf fields (In Dutch: Ajax laat vervangt kunstgrasvelden) (2016, October 14). *Trouw*, p. 19.

⁷Hendriks, B. Protect your children (In Dutch: Behoed uw kinderen) (2016, October 7). *Algemeen Dagblad*, p. 30.

⁸Voormolen, S. Scientists are critical about artificial grass report (In Dutch: Wetenschappers zijn kritisch over rapport kunstgras) (2016, December 21). *NRC Handelsblad*, p. 4.

⁹Unknown author. No danger of rubber granules, but a shower afterwards (In Dutch: Geen gevaar rubberkorrels, maar wel douchen na afloop) (2016, October 8). *NRC Handelsblad*, p. 15.

¹⁰Speksnijder, C. "Such pollution would not be allowed anywhere else" (In Dutch: 'Zulke verontreiniging zou nergens anders mogen') (2016, October 2016). *De Volkskrant*, p. 20.

¹¹Unknown author. Soccer on artificial grass is possible (for now) (In Dutch: Voetballen op kunstgras kan (nog)) (2016, November 30). *Nederlands Dagblad*, p. 4.

¹²Unknown author. Immediate stop on rubber artificial grass pitches (In Dutch: Per direct stop op rubber kunstgrasvelden) (2016, December 2). *De Telegraaf*, p. 15.

Approximately four out of 10 articles mentioned exposure to rubber granulate and various types of exposure were mentioned. Articles often discussed the frequency and intensity of contact that soccer players and children have with the rubber granulates when practicing sports on artificial grass. Other articles were more specific and mentioned the possibility of the substances being released from the rubber granulate or the possibility for substances in rubber granulate to become invasive in soccer players or children.

Potential health effects due to rubber granulate were mentioned in half of the articles. Both “cancer” and health effects in more general terms (e.g., “bad for health” and “harmful effects”) were mentioned frequently. A number of articles mentioned leukemia and/or lymphoma in specific as possible health effects (these cancers were also mentioned in the television broadcast).

Only a few articles contained a statement about the probability of health effects due to rubber granulate (in terms of low/high probability or numeric probabilities). Notably, the word “risk” was used in more than half of the articles. “Risk” can, but does not necessarily, indicate a probability of a harmful effect due to the exposure to a hazard. The use of this word was not coded as “probability of health effects” as it could be interpreted in various ways. Some articles mentioned for example the absence or possible presence of a risk, in other articles the question was raised what possible risks rubber granulate could pose for soccer players and children, and in other articles the question was raised how high the risk of rubber granulate would be (see Table III for illustrative text fragments).

4. DISCUSSION

Our study illustrates how the media set, and kept, a health risk on the public agenda, which was previously unknown to the public and is, according to experts, a negligible health risk. Our results provide insights into how the content of newspaper articles about this health risk posed by practicing sports on fields with rubber granulate might have contributed to the amplified perceived risks among the public (de Vries et al., 2019). This was done by describing the risk mainly as uncertain, by explicitly presenting controversy between various authorities and experts, by putting emphasis on certain lay responses such as concerns and commotion, and by emphasizing the presence of hazardous substances, while providing

insufficient contextualization about the actual threat to health. Only after new research from the National Institute for Public Health and the Environment (RIVM) confirming that practicing sports on fields with rubber granulate is safe, the reassuring risk message from authorities became more dominant in the newspaper articles. In our previous study (de Vries et al., 2019) we also observed a decline in the public’s perceived risk of rubber granulate consistent with this change in media reporting, suggesting attenuation following the amplification of the risk (Binder et al., 2014; Kasperson et al., 1988).

4.1. Risk Uncertainty and Controversy

Both the focus on risk uncertainty and the representation of controversy in the media coverage on rubber granulate could have increased perceived uncertainty with regard to the risks among the public. Perceived uncertainty has been associated with increased perceived risks (Miles & Frewer, 2003) and an increased demand for risk regulation (Poortvliet & Lokhorst, 2016). The controversy in the newspapers might have also had a negative impact on trust in authorities (Markon & Lemyre, 2013).

The observed representation of controversy between experts and authorities might be a result of the journalistic norm of balanced reporting. This norm should ensure neutral reporting by the equal representation of views from all legitimate stakeholders (Entman, 1990); however, it can lead to an overrepresentation of certain expert views which are not in line with the distribution of views among experts in the scientific community (Boykoff & Boykoff, 2004). The latter was the case in the media coverage in our study, in which one expert, who appraised the risk more often as high or uncertain, was given a highly central position in the mediated debate. Previous studies on media reporting about vaccines (Clarke, 2008) and global warming (Antilla, 2005; Boykoff & Boykoff, 2004) have also shown how the norm of balanced reporting can lead to overrepresentation of certain views and thereby to an inaccurate suggestion of a lack in scientific consensus. In order to provide indeed a balanced reporting, journalists need to provide more information about the support, or lack of support, the represented expert opinions have in the larger scientific community.

4.2. Public Responses

Another notable element in the newspaper coverage that possibly could have had an amplifying effect on public perceptions of the risk posed by rubber granulate was the high observed frequency of references to concerns, commotion, and adopted mitigation measures. Notably, whereas we did see some variation in the quotations from members of the public, the general references to public responses in the articles were strongly focused on concerns, commotion, and adopted risk mitigation measures. These references to concerns, commotion, and adopted measures have likely increased the emotional tonality of the news coverage and could have thereby heightened public perceptions to risks (Klemm *et al.*, 2019).

4.3. Contextualization of Risk

Our study additionally showed that the newspaper articles focused strongly on the presence of substances in rubber granulate, and their supposed hazardous or carcinogenic qualities, while the newspaper articles provided barely any information about the probability that exposure to these substances would lead to harm. This limited contextualization might have led to misinterpretations by the public, as members of the public often differ in their interpretation of toxicological principles from experts (Bearth *et al.*, 2014). For example, it was shown that a large majority of the public in eight European countries (incorrectly) disagrees with the statement “a small amount of toxic chemical substance in a consumer product is not necessarily harmful” (Bearth, Saleh, & Siegrist, 2019, p.3) and (incorrectly) agrees with the statement “being exposed to a toxic synthetic chemical substance is always dangerous, no matter what the level of exposure is” (Bearth *et al.*, 2019, p. 4). These misunderstandings suggest that the focus on the hazardous substances and the limited explanation of the dose response mechanisms might have caused people to believe that the rubber granulate risk poses a serious threat to health from reading the newspaper articles.

Newspaper articles sometimes seemed to refer to the probability of health effects using the term “risk.” The word risk, however, can vary in intended and perceived meaning; it could for example refer to the presence of a hazardous substance, the possibility of a health effect or the probability of a health effect. Furthermore, Jansen, Claassen, van Kamp, and

Timmermans (2019) found that laypersons associate “risk” often with danger (Jansen *et al.*, 2019). The observed lack in essential contextual information and in explanations of the technical terms used is in congruence with the results from previous studies on media coverage of risks (Freimuth *et al.*, 1984; Wahlberg & Sjoberg, 2000).

4.4. Risk Attenuation After the Publication of New Research

After the publication of new research by the RIVM, confirming the institute’s initial risk judgement that practicing sport on fields with rubber granulate is safe, we observed a shift in the media coverage. The RIVM became the most frequently cited authority in the newspaper coverage, the dominant risk appraisal was that of low risk instead of uncertain risk, and the reassuring conclusion from the RIVM research was adopted in the newspaper articles without much alterations. These elements have likely contributed to the observed decline in public perceived risks (de Vries *et al.*, 2019). One explanation for this shift in newspaper coverage might be that the television broadcast that put the risk on the public agenda was adopted by journalists as the main source of new information in the first period of the newspaper coverage, whereas the RIVM became the main source when the institute presented new information (McCarthy *et al.*, 2008; Vasterman & Ruigrok, 2013). There was also a difference in wording of the RIVM’s initial statement shortly after the television broadcast and the institute’s conclusion following the new research. The initial statement “Based on the information studied, the RIVM does not expect that the application of rubber granulate on synthetic turf will lead to health risks. There is now no reason to stop exercising sports on these fields.” (National Institute for Public Health and the Environment (RIVM), 2016b) was not very transparent nor clear. The message following the RIVM research was more transparent and clear about the reasoning behind the safety conclusion.

4.5. Limitations

Our study has a number of limitations which need to be considered. First, the scope of this study was limited to national newspaper coverage. Our study did not incorporate other important media sources such as radio, television, local newspapers, and internet platforms. As we did incorporate all but

one of the Dutch national newspapers, and spill overs between different media sources are likely, we expect nevertheless to have gained a sufficiently comprehensive picture of the news coverage about the risk posed by rubber granulate. Second, our research does not provide evidence for causality, it can only suggest a relation between the dynamics and content of newspaper coverage and public perceptions of risk. In addition, media are only one factor of possible influence on how the public perceives risks, and other factors, such as interpersonal communication, might have considerable impact.

4.6. Recommendations

Public health institutes and other authorities could mitigate amplification of modern risks with an appropriate preparedness and response to new risk media coverages. One important tool would be to prepare guidelines for communication about these modern risks, which are man-made, relatively new, and often characterized to some extent by scientific uncertainty. In these guidelines, specific attention should be given to providing comprehensible information about dose–response mechanisms and about probabilities of harm in relation to chemical substances. In addition, in providing information about the probability of harm due to a certain hazard, one needs to be cautious with the word “risk” as this word might be interpreted as “danger.” Of note, similar to the articles that were published prior to the RIVM research, the newspaper articles that reported on the RIVM results also did not include sufficient information about probabilities. Instead the word “risk” was used (e.g., “the risk posed by rubber granulate is practically negligible”). Finally, we recommend that authorities are transparent in their communication about discussions in the risk community with regard to remaining uncertainties of risk assessments and the precautionary principle, to enable the public to put opposing expert opinions in the media into perspective.

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