Public Engagement with Science in Everyday Life: Perceptions of Wi-Fi Radiation Risks in Schools

Keren Dalyot, Aviv J. Sharon, Daniela Orr, Yael Barel Ben-David & Ayelet Baram-Tsabari

Research in Science Education

ISSN 0157-244X

Res Sci Educ
DOI 10.1007/s11165-019-09894-w

Springer

Research in Science Education
https://doi.org/10.1007/s11165-019-09894-w

Check for updates

Public Engagement with Science in Everyday Life: Perceptions of Wi-Fi Radiation Risks in Schools

Keren Dalyot[1] • Aviv J. Sharon[1] • Daniela Orr[1] • Yael Barel Ben-David[1] • Ayelet Baram-Tsabari[1]

Published online: 21 September 2019

Abstract
Wi-Fi radiation is a type of radio frequency electromagnetic radiation (RF-EMR) that refers to the transfer of energy by radio waves. Nowadays, exposure to RF radiation is widespread including wireless internet connection (Wi-Fi) routers and cell phones. The proliferation of devices emitting RF radiation has entailed some public and media-generated controversy, although scientific evidence has not pointed to the existence of risk. Using the theoretical perspectives of science literacy, public engagement with science, and science media literacy, this work examines public engagement with science-related media reports in a context involving risk. A qualitative design was followed to address multiple viewpoints including an analysis of an authentic primetime TV program concerning the risks of Wi-Fi, its messages, and frames, solicited a public response to the coverage via interviews and decision-making simulation (n = 20), and unsolicited public response based on social media discussions (n = 315 comments). Our findings suggest that a lack of relevant scientific knowledge does not seem to be related to participants' general scientific literacy among people with higher education. Moreover, interviewees did not place much emphasis on having adequate knowledge in making their decision. These findings emphasize that we need to expand our

✉ Keren Dalyot
dalyotkeren@campus.technion.ac.il

Aviv J. Sharon
a.sharon@technion.ac.il

Daniela Orr
daniela.korbasmagal@gmail.com

Yael Barel Ben-David
yaelb@campus.technion.ac.il

Ayelet Baram-Tsabari
ayelet@technion.ac.il

[1] Faculty of Education in Science and Technology, Technion – Israel Institute of Technology, Haifa, Israel

understanding of the different ways that make scientific knowledge relevant when making decisions on scientific issues that relate directly to everyday life.

Keywords Scientific literacy · RF radiation · Public engagement with science · Social media

Introduction

Scientific literacy is assumed to help people "respond to issues and challenges that emerge in their personal and community contexts," including personal health decisions and civic decisions about environmental policies (National Academies of Sciences Engineering and Medicine 2016, p. 24). However, little is known about "how people actually reason with and about science in everyday settings" (Sandoval et al. 2014, p. 148). A few notable studies systematically examined how scientific literacy plays out in a variety of everyday life situations (Feinstein 2011; Ryder 2001), but this empirical base is small. Knowledge about everyday reasoning in authentic civic contexts, such as water fluoridation policy and vaccination policy, is especially lacking (Allchin 2011). Here, we examine one such example of lay reasoning on a science-related civic issue. Specifically, we focus on parents' reasoning about the deployment of Wi-Fi infrastructure in schools and how they perceived risks associated with it.

Wi-Fi radiation is a type of radio frequency electromagnetic radiation (RF-EMR) that is essentially the transfer of energy by radio waves.[1] According to the Australian Radiation Protection and Nuclear Safety Agency n.d, "RF-EMR is non-ionising radiation [NIR], meaning that it has insufficient energy to break chemical bonds or remove electrons (ionisation)."[2] Nowadays, exposure to RF radiation is widespread; from wireless internet connection (Wi-Fi) routers in workplaces, homes, restaurants, and even buses and trains, to cell phones and microwave ovens.

The proliferation of devices emitting RF radiation has entailed some controversy (Boehmert et al. 2017). In several high-income countries, groups of activists object to NIR for various reasons. Many of these activists claim that due to "electromagnetic hypersensitivity" and other adverse effects, the use of Wi-Fi radiation in public areas such as schools should be reduced or even eliminated. However, scientific studies have thus far not been able to establish this claim clinically (Bräscher et al. 2017; Eldridge-Thomas and Rubin 2013).

Current scientific evidence of harm from Wi-Fi routers (and RF radiation in general) is "inconclusive and inconsistent" (Wood and Roy 2017, p. 6). For the scientific community, this lack of definitive evidence simply implies that research has not yet determined the existence of risk. Epidemiological studies that examined the relationship between cell phone use and brain and central nerve system tumors have faced severe methodological issues and have thus far not been able to prove risk clearly. In Israel, a country that ranks second in smartphone ownership among advanced economies (PEW Research Center 2019), there is no evidence that the frequency of (malignant) brain and central nerve system tumors has increased between 1990 and 2014 (Ministry of Health 2018). Other studies, such as the one by the National Toxicology

[1] Wi-Fi is a radio frequency local area connection technology in the 5–10-cm wavelength range. Within the non-ionizing (NIR) spectrum, we find RF (radio frequency) and ELF (extremely low frequencies). Prevalently used appliances all emit radiation in the RF spectrum; these include cell phones and towers, microwaves, and Wi-Fi routers. An example for a source of ELF is power supply lines.

[2] As opposed to ionizing radiation (IR) which has enough energy to break chemical bonds and remove electrons.

Program (USA), have found limited effects: increase in heart tumors in male rats exposed to high levels of cellular radiation, but not in female rats and mice (National Toxicology Program 2018).

Regulatory systems apply the precautionary principle in relation to Wi-Fi radiation (Hedendahl et al. 2017). The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has published guidelines regulating exposure to NIR. These guidelines are based on the known thermal effects (an increase in heat), which is non-cumulative and negligible in common appliances such as cell phones and Wi-Fi routers. Despite many studies, there is no clear and unequivocal evidence that RF radiation causes cancer or other diseases (Croft 2018). Since there is a general consensus that children are more sensitive and might therefore be more vulnerable to potential radiation effects (Kheifets et al. 2005), extra precaution is taken where they are concerned (Balzano and Sheppard 2011; Foster and Moulder 2013; Timotiejevic and Barnett 2006). Following the precautionary principle, several studies conducted recently found that RF measurements in schools (from Wi-Fi and other sources) were even lower than the minimum exposure levels recommended by international guidelines and standards (Choi et al. 2018; Hedendahl et al. 2017; Karipidis et al. 2017).

Nevertheless, the precautionary principle can be interpreted and implemented by the public in various ways. For example, UNESCO's (2005) definition states "when human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm" (p. 14). Different people may understand in different ways what these actions actually are, what level of harm diminishment is acceptable, and how "morally unacceptable harm" should be defined. In the developed world there is growing public concern that the health risks associated with RF radiation are underestimated and that therefore appropriate precautionary measures are not taken—a concern that is often magnified by the media (Wood and Roy 2017).

Public engagement with radiation from Wi-Fi routers is studied here as an example for public engagement with a scientific issue relevant to everyday life. This is an emerging social issue in Israel, where this study takes place, particularly given the growing use of Wi-Fi in schools. We specifically ask how parents engage with science in a specific context—RF radiation in general and radiation from Wi-Fi routers in particular.

Literature Review

The issues related to our research crosscut several scholarly disciplines and they especially lay in the intersection of science literacy, public engagement with science, and science media literacy. These issues will be explored here to present a cohesive framework for our study.

Scientific Literacy and Public Engagement with Science Central to the entire discipline of science education are the concepts of science literacy and scientific literacy. While some researchers have suggested that they are not exactly parallel concepts, many still use them interchangeably (Roberts 2007). Roberts and Bybee (2014) suggest that science literacy embodies an approach "that science is the preferred and sufficient way to think about situations that have personal and societal components" (p. 546) and that the purpose of science education is training of future scientists whereas scientific literacy requires science education to train future citizens in light of Vision II of the term (Roberts and Bybee 2014). Vision II emphasizes a vision for science education that helps individuals "respond to issues and challenges that emerge in their personal and community contexts," such as decisions relating to health and energy consumption (National Academies of Sciences Engineering and Medicine 2016, p. 24). Our approach follows the concept of scientific literacy, especially as it relates to a critical understanding of science reports in the media, a complex skill that requires a variety of evidentiary practices, as well as dispositions and habits of mind, like intellectual humility and open-mindedness (Authors, submitted; Roberts and Bybee 2014).

Research has offered some preliminary insights into the ways individuals and communities engage with science in everyday life and offered some implications for the instruction of scientific literacy in schools (Feinstein 2011; Ryder 2001; Weeth Feinstein et al. 2013). After Weeth Feinstein (Weeth Feinstein 2014), we define engagement with science as “the intra- and inter-personal process of connecting science with lived experience” (p. 593).

One insight emerging from these studies is that scientific knowledge is useful for everyday life in diverse ways, but it is seldom useful in its canonical form. For example, a case study examining engagement with science among parents of children with Down’s syndrome found that they were provided information about the genetic basis of the syndrome, and rejected it as “inappropriate, untimely, and irrelevant to their immediate concerns” (Layton et al. 1993, p. 118). Instead, they were more interested in clinical research which related to “what needed to be done, short term, immediately, within their own particular setting” (p. 44).

This also serves as an example of a more general trend: “[M]any [people] engage with science in response to situation-specific needs and tend to be interested in science only insofar as it helps them solve their problems” (Weeth Feinstein et al. 2013, p. 315). Along these lines, Noah Weeth Feinstein has suggested that to be considered “science literate,” people must be able to identify when science is useful for their own needs and interests and “interact with sources of scientific expertise in ways that help them achieve their own goals,” and that people who are able to do so are “competent outsiders” to science (Feinstein 2011, p. 180).

Other case studies in this field highlighted the importance of understanding uncertainty in science and its implications for risk assessment. Case studies suggest that laypeople often expect science to provide unequivocal answers to their questions, despite its limitations. These can include the complexity of the phenomena studied and the difficulty of transferring scientific knowledge from laboratory settings to “complex settings outside of the laboratory” (Ryder 2001, p. 26).

Public Engagement with Science in the Media Despite the progress achieved in this area, little is known about public engagement with science-related media coverage specifically. Moreover, little research has been conducted on the teaching and assessment of “scientific media literacy” within schools (Reid and Norris 2016). This is surprising, given the highly mediated ways people are exposed to science in everyday life: surveys indicate that mass media are by far the primary source of information about science and technology information for most individuals (National Science Board 2018). The lack of research in this area is also surprising considering that several science education policy documents ascribe great importance to teaching children and youth how to critically engage with science in the media (McClune and Jarman 2010).

A few studies have characterized how members of the public make sense of science-related news coverage (Davis and Russ 2015; Laslo et al. 2011; Leung et al. 2017; Tseng 2018). Some of these findings are based on “solicited” methods, in which researchers provide study participants with pre-selected science-related news items and observe how they interpreted it. For example, van den Brul (1995) compared scientists’ and non-scientists’ responses to television news items about a tentative correlation between vitamin K injections and childhood cancer and found that non-scientists can be “more accepting of uncertainty than many scientists believe them to be" (p. 232). More recently, Davis and Russ (2015) provided adults with a printed newspaper item about the prescription and use of acid reflux medications and used think aloud and follow-up interviews to study how lay adults made sense of it. They found that lay readers interpreted these news items using frames that may diverge from those of the scientist or of the reporter who produced the media report. For example, the scientists and reporters may frame the discovery of a new drug as "social progress," but lay readers may frame it as "runaway science" suggestive of corruption and immorality.

Other studies have focused on spontaneous engagement with science in the media, such as among online forum participants, commenters on news websites, and social media users (Hargittai et al. 2018; Orr et al. 2016; Laslo et al. 2011, Baram-Tsabari and Segev 2015). Like Davis and Russ (2015), Laslo et al. (2011) found that when commenters on online news websites discuss animal experimentation, their discourse introduces "audience frames" which may or may not replicate the media frames appearing in the news article itself. In the context of animal experimentation, these audience frames tend to focus on moral, rather than scientific, aspects of scientific research. In the context of climate change, studies have found that "the effects [of media framing] are complex and dynamic and there is no straight forward relationship between information campaigns and behaviour change" (Anderson 2009, p. 166). However, in the context of policy, Drews and Van den Bergh (2015) explain that how the audience perceive policy options presented in the media is often mediated by individual and context factors. These need to be taken into consideration when designing coverage. They do however, make a suggestion for media frames centered "on strategies and solutions for the problem," thus presenting to the audience the idea that climate change is an issue with possible solutions within reach (p. 868).

Another relevant line of previous work has focused on public perceptions of uncertainty and risk in the media. Evidence in this field suggests that when people are exposed to uncertain tones and non-definitive messages, these messages can sometimes be interpreted as a pretext for anxiety and outrage or, at the other extreme, disregard (Borraz 2011; Covello 2011; Fogarty et al. 2011). Indeed, studies have found that when people encounter unpredictable and inconsistent findings, they are likely to feel uncertainty or disorientation, which may easily lead to fear and anger (Chang 2015). Many scientific issues, associated with scientific advancements are characterized by some ambiguity and cause uncertainty, especially in the context of decision-making. These issues include some conspicuous sources of non-ionizing radiation, for example, high voltage power lines and mobile phone towers (Christensen 2009).

Although there are many studies on framing and perception of cell phone radiation (for example Elvers et al. 2009; Wiedemann et al. 2013), the issue of Wi-Fi radiation risk perception in general and in schools, in particular, has yet to be studied comprehensively. A study that examined risk perception of various RF-EMF sources found that Wi-Fi routers were perceived as less dangerous than mobile towers (on roofs of schools) and mobile phone calls (Freudenstein et al. 2015). Regarding Wi-Fi radiation specifically, Bräscher et al. (2017) found that after watching a TV report about the detrimental health effect of RF-EMF and Wi-Fi, participants tended to "increase their self-evaluation as electrosensitive…were more concerned about EMF in general, and more anxious regarding the WiFi signal after the experiment" (p. 269).

In sum, while previous work has provided essential groundwork on scientific literacy and public engagement with science, the field is ripe for further research, especially in the context of media consumption and risk perceptions. The current study, therefore, aims to examine public engagement with science-related media reports in a context involving risk. Namely, we focus on a prime-time TV program concerning the risks of RF radiation and Wi-Fi in schools.

In this study, we ask how scientific literacy plays a part in how viewers make sense of the information on the program when solicited to do so, and how social media users spontaneously engage with the issue of RF radiation prompted by the program. We then suggest some implications for the teaching and learning of scientific literacy and scientific media literacy.

Methodology

Our research approach was inspired by Davis and Russ' (2015) work on dynamic framing. Davis and Russ discuss microframing that guides laypeople's sense making of scientific information in context and offer dynamic framing as a bridge between science communication and science education. Specifically, they argue that dynamic framing "can be successfully employed to make sense of common phenomenon surrounding public knowledge of science" (p. 223). They offer an example of looking at how in the climate change debate "open questions and scientific uncertainty" are highlighted (p. 232) resulting in an overemphasis on a skeptical approach to the debate and thus how this leads to an inclination not to support mitigation through policy efforts. Their approach supports formulating research in the nexus of science education and science communication. In our study, we aimed to better understand this in the context of RF radiation from Wi-Fi routers; thus, we followed a qualitative design to address multiple viewpoints. Qualitative research allows for "significant descriptions about complex processes and relationships" (Piotrkowski 1979, p. 290). Our study includes an analysis of an authentic TV program, its messages, and frames, as well as solicited public response to the coverage via interviews, and unsolicited public response based on social media discussions about the program.

Social media discussions provide the social scientist with access to "a naturally occurring form of focus group which has the added advantage of being ready transcribed" (Hine 2011, p. 3). Social media is increasingly used as an unobtrusive research method, complementing other methods that require direct interaction with informants (Kahle et al. 2017; Lee 2000).

These different sources enabled us to examine the "complex processes and relationships" in the different ways people understand and react to media frames on scientific issues.

Research Context

This study was conducted in Israel, a high-income country with a highly educated population—50.9% of population aged 25–64 hold a tertiary degree, as compared with the OECD average which is 36.91% (OECD 2017a). ICT use is also very high, e.g., 129 cell phone subscriptions per 100 people (World Bank 2018), and 80.6% of the adult population (ages 16–74) use the internet (similar to the OECD average, OECD 2017a). Social media use is also significant, especially Facebook. At the end of 2017, there were 5,800,000 *Facebook* subscribers (Internet World Stats 2018), which is 68.6% of the population.

For the past several years, the Israeli Ministry of Education has been working on the implementation of a National ICT Program which includes the widespread use of tablets and laptops and thus requires reliable Wi-Fi access in schools. According to the most current data published, the program includes 12% of all elementary and 23% of all junior high schools.[3]

[3] Percentages were calculated based on data published in https://data.gov.il/ and on information provided on the ICT program website: http://sites.education.gov.il/cloud/home/tikshuv/Pages/mida_clali_tikshuv.aspx (retrieved in December 2018).

Data Sources

Our study followed a unique methodological path that enables us to investigate multiple data sources not as a triangulation exercise but as a way to actively examine engagement and interconnections between all sources. We start by describing these sources methodologically and conceptually.

Science on TV: Radiation in Prime-Time TV

On April 12, 2016, the program "How We Kill Ourselves: Radiation"[4] was broadcasted nationwide on a major commercial channel during prime time. The 25-min show was viewed by 8.2% of TV owners in Israel.[5]

The anchor of this program is a well-known TV celebrity in Israel who hosts regular morning TV shows and radio programs and maintains a strong social media presence.

The TV program was dedicated to the issue of RF radiation in general and Wi-Fi radiation in schools in particular. However, the language used referred to either radiation in general or non-ionizing radiation. The program reported on a phenomenon referred to as "sensitivity to radiation," which seems to be identical to the controversial construct of electromagnetic hypersensitivity. Additionally, it focused on a group of parent activists fighting against the installation of Wi-Fi networks in elementary schools that were part of the Ministry of Education's National ICT Program. It included several interviews with people described in the program—a public health professor from the Hebrew University, a (self-proclaimed) radiation engineer, and a lawyer active in the field of radiation (Fig. 1).

Semi-structured Interviews

Data Collection Procedure Our interview protocol was developed by several of the authors as part of a graduate seminar on scientific literacy and following the conceptual path of Davis and Ross (2015) with the goal of understanding interviewees' engagement and decision-making in a daily scientific context. Participants were interviewed in their homes or workplaces or public areas such as cafés, according to their preference. The interviewers (the second and fourth authors and other course participants) read aloud a scenario that included a narrative about a discussion in a parent association. This discussion included a debate concerning whether to join the government's National ICT Program and connect their children's school to Wi-Fi (see Appendix 1 for the complete scenario text). After reading the scenario, the interviewer screened the TV program (on a laptop); after which, the participants had up to 30 min to research the topic and make their decision. The time was limited to 30 min to keep the full session to under 90 min. The information seeking was followed by a structured interview that lasted about 30 min. Interview questions included the following subjects: contextual science knowledge in the field of non-ionizing radiation, the role of science in decision-making, the usefulness and credibility of information sources, perception of the TV show and its credibility, and demographics (see Appendix 2 for the interview protocol). Finally, participants were asked to orally answer a short and standardized scientific literacy test based on 13

[4] http://reshet.tv/item/news/documentary/season-01/episodes/zbuid-468588/

[5] 337,600 households throughout. As an illustration of the program's popularity, on that same evening, a European soccer match was viewed in 267,200 households and a well-known travel and cooking show was viewed in 278,600 households on competing channels: http://rashut2.org.il/info_tv.asp.

Fig. 1 Screenshots from the beginning of the program “How We Kill Ourselves: Radiation,” showing extreme close-ups of the light-emitting diodes (LEDs) of a Wi-Fi router. Set against the backdrop of dramatic, pounding drums, the anchor declares that among people with electromagnetic hypersensitivity, “even exposure to very low intensity of radiation, like Wi-Fi routers, can cause severe symptoms”. Reshet Broadcasting. (2016). Radiation: How We Kill Ourselves

questions used for decades as part of the US Science and Engineering Indicators (National Science Board 2016), which were translated and validated in Hebrew (Shauli and Baram-Tsabari 2019).

Sample Twenty Hebrew-speaking parents aged 30–55 (average age 40),[6] primary caregivers of at least one child under the age of 18, were contacted using convenience sampling. In order to control for levels of education, all the participants had at least a bachelor’s degree, but they varied with regard to their educational attainments in science and technology (see Table 1). The average score in the scientific literacy test was 76% (10/13), which was close to the Israeli national average (70.5%) (Ministry of Science and Technology and Space 2018). Six of the interviewees answered all the questions correctly, only one of whom had studied science at the tertiary education level.

Social Media Discussions

Two publicity posts about the program appeared on the broadcasting company’s Facebook page: one was a general publicity post, and the other was a live Q&A session (video) that followed the airing of the show with one of the participants—the radiation engineer or radiation inspector. Of the 414 textual comments on the posts, 99 were excluded from our analysis for being irrelevant (e.g., “Noa—marry me,” Noa was the host of the Q&A) or repetitive (e.g., the same question posted multiple times). Of the 315 analyzed comments, almost 10% (31) were posted by the same individual—an activist who appeared on the program—and 6% (19) were posted by the radiation inspector who was also part of the live Q&A session (in addition to the video). These were included in the analysis since they are part of the information environment available to the public and are a vital part of the discussion taking place on this issue.

[6] Physics curriculum in the 1990s (when most of our interviewees were in school) was mostly limited to self-selected teens who studied high level physics (in high school), and electromagnetic radiation was not included in other curriculum.

Table 1 Sample demographics and scientific knowledge of interviewees, ordered by levels of science education background

Pseudonym	Gender	Occupation	Age	Highest level of science education	No. of correct answers on a science knowledge test[a]	Time spent independently researching the topic after watching the TV show	Decision on Wi-Fi in class
Avivit	F	Electrical engineer	31	Academic level chemistry, biology, and physics	13/13	0 min	Against
Shoshi	F	Water engineer	31	Academic level water engineering (high school physics)	9/13	30 min	Against
Sivan	M	Electrical engineer	55	Academic level chemistry, physics, and biology	9/13	5 min	Against
Yaron	M	Mechanical engineer	40	Academic level physics	13/13	0 min	Against
Sigal	F	HR	45	High school biology	10/13	10 min	Against
Sarit	F	Manager in a nonprofit organization	51	High school biology	12/13	0 min	Against
Ora	F	Educational counselor	32	High school biology	10/13	0 min	Against
Yuli	F	Teacher	35	High school biology	12/13	0 min	Against
Sasson	M	Economist	39	High school chemistry	9/13	0 min	For
Yelena	F	Events producer	33	High school chemistry	9/13	15 min	Against
Ana	F	Clinical psychologist	47	High school physics	12/13	0 min	Against
Ornit	F	Architect and town planner	46	High school physics	13/13	0 min	Against
Ya'akov	M	Occupational therapist	47	High school physics and geography	13/13	0 min	Against
Sima	F	Welfare worker	45	Junior high school[b]	8/13	0 min	Against
Solomon	M	Administrator	45	Junior high school	8/13	0 min	For
Keren	F	Social worker	34	Junior high school	12/13	0 min.	Against
Limor	F	Social worker	32	Junior high school	11/13	0 min	Against
Ori	M	Lawyer	46	Junior high school	13/13	0 min	Against
Yona	F	Town planner	34	Junior high school	13/13	0 min	Against
Yosefa	F	Teacher	38	Junior high school	9/13	0 min	Against

[a] These comprise 13 close-ended true/false questions from the General Social Survey questions used by the NSB bi-annual survey. These questions have been used to assess scientific literacy in the USA since 1979 and in Israel since 2015

[b] Science is a mandatory school subject in Israel up to the age of 15. If participants did not choose advanced science in high school, they were classified as having a junior high school science level

Data Analysis

All data was imported into MAXQDA for systematic analysis, which included generating themes as they appeared in each data source and then across all data sources. We started our analysis by immersing ourselves in the data, while thinking about the related literature and research questions (Marshall and Rossman 2016). Two leading themes emerged in relation to our research aim which was understanding engagement with science in daily life. We examined how our data supports and explains the relevant literature on scientific literacy and risk perception (Aven 2018& Feinstein 2011), thus sensitizing the existing conceptual framework to our specific study (Patton 2015).

Ethics

All interview participants signed a consent form as a precondition for taking part in this study, and their identities were protected by pseudonyms. Participants were not financially compensated for their time. The interview protocol was approved by the Social & Behavioral Sciences Institutional Review Board (SBS-IRB, Approval No. 2016–22). Ethical consideration for using data on social media platforms presents a more challenging aspect of research ethics. Our Facebook data was collected from a public page and according to their policies: "Content posted to a Page is public and can be viewed by everyone who can see the Page."[7] Taking into account the terms of use and the nature of the platform we collected data from (public) as well as considering the potential sensitivity of the data (not sensitive), we decided on the following steps: the first to preserve anonymity commentator's names were excluded. Second, since comments were written originally in Hebrew the process of translating them preserve the spirit of the comment without using the exact identifiable words (Townsend and Wallace n.d.).

Findings

Here we report on the solicited (interview setting) and unsolicited (social media setting) engagement with a prime-time TV program about non-ionizing radiation.

All the interviewees in the study watched the full 25-min TV program. Although they were offered the opportunity to independently perform further research using all the resources available to them, only four of the 20 did so, one of whom used all of the 30 min available before making up her mind. About half of the interviewees stated having prior knowledge about the implications and risks of Wi-Fi, but most indicated that they relied on the TV program to some extent when making their decision. Only two of the 20 (Sasson and Solomon, see Table 1) voted in favor of using of Wi-Fi in their children's schools.

Our findings are described below using two broad categories: first, we looked at scientific knowledge in the context of scientific literacy, discussing how participants understood and perceived the differences between RF radiation and NIR in general. Second, we examined how our audience dealt with uncertainty and risks in the context of radiation from Wi-Fi. Both categories include findings from all three data sources, which converged in many aspects. We found, on the whole, that the inability to clearly understand the difference between NIR and IR

[7] Facebook Pages-Specific Policies, retrieved from: https://www.facebook.com/policies/pages_groups_events/, accessed on May 2, 2019.

(which is emitted by sources such as X-rays and gamma rays) contributed to feelings of uncertainty and risk.

Scientific Literacy in Context: on TV All Radiations Are Born Equal

The language used in the TV program was vague and general, with frequent use of the word "radiation." Mention of the difference between NIR and IR is superficial. For example, at the start of the program the radiation engineer attempts to explain the difference: "There are many kinds of radiation. Ionising radiation, everyone knows, like X-rays, like atomic radiation, nuclear, it's dangerous and people know to be cautious of it. Our problem is non-ionising radiation." However, other people interviewed later in the program convey messages that blur the lines: "[with Wi-Fi] every classroom is now like a little atomic reactor" (self-identified anti-radiation activist parent).

In the Facebook conversation, there is one attempt to describe the differences between NIR and IR by the anti-radiation activist who appears on the TV show. He explained that "Non-ionising radiation is not harmless. The fact that it does not emit an electron from the atom doesn't make it safe and doesn't mean there are no other influences." Most of the *Facebook* comments referred to radiation generically without distinguishing between NIR and IR or between different sources of NIR. The word "radiation" appears over 200 times in the *Facebook* discussion, including comments such as "Schools should be free of radiation sources" and "How many people will die of cancer from this radiation?" The term "non-ionizing radiation," on the other hand, appears only seven times. In the TV program, the word radiation is said 69 times, whereas the phrase non-ionizing radiation is only said twice. It is evident in all three of our data sources that people use the term "radiation" widely without really distinguishing the type of radiation (NIR or IR) they are referring to, or the source (cell phone, routers, etc.).

It is therefore not surprising that our interviewees were unable to distinguish between the two types of radiation after watching the TV program. One of the first interview questions after stating their decision was "What is the difference between ionising and non-ionising radiation?" Six interviewees said outright that they did not know what the difference was and made no attempt to explain it. Of them, three replied, "I don't know," and another three said while they knew there was a difference, they could not explain it. The remaining 14 interviewees tried to describe the difference. Of them two, Sima and Shoshi, gave answers that were completely wrong. Sima (a welfare worker who took only mandatory science up to 9th grade) said "Ionizing is all the Wi-Fi, non-ionizing is maybe the wired network"; Shoshi (a water engineer who took physics in high school and as part of her university studies) gave a long monologue in which she completely confused the two: "I remember that one of them hurts the body for sure, and I think that is non-ionising, and the ionising is what they said is hard to quantify."

Of the other 12 interviewees, the majority (8) gave partial or inaccurate answers. For example, Yosefa (a teacher) said "Ionising—the person is exposed to an instrument, non-ionising is in the air all the time." Solomon (an administrator) attempted to explain thus "I am not a 100% sure, but I think that ionising radiation has more aggressive rays…it's the radiation in medical examinations where they cover us…so it must be something more violent or more direct." While Solomon made his own inference and showed a basic understanding of the uses of radiation, others came up with explanations that were based on information from the TV program. Sarit postulated that "They are not sure about non-ionising; according to the testimonies, yes, the headaches, the metallic taste in your mouth, but they are not sure how."

Two other interviewees repeated the issue of the metallic taste in one's mouth that was mentioned in the program as an effect of NIR.

To conclude, the ability to distinguish between NIR and IR was not obvious or clear to most of our interviewees as well as to the *Facebook* commentators, rather they combined all types of electromagnetic radiation into one entity: "radiation." In the case of our interviewees, this lack of knowledge did not seem to be related to their scientific education. Of the four interviewees with a background in academic levels of science, one could not answer the question, two gave very partial and inadequate answers, and one gave a completely wrong answer. Our interviewees were influenced by the language used in the program and they often repeated it.

Is Wi-Fi Radiation Dangerous? Perceived Uncertainty and Risk

The duplicitous language used in the program reinforced a framing of danger and risk. One of the leading interviewees in the program, the head of the Cancer and Radiation Epidemiology Unit in a major hospital, said in the opening sequence: "It might be that in 10 years' time we will find that we have made a mistake and that the damages are greater than we thought." Towards the end of the show, she expressed a more ambiguous position: "People want clear messages. I can't give you a conclusive answer whether this [NIR] causes cancer, how much and how NIR causes it." For the most part, the program's message is that, notwithstanding some ambiguity, NIR is dangerous. There is no reference to specific studies or their sources, only general statements such as, "in 2017, 50% of the world population will suffer from symptoms of radiation sensitivity," which is said by the anti-radiation activist lawyer and later repeated by the anchor.

The *Facebook* comments tended to be supportive of the program's framing of NIR as dangerous. Of the 315 comments analyzed, fewer than 10 manifested an approach that NIR was not dangerous: e.g., "It is interesting that you didn't choose to bring the opinion that it [electromagnetic hypersensitivity] is a psychosomatic disorder…[You have to] understand that the sun emits more electromagnetic radiation than Wi-Fi." There were also a few comments that tried to engage other anti-radiation commentators and called for relevant data to be posted: "What research shows that NIR is harmful to human beings? Can you direct me to this research?"

In contrast, almost all the remaining comments in the online discussions reinforced the idea that there is clear proof that NIR is dangerous: "*Obviously* radiation causes cancer, there are even examples when the Electric Company needed to move their dangerous equipment from places that are close to people's living environment" and "*It is clear* that cell phones have strong radiation—that is the headache most people have."[8] One commentator even went as far as accepting all the data presented in the program prima facie as school science resources: "I have to say that the report [TV programme] really helped high school students in an environmental science programme to understand what radiation is and how it affects our lives…A wonderful investigation and full of information."

Our interviewees mostly described a sense of ambiguity regarding NIR's potential risk and a need for further investigation. Several admitted that relying solely on a TV show for scientific information was amateurish, despite their general agreement that NIR might be dangerous. For example, the welfare worker Sima said:

> No one knows what this is really about. What are the risks, what is the extent? No one knows anything really. They know it's dangerous but they can't…like…define it….That

[8] The emphasis in quotes both here and elsewhere is ours.

> is the scariest part. Not knowing. It stresses me out….The one who really wants to know has to learn more.

Similarly, Avivit (electrical engineer) exclaimed: "Sensitivity to radiation? Does it exist? There is no proof it doesn't exist." Like Sima, many of the parents emphasized their uncertainty about Wi-Fi radiation risks and their inability to evaluate risk in these circumstances. For example, when asked if she had any questions, Anna (Clinical psychologist who elected high school physics) replied: "How dangerous is it really or what are its consequences? I don't think anyone knows or can really give me an informed answer."

Many of the *Facebook* comments presented questions to alleviate their concern about risks from specific appliances that were relevant to their lives. These included a high school student asking about a video projector that he sits underneath for 8 h a day, a mother who often goes to a shopping mall which has a strong Wi-Fi signal, and a man who wanted to know whether the size of a cell phone influences the amount of radiation it emits. Interviewees often wanted clear answers to questions such as: Is NIR dangerous? Does it cause cancer? Is there such a thing as "sensitivity to radiation?" What kind of research is being done? Is enough research being done? The TV program provided them with answers that left them concerned about the potential risk of Wi-Fi radiation.

Discussion: Understanding Science and Decision-Making in an Ambiguous World

Our study set out to investigate engagement with science as it is manifested in how people interact with one prime-time TV program on the use of Wi-Fi in schools. We examined two kinds of engagement with the program and how the risks from NIR are framed in it. These different engagements included solicited responses by screening the program to study participants and then interviewing them and unsolicited responses generated by a *Facebook* discussion.

The need to engage with a science-related topic that appears on TV is a daily activity for most people in the modern world. When the public encounters media frames that inform them that they are not sufficiently concerned about a particular scientific issue, it feeds into their risk perception.

Studies have demonstrated that media reports can enhance negative perceptions of scientific issues, especially complex ones, and that the non-scientist public make decisions based on these media messages (Bräscher et al. 2017; Faasse et al. 2012; Fensham 2014; Strum et al. 2005). Furthermore, popular media tend to display scientific findings as opinions, with the implication that there are different opinions. There were many people interviewed in the program, some were scientists but many were not and their opinion (or perception) of the science of NIR was presented as credible as scientists.

Scientific uncertainty, on the other hand, is often confused with a complete lack of knowledge, making results seem unimportant (Fensham 2014). This was demonstrated by how most of our interviewees, as well as the Facebook commentators, accepted that NIR is dangerous and not that there is some uncertainty. Our interviewees were given time after watching the program to search for further information independently. However only four of them did, the rest felt comfortable with their decision based solely on the program (and what additional knowledge they already had). Promoting critical evaluation of science-related news and information among adults is beyond the scope of this paper. We do believe, however, that creating meaningful engagement and participation opportunities for the public in topics they find relevant would assist individuals and communities in developing informed and critical habits of mind towards science in their lives. Creating this meaningful engagement requires developing in adults and especially young adults' life-long learning habits (of science) and not rely solely on school-based science curriculum.

Although the sample included only people with at least a bachelor's degree, we saw that educational background was not closely related with how they made scientific decisions, nor with how well they could understand scientific knowledge in context of this specific issue. Most of the science-educated interviewees did not use or rely on their scientific background when having to decide about the risks of Wi-Fi radiation. Some participants made their decision solely based on the information conveyed by the media, whereas others did not consider the news media reliable.

Implication for School Science

In the case of radiation from Wi-Fi routers, it seems that scientific knowledge is important but not enough. This socio-scientific issue (SSI) has several viable alternatives (Sadler and Donnelly 2006). Science education scholars have argued that argumentation skills, as well as social, economic, and cultural factors of SSI should be addressed by the school curriculum (Weeth Feinstein et al. 2013). Kinslow and Sadler (2018) suggest for teachers and educators a framework for teaching SSIs that incorporates science content knowledge but at the same time also develops argumentation, modeling and reasoning skills. They claim that "Teaching SSIs allows students to explore science ideas and practices intertwined with complex social phenomena, which can promote significant growth in critical thinking" (p. 41).

Returning to the science literacy vs. scientific literacy debate, implications for public engagement and science curriculum could be diverse, since "Education is a normative endeavor, fundamentally concerned with improvement…it may ultimately be our job to distinguish among more and less desirable forms of engagement with science…" (Feinstein 2011, p. 182). Indeed, our findings attest to the need in distinguishing more and less desirable formats of public engagement with SSI—and in preparing students for these different types of engagement. Science educators would naturally like to see their students engage with science based on the available evidence and developed scientific literacy. Other desirable formats of engagement include critical evaluation of science stories on traditional and new media, and developing habits of source evaluation and questioning when faced with unfamiliar science-related subjects. As McClune and Jarman (2010) reported, a panel of experts in science education, media education, science communication, and journalism agreed that students should display an inclination to ask questions about sources of science stories and expect to make judgments about them, while avoiding "both misplaced confidence and unwarranted scepticism" (p. 747). Moreover, policy documents such as the PISA 2015 Science Framework also call for a "skeptical attitude towards all media reports in science" (p. 25). Some design principles for teaching this sense of skepticism can be derived from the Grasp of Evidence Framework (Duncan et al. 2018). Moreover, Students must be given opportunities to practice these skills in "epistemically messy environments" at school (p. 929) if we expect them to be able to perform well in everyday life.

Christensen (2009) makes an important point:

> In situations where scientific knowledge and risk are connected, the confidence of young people to participate in decision making and to exert personal control in relation to

uncertainty (for example, through making sound risk assessments) may link back to their schooling (p. 206).

There are indeed uncertainties (or perceived uncertainties) in science informing citizens' lives; however, science in the classroom often neglects this aspect, thus not preparing future citizens to deal with the realities of science and scientific research.

The program "How We Kill Ourselves: Radiation" demonstrates some of the tactics used to induce fear and mistrust identified by Fensham (2014). First, an anchor who uses his status to claim attention, accusations aimed at the scientific community and other regulatory bodies of neglecting their duties (e.g., "what are the dangers of the Ministry of Education ICT program?" and "In Israel there is still no decision that bans Wi-Fi in schools") and, second, cherry-picking data from unknown sources.

Even though some of our interviewees were well aware of these manipulations, it did not affect their behavior or overall perception of the issue. Similarly, it has been demonstrated by Rosentrater et al. (2013) in the case of climate change that there is a disconnect between peoples' perception of the issue and what public steps they are willing to take or accepted. As mentioned in the literature review, when we discussed the definitions of scientific literacy, critical understanding of science in the media should be incorporated into the curriculum, an issue that is rarely addressed in schools currently.

Study Limitations

This study was exploratory in nature and sought to use various perspectives to gain insights into public perceptions of RF radiation from Wi-Fi. However, as in most qualitative studies, the sample does not allow statistical inference to broader populations because of both its size and the sampling method. In addition, our attempt to control for a general education level (all of our participants had tertiary education levels, while only 50% of adults in Israel have tertiary education, OECD 2017b) created an unrepresentative sample with regard to educational background. However, the scientific literacy scores indicate that educational background was not connected with scientific literacy. Quite a few interviewees without even high school science scored 100% on the literacy questionnaire.

An additional limitation is the proximity of time between the screening of the program and the interview. Most of our participants were opposed to the use of Wi-Fi in schools when asked as soon as they finished watching. Possibly, if interviewed again after some time has passed, participants' attitudes and responses might be different and less extreme.

Nonetheless, our study gives a glimpse into the complex process of decision-making in the face of uncertainty, which perplexes even educated individuals.

Concluding Remarks

The question remains: in what ways is scientific knowledge relevant when making decisions on scientific issues that relate directly to our own lives? In a society where information is too abundant (Baram-Tsabari and Schejter 2019), where people use acronyms like "TMI" (too much information) and "tl:dr" (too long; did not read) to describe how they deal with complex issues, our vision for non-scientists' engagement with scientific issues should be of cultivating "the ability to integrate and interpret information, as well as the time and ability for reflection and evaluation" (National Academies of Sciences Engineering 2016, p. 23). This implies that the teaching and learning of science in schools should (also) be oriented towards these goals, taking into consideration that media and especially social media play an increasing part in how people learn about and engage with science.

Acknowledgments The authors would like to thank the graduate students who took part in this project as part of a course assignment and who contributed their interviews to our database.

Funding Information This work was supported by the Ministry of Science and Technology under Grant Number 3-13697.

Appendix 1. Scenario

"Your child's school is about to join the National ICT Program. The children will receive tablet computers which are connected to the internet via Wi-Fi, and they will use them daily during lessons. Some parents are worried that the radiation may have health implications, while others say there is no danger, and there is a great educational benefit in the program. Tomorrow there will be a special parents' meeting to vote about the use of Wi-Fi in the school, and you have to decide how to vote using any available resources you might have in everyday life (including searching the internet and consulting other people). First, please watch this TV program which was broadcast recently on national TV. Then you'll have another 30 minutes to look for additional information. You don't have to use all of the time and can tell me whenever you make your decision."

Appendix 2. Interview Protocol

Decision: At the end of the process (after half an hour, or when the interviewee has finished):

1. What have you decided? How will you vote? Why?
2. What was your impression of the show you watched? Could you have made your decision just based on the show?
3. Did any of the statements said on the show affect your decision?
4. What questions are still open, as far as you are concerned?

Scientific Knowledge in Context

5. What is the difference between ionizing radiation and non-ionizing radiation?
6. Does ionizing radiation harm the human body?
7. If so, in what way does ionizing radiation harm the human body?
8. Does non-ionizing radiation harm the human body?
9. If so, in what way does non-ionizing radiation harm the human body?
10. What is radiation sensitivity (electromagnetic hypersensitivity)? Do researchers agree that this phenomenon exists?

11. How is it possible to find out if radiation sensitivity is a real phenomenon?
12. How is it possible for people to think different things about a scientific topic?
13. How can someone tell apart a person with well-founded beliefs from a person with less well-founded beliefs?

Additional Sources

14. What other information sources did you choose?
15. Why did you choose these sources?
16. How would you rate their credibility?
17. How would you rate their expertise in the matter?
18. Were there other sources of information you wanted to rely on? Why? What prevented you from using them?

Scientific Knowledge and Decision-Making

19. Did you have knowledge/information that you felt you were missing for making a better decision? What is it?
20. Did you have prior knowledge that helped you make a decision? What is it?
21. Was there any scientific knowledge you were missing so that you could better understand the problem and make a decision? What is it?
22. Was there any scientific knowledge that helped you understand the problem and make a decision? What is it? Please give an example of how this knowledge supported you in making a decision.
23. If or when you come across a medical, scientific or technological problem, do you search for information? Where (internet, literature, experts)? Can you please give me specific details about the websites and books you use?
24. Can you share an example of a situation where you needed information and how you obtained it?
25. In what circumstances, if at all, did your scientific background help you to solve a problem? (Understand what information you are missing, obtain that information, assess its credibility, ask the doctor a question.). Please give examples.
26. In what circumstances did you think that if you had more scientific knowledge it would have helped you? (If you encountered such situations.)

References

Allchin, D. (2011). Evaluating knowledge of the nature of (whole) science. *Science Education, 95*(3), 518–542. https://doi.org/10.1002/sce.20432.

Anderson, A. (2009). Media, politics and climate change: towards a new research agenda. *Sociology Compass, 3*(2), 166–182. https://doi.org/10.1111/j.1751-9020.2008.00188.x.

Australian Radiation Protection and Nuclear Safety Agency. (n.d.). What is radiation? ARPANSA. Retrieved August 28, 2018, from https://www.arpansa.gov.au/understanding-radiation/what-is-radiation

Aven, T. (2018). An emerging new risk analysis science: foundations and implications. *Risk Analysis, 38*(5), 876–888. https://doi.org/10.1111/risa.12899.
Balzano, Q., & Sheppard, A. R. (2011). *The influence of the precautionary principle on science-based decision-making: questionable applications to risks of radiofrequency fields*. https://doi.org/10.1080/13669870210154485.
Baram-Tsabari, A., & Schejter, A. M. (2019). *New Media: A Double-Edged Sword in Support of Public Engagement with Science*. In Y. Kali, A. Baram-Tsabari, & A. M. Schejter (Eds.), Learning In a Networked Society (pp. 79–95). https://doi.org/10.1007/978-3-030-14610-8_5
Baram-Tsabari, A., & Segev, E. (2015). The half-life of a "teachable moment": The case of Nobel laureates. *Public Understanding of Science, 24*(3), 326–337. https://doi.org/10.1177/0963662513491369
Boehmert, C., Wiedemann, P., Pye, J., & Croft, R. (2017). *The effects of precautionary messages about electromagnetic fields from mobile phones and base stations revisited: the role of recipient characteristics*. *Risk Analysis*. https://doi.org/10.1111/risa.12634.
Borraz, O. (2011). From risk to the government of uncertainty: the case of mobile telephony. *Journal of Risk Research, 14*(8), 969–982. https://doi.org/10.1080/13669877.2011.574316.
Bräscher, A.-K., Raymaekers, K., Van den Bergh, O., & Witthöft, M. (2017). Are media reports able to cause somatic symptoms attributed to WiFi radiation? An experimental test of the negative expectation hypothesis. *Environmental Research, 156*, 265–271. https://doi.org/10.1016/J.ENVRES.2017.03.040.
Chang, C. (2015). Motivated processing: how people perceive news covering novel or contradictory health research findings. *Science Communication, 37*(5), 602–634 Retrieved from http://scx.sagepub.com.dcu.idm.oclc.org/content/37/5/602.
Choi, J., Hwang, J.-H., Lim, H., Joo, H., Yang, H.-S., Lee, Y.-H., Eeftens, M., Struchen, B., Röösli, M., Lee, A. K., Choi, H. D., Kwon, J. H., & Ha, M. (2018). Assessment of radiofrequency electromagnetic field exposure from personal measurements considering the body shadowing effect in Korean children and parents. *Science of the Total Environment, 627*, 1544–1551. https://doi.org/10.1016/j.scitotenv.2018.01.318.
Christensen, C. (2009). Risk and school science education. *Studies in Science Education, 45*(2), 205–223. https://doi.org/10.1080/03057260903142293.
Covello, V. T. (2011). Risk communication, radiation, and radiological emergencies: strategies, tools, and techniques. *Health Physics, 101*(5), 511–530. https://doi.org/10.1097/HP.0b013e3182299549.
Croft, R (2018). *ICNIRP radiofrequency guidelines public consultation version*. Retrieved from: https://www.icnirp.org/cms/upload/consultation_upload/ICNIRPCroft_PCD_BioEM2018.pdf
Davis, P. R., & Russ, R. S. (2015). Dynamic framing in the communication of scientific research: texts and interactions. *Journal of Research in Science*.
Drews, S., & Van Den Bergh, J. C. J. M. (2015). What explains public support for climate policies? A review of empirical and experimental studies. *Climate Policy, 16*, 855–876. https://doi.org/10.1080/14693062.2015.1058240.
Duncan, R., Chinn, C., & Barzilai, S. (2018). Grasp of evidence: problematizing and expanding the next generation science standards' conceptualization of evidence. *Journal of Research in Science Teaching, 55*(7), 907–937. https://doi.org/10.1002/tea.21468.
Eldridge-Thomas, B., & Rubin, G. J. (2013). Idiopathic environmental intolerance attributed to electromagnetic fields: a content analysis of British newspaper reports. *PLoS One, 8*(6), e65713. https://doi.org/10.1371/journal.pone.0065713.
Elvers, H.-D., Jandrig, B., Grummich, K., & Tannert, C. (2009). Mobile phones and health: media coverage study of German newspapers on possible adverse health effects of mobile phone use. *Health, Risk & Society, 11*(2), 165–179. https://doi.org/10.1080/13698570902784273.
Faasse, K., Gamble, G., Cundy, T., & Petrie, K. J. (2012). Impact of television coverage on the number and type of symptoms reported during a health scare: a retrospective pre-post observational study. *BMJ Open, 2*(4), e001607. https://doi.org/10.1136/bmjopen-2012-001607.
Feinstein, N. (2011). Salvaging science literacy. *Science Education, 95*, 168–185. https://doi.org/10.1002/sce.20414.
Fensham, P. J. (2014). Scepticism and trust: Two counterpoint essentials in science education for complex socio-scientific issues. *Cultural Studies of Science Education, 9*(3), 649–661. https://doi.org/10.1007/s11422-013-9560-1.
Fogarty, A. S., Holland, K., Imison, M., Blood, R. W., Chapman, S., & Holding, S. (2011). Communicating uncertainty—how Australian television reported H1N1 risk in 2009: a content analysis. *BMC Public Health, 11*(1), 181. https://doi.org/10.1186/1471-2458-11-181.
Foster, K. R., & Moulder, J. E. (2013). Wi-Fi and health: review of current status of research. *Health Physics, 105*(6), 561–575. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/24162060.
Freudenstein, F., Wiedemann, P. M., & Varsier, N. (2015). Exposure knowledge and risk perception of RF EMF. *Frontiers in Public Health, 2*, 289. https://doi.org/10.3389/fpubh.2014.00289.

Hargittai, E., Füchslin, T., & Schäfer, M. S. (2018). How do young adults engage with science and research on social media? Some preliminary findings and an agenda for future research. *Social Media + Society, 4*(3), 205630511879772. https://doi.org/10.1177/2056305118797720.

Hedendahl, L. K., Carlberg, M., Koppel, T., & Hardell, L. (2017). Measurements of radiofrequency radiation with a body-borne exposimeter in Swedish schools with Wi-Fi. *Frontiers in Public Health, 5*, 279. https://doi.org/10.3389/fpubh.2017.00279.

Hine, C. (2011). Internet research and unobtrusive methods. *Social Research UPDATE, 61*, 1–4.

Internet World Stats. (2018). *Israel*. Retrieved from: https://www.internetworldstats.com/me/il.htm

Kahle, K., Sharon, A. J., & Baram-Tsabari, A. (2016). Footprints of fascination: Digital traces of public engagement with particle physics on CERN's social media platforms. *PLoS ONE, 11*(5), 1–22. https://doi.org/10.1371/journal.pone.0156409

Karipidis, K., Henderson, S., Wijayasinghe, D., Tjong, L., & Tinker, R. (2017). Exposure to radiofrequency electromagnetic fields from Wi-Fi in Australian schools. *Radiation Protection Dosimetry, 175*(4), 432–439. https://doi.org/10.1093/rpd/ncw370.

Kheifets, L., Repacholi, M., Saunders, R., & van Deventer, E. (2005). The sensitivity of children to electromagnetic fields. *Pediatrics, 116*(2), E303–E313.

Kinslow, A. T., & Sadler, T. D. (2018). Making science relevant: using socio-scientific issues to foster critical thinking. *The Science Teacher, 86*(1), 40–45 Retrieved from www.nsta.org/highschool.

Laslo, E., Baram-Tsabari, A., & Lewenstein, B. V. (2011). A growth medium for the message: online science journalism affordances for exploring public discourse of science and ethics. *Journalism: Theory, Practice & Criticism, 12*(7), 847–870.

Layton, D., Jenkins, E., Macgill, S., & Davey, A. (1993). *Inarticulate science? Perspectives on the public understanding of science and some implications for science education*. Nafferton, Driffield, East Yorkshire: Studies in Education.

Lee, R. M. (2000). Introduction to unobtrusive methods. In R. M. Lee (Ed.), *Unobtrusive methods in social research* (pp. 1–16). Buckingham: Open University Press.

Leung, J. S. C., Wong, A. S. L., & Yung, B. H. W. (2017). Evaluation of science in the media by non-science majors. *International Journal of Science Education, Part B, 7*(3), 219–236. https://doi.org/10.1080/21548455.2016.1206983.

Marshall, C., & Rossman, G. B. (2016). *Designing qualitative research* (6th ed.). Thousand Oaks: Sage.

McClune, B., & Jarman, R. (2010). Critical reading of science-based news reports: establishing a knowledge, skills and attitudes framework. *International Journal of Science Education, 32*(6), 727–752. https://doi.org/10.1080/09500690902777402.

Ministry of Health. (2018). *Trends in prevalence of brain and central nervous system tumors, Israel, 1990-2014*. Retrieved from: https://www.health.gov.il/PublicationsFiles/brain1990_2014.pdf (Hebrew).

Ministry of Science Technology and Space. (2018). *Perceptions and attitudes of the public in Israel on science, technology and space* (pp. 83).

National Academies of Sciences Engineering and Medicine. (2016). *Science literacy: concepts, contexts, and consequences* (p. 10.17226/23595). Washington, D.C.: The National Academies Press.

National Science Board. (2016). *Science and engineering indicators*. Arlington VA.

National Science Board. (2018). *Science and engineering indicators 2018*. Alexandria, VA: National Science Foundation Retrieved from https://www.nsf.gov/statistics/indicators/.

National Toxicology Program. (2018). *Cell phone radio frequency radiation studies.* Retrieved from: https://www.niehs.nih.gov/health/materials/cell_phone_radiofrequency_radiation_studies_508.pdf

OECD Digital Economy Outlook 2017 (2017a). OECD. https://doi.org/10.1787/9789264276284-en. Retrieved from: http://www.oecd.org/internet/oecd-digital-economy-outlook-2017-9789264276284-en.htm.

OECD (2017b), "Israel", in education at a glance 2017: OECD indicators, OECD Publishing, Paris. https://doi.org/10.1787/eag-2017-53-en. Retrieved from: http://www.oecdilibrary.org/docserver/download/9617041ec053.pdf?expires=1514800219&id=id&accname=guest&checksum=AA6F0F91CA1E007F072B8CCE27147CE9.

Orr, D., Baram-Tsabari, A., & Landsman, K. (2016). Social media as a platform for health-related public debates and discussions: the Polio vaccine on Facebook. *Israel Journal of Health Policy Research, 5*(1), 34. https://doi.org/10.1186/s13584-016-0093-4

Patton, M. Q. (2015). *Qualitative research and evaluation methods: integrating theory and practice* (4th ed.). Thousand Oaks: SAGE Publications.

Pew Research Center. (2019). *Smartphone ownership is growing rapidly around the world, but not always equally*. (2019). Retrieved from: https://www.pewglobal.org/2019/02/05/smartphone-ownership-is-growing-rapidly-around-the-world-but-not-always-equally/ last visited on May 5th, 2019.

Piotrkowski, C. S. (1979). *Work and the family system*. New York, NY: The Free Press.

Reid, G., & Norris, S. P. (2016). Scientific media education in the classroom and beyond: a research agenda for the next decade. *Cultural Studies of Science Education, 11*(1), 147–166. https://doi.org/10.1007/s11422-015-9709-1.

Roberts, D. A. (2007). Scientific literacy/science literacy. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 729–780). Mahwah, NJ: Lawrence Erlbaum Associates.

Roberts, D. A., & Bybee, R. W. (2014). Scientific literacy, science literacy, and science education. In G. Lederman, Norman & K. Abell, Sandra (Eds.), *Handbook of research on science education, Volume II* (2nd ed., pp. 545–558). https://doi.org/10.4324/9780203097267-38.

Rosentrater, L. D., Saelensminde, I., Ekström, F., Böhm, G., Bostrom, A., Hanss, D., & O'connor, R. E. (2013). Efficacy trade-offs in individuals' support for climate change policies. *Environment and Behavior, 45*(8), 935–970. https://doi.org/10.1177/0013916512450510.

Ryder, J. (2001). Identifying science understanding for functional scientific literacy. *Studies in Science Education, 36*(1), 1–44. https://doi.org/10.1080/03057260108560166.

Sadler, T. D., & Donnelly, L. A. (2006). Socioscientific argumentation: the effects of content knowledge and morality. *International Journal of Science Education, 28*(12), 1463–1488.

Sandoval, W. A., Sodian, B., Koerber, S., & Wong, J. (2014). Developing children's early competencies to engage with science. *Educational Psychologist, 49*(2), 139–152. https://doi.org/10.1080/00461520.2014.917589.

Shauli S, & Baram-Tsabari, A (2019). The usefulness of science knowledge for parents of hearing-impaired children. *Public Understanding of Science, 28*(1), 19–37. https://doi.org/10.1177/0963662518772503

Strum, L. A., Mays, R. M., & Zimet, G. D. (2005). Parental beliefs and decision making about child and adolescent immunization: From polio to sexually transmitted infections. *Developmental and Behavioral Pediatrics., 26*(6), 441–452.

Timotiejevic, L., & Barnett, J. (2006). Managing the possible health risks of mobile telecommunications: public understanding of precautionary action and advice. *Health, Risk & Society, 8*(2), 143–164.

Townsend, L., & Wallace, C. (n.d.). *Social media research: a guide to ethics*. Retrieved from https://www.gla.ac.uk/media/media_487729_en.pdf

Tseng, A. S. (2018). Students and evaluation of web-based misinformation about vaccination: critical reading or passive acceptance of claims? *International Journal of Science Education, Part B,* 8(3), 250–265. https://doi.org/10.1080/21548455.2018.1479800.

UNESCO. (2005). *The precautionary principle: World commission on the ethics of scientific knowledge and technology*. Paris: UNESCO Retrieved from: http://unesdoc.unesco.org/images/0013/001395/139578e.pdf.

van den Brul, C. (1995). Perceptions of science: how scientists and others view the media reporting of science. *Studies in Science Education, 25*(1), 211–237. https://doi.org/10.1080/03057269508560055.

Weeth Feinstein, N. (2014). Making sense of autism: progressive engagement with science among parents of young, recently diagnosed autistic children. *Public Understanding of Science, 23*(5), 592–609. https://doi.org/10.1177/0963662512455296.

Weeth Feinstein, N., Allen, S., & Jenkins, E. (2013). Outside the pipeline: reimagining science education for nonscientists. *Science, 340*(6130), 314–317. https://doi.org/10.1126/science.1230855.

Wiedemann, P. M., Schuetz, H., Boerner, F., Clauberg, M., Croft, R., Shukla, R., Kikkawa, T., Kemp, R., Gutteling, J. M., de Villiers, B., da Silva Medeiros, F. N., & Barnett, J. (2013). When precaution creates misunderstandings: the unintended effects of precautionary information on perceived risks, the EMF case. *Risk Analysis*. https://doi.org/10.1111/risa.12034.

Wood, A., & Roy, C. (2017). Overview: the electromagnetic spectrum and nonionizing radiation. In A. Wood & K. Karipidis (Eds.), *Non-ionizing radiation protection* (pp. 1–9). Hoboken, NJ: John Wiley & Sons, Inc.. https://doi.org/10.1002/9781119284673.ch1.

World Bank. (2018). Israel: country data. Retrieved from: https://data.worldbank.org/country/israel?view=chart.