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Radiofrequency electromagnetic field exposure and risk perception: A pilot experimental study

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Background: Exposure to far-field radiofrequency electromagnetic fields (RF-EMF) has raised public concerns in recent decades. However, it is not known if individuals' perception towards the health risks of RF-EMF is dependent on their knowledge of the objectively measured personal RF-EMF exposure levels.

Objectives: This pilot study aimed to demonstrate the feasibility of objectively measuring personal RF-EMF exposure from mobile phone base stations (MPBS) and to determine if the risk perception of people to the potential health risk of exposure to RF-EMF from MPBS is dependent on their knowledge of personal RF-EMF exposure levels.

Design: An experimental study was conducted in 383 adults, recruited in Melbourne, Australia. Participants were randomized to one of the three groups: 1) *basic information group* who were provided with basic information about RF-EMF to read prior to completing a risk perception assessment questionnaire; 2) *precautionary group* who were provided with an information pack which included precautionary messages; and 3) *personal exposure measurement group* who were provided with a summary of their quantitative RF-EMF exposure from MPBS. The same basic information about RF-EMF was also given to the precautionary and personal exposure measurement groups.

Results: Participants had a mean (± SD) age of 36.9 ± 12.5 years; 66.7% were women. Overall, 44.1% had noticed an MPBS in their neighbourhood. The mean (SD) values (from 1 to 7) for risk perceptions to RF-EMF from MPBS were 4.02 (1.67) for basic information, 3.82 (1.62) for precautionary messages, and 3.97 (1.72) for the personal exposure measurement groups. These differences were not statistically significant. Nevertheless, the personal exposure measurement group were more confident that they could protect themselves from RF-EMF than the precautionary or basic information groups.

Conclusion: Our findings suggest that providing people with personal RF-EMF exposure measurements may not affect their perceived risk from MPBS, but increase their confidence in protecting themselves.

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Radiofrequency Electromagnetic Field Exposure and Risk Perception: A Pilot Experimental Study

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Abstract

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These differences were not statistically significant. Nevertheless, the personal exposure measurement group were more confident that they could protect themselves from RF-EMF than the precautionary or basic information groups.

Conclusion: Our findings suggest that providing people with personal RF-EMF exposure measurements may not affect their perceived risk from MPBS, but increase their confidence in protecting themselves.

Keywords – Personal exposure, Personal measurements, Mobile phone base stations, Risk perception, Radiofrequency electromagnetic fields

Abbreviations

RF-EMF	Radiofrequency Electromagnetic Field
MPBS	Mobile Phone Base Station

1. Introduction

In 2011, the International Agency for Research on Cancer, based on epidemiological evidence of long-term mobile phone exposure, listed radiofrequency electromagnetic fields (RF-EMF) as a possible human carcinogen (Group 2B) (Baan et al. 2011, Wiedemann et al. 2014). The World Health Organization (WHO) prioritized research into understanding the health effects of RF-EMF, emphasizing the need to measure personal exposures in human epidemiological studies (van Deventer et al. 2011). Subsequently, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) provides precautionary messages to the public regarding minimizing exposure to RF-EMF (ARPANSA 2017).

Radiofrequency electromagnetic field exposure can be either from far-field sources in the surrounding environment such as mobile phone base stations (MPBS) or from near-field sources that are in close proximity to the person, such as those emanating from mobile phone handsets (Roser et al. 2017). Mobile phones are reported to be the main contributors to overall personal RF-EMF exposure (Roser et al. 2017). Conversely, far-field RF-EMF sources are fixed site transmitters and result in a much lower, but continuous and individually uncontrollable levels of RF-EMF exposure than near-field sources (Bolte and Eikelboom 2012, Martens et al. 2016). Although there is no clear evidence for an association between RF-EMF from either mobile phones or MPBS and health outcomes, people often express concerns and perceive the risk from MPBS exposure to be higher than that from their personal phone use (Rubin et al. 2005, Roosli et al. 2010, Rubin et al. 2010, Freudenstein et al. 2015).

Risk perception of people from RF-EMF exposure has been previously assessed by questionnaire-based studies with one or more items asking participants how risky, dangerous or threatening is a particular situation or behaviour (Siegrist et al. 2005, Freudenstein et al. 2014, Freudenstein et al. 2015, Boehmert et al. 2016). However, research investigating the impact on risk perception from provision of precautionary messages has been equivocal. Some studies (Wiedemann and Schutz 2005, Wiedemann et al. 2006) reported increased risk perceptions of people provided with precautionary measures, while others did not observe this effect (Cousin and Siegrist 2010, Claassen et al. 2017). Thus, precautionary messages about RF-EMFs appear to affect different people in different ways.

Studies were conducted by providing participants with precautionary information explaining the distance-exposure relationship and also the relative contribution of near-field (eg. mobile phones) versus far-field RF-EMF sources (e.g. MPBS) and to use these facts to explain the relative effects of precautionary measures (Wiedemann et al. 2013, Boehmert et al. 2016, Boehmert et al. 2017). Although some studies have reported personal exposures to RF-EMF in various microenvironments using exposimeters (Joseph and Verloock 2010, Roosli et al. 2010, Durrenberger et al. 2014), the association between the risk perception of people to the potential health risks of MPBS and personal exposure measurements from MPBS is not investigated so far. It remains unclear whether the risk perception of people depended on their knowledge of personal RF-EMF exposure levels. Although the provision of precautionary measures is speculated to trigger concerns and amplify RF-EMF-related risk perceptions amongst people (Wiedemann and Schutz 2005, Wiedemann et al. 2013), yet it is unknown if the provision of personal RF-EMF exposure levels will have similar effect. It has been indicated that non-experts' risk perception of RF-EMF sources are mainly determined by subjective exposure perception i.e. the estimated intensity of exposure to an RF-EMF source, and that exposure reduction leads to lower risk perceptions (Freudenstein et al. 2015). Due to lay people`s lack of understanding regarding exposure to RF-EMF, exposure communication seems to be a promising way to help the general public in making informed decisions about the safety and acceptability of these wireless technologies. Therefore, assessing the effect of providing people with objectively measured RF-EMF exposure in everyday life situations on risk perception regarding telecommunication technologies (eg. MBPS) is important. The use of wearable personal RF-EMF exposimeters is proved to be feasible (Bogers et al. 2018) and provide the best means to observe the exposure of people during the entire day without having to assume proxies, provided the measurement uncertainties can be kept as small as possible (Bolte et al. 2011, Lauer et al. 2012). The provision of personal RF-EMF exposure levels and its impact on risk perception of people is not assessed so far. Thus, more research that examine individual differences in the personal RF-EMF exposure levels and the risk perception of people to the potential health risks is much needed. This study aimed to demonstrate if people provided with objectively measured RF-EMF levels from the 900 MHz downlink, compared to those provided with precautionary principles or only basic information, will be less likely to consider MPBSs risky to their health.

2. Materials and Methods

2.1.Study design, participant recruitment and data collection

An experimental study was conducted of 383 participants, aged between 18 and 80 years. Data collection was undertaken between June and November 2017. Participants were invited to participate in the study via advertisements posted on notice boards at public libraries, universities, and hospitals across Melbourne, Australia. Participants were also individually approached at sporting clubs and invited to participate in the study. They were then given a plain language information pack detailing the study and consent forms.

After providing written consent to take part in the study, participants were randomized into one of three study groups (Figure 1): *1) basic information group (n=162)* who were provided with basic information about RF-EMF to read prior to completing a risk perception assessment questionnaire; *2) precautionary group* (n=158) who were provided with an information pack containing a precautionary message which was similar to that provided by the ARPANSA (ARPANSA 2002), in addition to the basic text; and *3) personal exposure measurement group (n=63)*, who were provided with a portable RF-EMF measurement device (ExpoM-RF) (www.fieldsatwork.ch) measuring 16 frequency bands, including 900 MHz downlink followed by a summary of the magnitude of RF-EMF exposure presented as "*personal RF-EMF exposure from MPBS*". Randomization was performed following a protocol to allow at least twice as many participants to be recruited into each of the non-measurement groups than the *personal exposure measurement* group. The study obtained ethics approval from Monash University Human Research Ethics Committee (MUHREC: Project Number: 8965). Each participant was given an A$25 voucher upon completion as a reimbursement for the time to take part in the study.

2.2. Personal exposure measurements

The personal exposure measurement group was first provided with a portable RF-EMF measurement device to be carried in a small hip-bag over a period of 24 consecutive hours

(ExpoM-RF with a sampling frequency of 10 seconds). This measured electric field strengths in 16 different frequency bands between 0.005 and 5 V/m. The detailed methods and protocols of personal measurement, and RF-EMF personal exposure from these frequency bands, have been previously reported (Zeleke et al. 2018). In brief, the instructions for the personal measurements were given at the time of receiving the device from the researchers. Participants were asked to continue their daily activities as usual while wearing the ExpoM-RF, except during sleep and showering. They were asked to place it on their bedside table or close to their bed during sleep.

Upon completion of dosimetric measurements, researchers collected the dosimeter from participants, downloaded the data into an Excel file, and computed the mean RF-EMF levels from 900 MHz downlink over the total hours of measurement for each participant. The mean personal exposure levels referred to the time-weighted average from 900 MHz downlink of the total hours of measurement which was further converted to a proportion of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) general public limit for the specified frequency band (ARPANSA 2002), summarized as "*personal RF-EMF exposure from MPBS*" and provided to the participant. This frequency band was chosen since it is one of the highest contributors to total exposure from mobile phone base stations (Bhatt et al. 2016, Bhatt et al. 2016, Sagar et al. 2016). The mean exposure and percentage of ARPANSA reference results mentioned in a separate sheet were then given to the participants of the dosimetry group together with a question assessing the clarity of the information on a Likert-scale (1 = not at all clear; …. to 5 = very clear) at the same time whilst a questionnaire assessing risk perception towards the health risks imposed by their exposure to MPBS were provided. For the majority of participants, this process was completed within 1-2 hours from the completion of exposure measurement. In a few instances, when it was not possible to meet with the participant within 2 hours of the completion of exposure measurement, the participants were contacted within the first 24 hours to provide them with dosimetric data and the questionnaire.

2.3. Questionnaire

For all participants in each group, a similarly structured self-administered questionnaire was provided. The questionnaire inquired about socio-demographic variables (age, gender, educational level, residential postcode, ethnicity, occupational description). Respondents were also asked whether they noticed the existence of an MPBS in their neighbourhoods, and if so to estimate how far from their homes. Using postcodes, participants' residential locations were classified into metropolitan or non-metropolitan areas according to the Australian Bureau of Statistics Geographical classification (ABS July 2011).

Exposure perception towards RF-EMF from MPBS in particular was measured by asking "*To what extent (on a scale of 1–7, where 1 = not at all and 7 = very much) do you think you are exposed to electromagnetic fields/radiation from MPBS?*". Risk perception to RF-EMF in general, as well as that from MPBS, were assessed in a similar fashion. Participants were also asked to rate their degree of confidence that they were able to protect themselves from RF-EMF emissions on a scale of 1-to-7 (1=not-at-all …. 7=absolutely certain).

2.4. Statistical Analysis

Descriptive statistics are presented as frequencies, percentages, means and standard deviations (SD), and ranges. The average RF-EMF personal exposures from the 900 MHz downlink were calculated. Four outcome variables were considered: (1) risk perception to RF-EMF in general, (2) exposure perception to MPBS, (3) Risk perception from MPBS, and 4) Confidence in protection from RF-EMF. Pearson correlation coefficients were calculated to assess the level of correlation between participants` levels of exposure and risk perception towards RF-EMF emission from MPBS.

Unadjusted tests of associations between outcome variables and each determinant variable were investigated using independent t-tests or one-way Analysis of Variance (ANOVA). A separate analysis by means of a post hoc test (Tukey HSD) was performed if ANOVA was significant. Adjusted analyses were performed using simultaneous multiple linear regression models. All analyses were performed using STATA version 13.0 (StataCorp, College Station, TX). All tests were two sided and $P<0.05$ was considered statistically significant.

3. Results

3.1. Characteristics of study participants

Of 383 participants, 222 (58.0%) were females and 161 (42.0%) were males, aged between 18 and 80 years (mean±SD: 34.3 ±12.2 years). Almost all of the participants (97.2%) were from metropolitan areas of Melbourne. Over half of them (55.7%) were educated beyond high school and 56.7% identified themselves as Caucasian. As depicted in table 1, the three groups had similar socio-demographic profiles. Overall, 169 (44.1%) participants had noticed an MPBS in their neighbourhood. The median estimated distance between residence and the closest MPBS was 500 meters (range: 10-3000 meters).

3.2. Personal exposure measurements

For the personal exposure measurement, 63 participants carried a dosimeter (ExpoM-RF) for an average of 27.4±4.5 hours (range: 20.1-37.6 hours) including time spent outside the home and night-time. On average, 9,764 (range: 7,236–13,536) measurements were recorded per participant. Over two-thirds of the participants (69.8%) rated their level of understanding of the RF-EMF exposure measurement results provided to them as "clear" or "very clear". The median personal RF-EMF exposure across the 900MHz downlink band was 22.0 mV/m (inter quartile range: 21.1 mV/m) for the 63 participants. All the personal exposure measurements summarized as a proportion of the general public limit provided to the participants were in the order of less than 1% for 900 MHz downlink.

Table 1. Socio-demographic characteristics of participants (N=383)					
Characteristics	**Total sample (n=383)**	**Group**			**p-value ***
		Basic information n (%)	**Precautionary information n (%)**	**Personal measurement n (%)**	
Age, mean±SD (years)	34.3±12.2	34.1±12.0	33.6±12.3	36.9±12.5	0.357
18-24 years	98 (25.6)	42 (25.9)	48 (30.4)	8 (12.7)	
25-34 years	130 (33.9)	57 (35.2)	47 (29.8)	26 (41.3)	
35-44 years	84 (21.9)	35 (21.6)	35 (22.1)	14 (22.2)	
45-54 years	38 (9.9)	14 (8.6)	16 (10.1)	8 (12.7)	
55+ years	33 (8.6)	14 (8.6)	12 (7.6)	7 (11.1)	
Sex					
Male	171 (42.0)	68 (42.0)	72 (45.6)	21 (33.3)	0.251
Female	222 (58.0)	94 (58.0)	86 (54.4)	42 (66.7)	
Race/Ethnicity					
Caucasian	217 (56.6)	93 (57.4)	91 (57.6)	33 (52.4)	0.091
Asian	90 (23.5)	32 (19.8)	35 (22.2)	23 (36.5)	
Other*	76 (19.9)	37 (22.8)	32 (21.2)	7 (11.1)	
Residential location					
Metropolitan	354 (97.2)	151 (96.2)	148 (98.0)	55 (98.2)	0.549
Education					
High school or less	171 (44.6)	70 (43.2)	76 (48.1)	25 (39.7)	0.466
Beyond high school	212 (55.4)	92 (56.8)	82 (51.9)	38 (60.3)	
Noticed a base station in the vicinity					
Yes	169 (44.1)	74 (45.7)	69 (43.7)	26 (41.3)	0.827
Base station distance (meters, median)	500	600	500	600	0.628
*Chi-squared test performed					

3.3. Exposure Perception and Risk Perception

Figure 2 presents the mean values (range: 1-7) of exposure and risk perception of participants in each of the study groups to RF-EMF in general, to MPBS, and their confidence in protecting themselves from RF-EMF. The difference between the three groups in their mean scores for exposure or risk perception to MPBS was not statistically significant. Nevertheless, the "*personal exposure measurement*" group were more confident that they could protect themselves from RF-EMF than those in the precautionary messages (p=0.019) or the basic information groups (p=0.045). A separate post hoc analysis confirmed that the "*personal exposure measurement*" group had a statistically higher level of confidence in protecting themselves from RF-EMF ($p < 0.01$) than those in the "*basic information*" or "*precautionary information*" groups (Figure 2). Furthermore, exposure perception was correlated with risk perception towards RF-EMF from MPBS ($r^2 = 0.59$, $p < 0.001$).

The results also showed that most respondents (69.9%) believed that they needed to protect themselves from RF-EMF. However, a lower proportion of participants in the "*personal exposure measurement*" group believed that they needed to protect themselves from RF-EMF than either the basic information (57.9% vs. 69.8%; p=0.021) or precautionary messages groups (57.9% vs. 74.7%; p=0.359).

In tables 2, linear regression models are presented for each of the outcome variables considered (risk perception from RF-EMF in general, from MPBS, exposure perception from MPBS, and confidence in protection from RF-EMF). After adjusting for potential confounders (gender, age, ethnicity, education, and awareness of the presence of MPBS in the vicinity), the findings indicated some significant associations, especially for gender (β-coefficient = .363, p= .035), age (β-coefficient = .020, p<.001) and ethnicity (β-coefficient = .688, p<.001). It seems that female respondents and non-Caucasian ethnic groups have higher perceptions of exposure and risk towards RF-EMF in general, as well as that from MPBS (tables 2). Older participants and those in the personal exposure measurement group have higher mean scores for protecting themselves from RF-EMF (p<0.05).

Table 2. Linear regression for the predictors of perceived exposure, health-related risk perception, and trust in self-protection related RF-EMF of RF-EMF and mobile phone base stations (β-coefficients and p-values presented for both unadjusted and adjusted analyses)

	Un-adjusted Analysis								Adjusted Analysis							
Variables	**Perceived risk from RF-EMF in general**		**Perceived exposure to MPBS**		**Perceived risk of RF-EMF from MPBS**		**Trust in protecting self from RF-EMF**		**Perceived risk from RF-EMF in general**		**Perceived exposure to MPBS**		**Perceived risk of RF-EMF from MPBS**		**Trust in protecting self from RF-EMF**	
	β	***p* value**	**β**	***p* value**	**β**	***p* value**	**β**	***p* value**	**β**	***p* value**	**β**	***p* value**	**β**	***p* value**	**β**	***p* value**
Experiment group																
Precautionary vs. Basic information	-0.342	0.051	0.142	0.453	-0.202	0.276	-0.071	0.676	-0.309	0.067	0.129	0.493	-0.175	0.334	-0.081	0.635
Personal measurement vs. Basic information	-0.767	0.741	0.170	0.499	-0.050	0.838	**0.551**	**0.015**	-0.140	0.535	0.029	0.908	-0.183	0.453	**0.619**	**0.007**
Age (years)	**0.144**	**0.028**	0.007	0.351	0.126	0.069	**-0.014**	**0.024**	**0.022**	**0.001**	0.014	0.062	**0.020**	**0.006**	**-0.015**	**0.021**
Sex (Female vs. Male)	**0.410**	**0.011**	0.164	0.349	0.292	0.089	-0.111	0.487	**0.521**	**0.001**	0.227	0.201	**0.363**	**0.035**	-0.101	0.533
Educational status (Beyond high school Vs. High school or less)	-0.089	0.579	-0.249	0.153	0.206	0.226	-0.063	0.692	-0.264	0.095	-0.378	**0.032**	0.041	0.812	-0.050	0.759
Ethnicity																
Asian vs Caucasian	0.312	0.107	**0.621**	**0.003**	**0.607**	**0.003**	0.163	0.399	**0.575**	**0.004**	**0.802**	**0.001**	**0.794**	**0.001**	0.008	0.967
Others vs. Caucasian	**0.783**	**0.001**	0.150	0.504	**0.501**	**0.019**	0.158	0.440	**1.030**	**0.001**	0.313	0.175	**0.688**	**0.002**	0.092	0.662
Noticed an MPBS in the neighbourhood																
Yes vs. No	0.107	0.507	0.043	0.807	-0.046	0.787	-0.110	0.487	-0.209	0.183	-0.045	0.795	-0.164	0.333	-0.103	0.519

4. Discussion

The main purpose of the current study was to compare risk and exposure perceptions of people related to RF-EMF associated with MPBS, as a function of the information provided (basic text, precautionary information, or personal RF-EMF exposure measurement). The three groups did not significantly differ from each other in relation to their risk perception to RF-EMF exposure. Nevertheless, the participants in the "*personal exposure measurement*" group were less likely to need protection, but more confident that they could protect themselves from RF-EMF risks.

Previous studies have assessed risk perceptions of people towards RF-EMF in general (Freudenstein et al. 2014, Freudenstein et al. 2015, Boehmert et al. 2016), or specifically to Wireless Local Area Networks (WLAN) (Boehmert et al. 2018) as well as that from MPBS (Siegrist et al. 2005, Kowall et al. 2012). However, those findings were solely dependent on information obtained from a questionnaire without measuring personal exposure, or had only assessed personal exposure measurements without investigating risk perception (Bolte and Eikelboom 2012, Bhatt et al. 2016, Roser et al. 2017). Our study is unique in that participants were provided with multiple modes of information (basic text information, precautionary measures, or personal exposure measurement) and subsequently their perceptions of RF-EMF exposure and risk were assessed.

Previous studies reported that precautionary measures may trigger concerns and amplify RF-EMF related risk perceptions, although discrepancies exist between expressed concerns and intended behaviour (Wiedemann and Schutz 2005, Wiedemann et al. 2006, Nielsen et al.

2010). Our hypothesis of a lower risk perception given that individuals knew their levels of RF-EMF exposure was not supported by the findings of this study.

In a previous RF-EMF exposure measurement survey, it was demonstrated that 900 MHz downlink signals may be highly variable in the same microenvironment on different days, although they were observed to be the largest source of environmental and far-field personal exposures (Frei et al. 2009, Bolte and Eikelboom 2012, Bhatt et al. 2016, Bhatt et al. 2016).

The absence of a significant difference in the risk perception between the three groups in the current study might be due to the fact that personal RF-EMF exposure levels from MPBS were well below the reference levels (less than 1%) for the general public as provided in the guidelines of the International Commission on Non-Ionizing Radiation Protection, and the Australian Radiation Protection Standards (ARPANSA 2002, ICNIRP 2009). Overall, the RF-EMF exposure levels from 900 MHz downlink frequency were similar to those reported by previous studies conducted in Melbourne, Australia (Bhatt et al. 2016, Thielens et al. 2018).

In line with previous research suggesting that women and men differ in their risk perceptions (Gustafson 1998, Boehmert et al. 2016), the current study also found that women reported higher perceptions than men of both RF-EMF exposure and associated risks. Although the relationship between education and exposure perception is not strong, participants educated beyond high school were less concerned about RF-EMF exposure from MPBS than those who completed high school or lesser levels. This is consistent with previous studies that indicated that people with higher education in general, men in particular, perceive risk as lower (Hakes and Viscusi 2004). Risk perception may reflect non-specific fears and a lack of trust in the authorities (Peretti-Watel and Vergelys 2012). Education is known to be an important determinant of trust (Clark and Royer 2013), and hence more educated people may acquire information, build trust, and report lower levels of exposure perception. Cousin and Siegrist previously reported that people with high level of education better understand exposure and exhibit lower risk perceptions and more acceptance of MPBSs (Cousin and Siegrist 2010). The age of a person influences the perception of risk. In this study, older people had higher risk perception to RF in general and that from MPBS in particular, exhibited lesser levels of trust in protecting themselves from RF-EMF than younger people.

Participants with high exposure perception also tended to have higher mean values for risk perception, which supported the assumption that exposure perception was a good predictor of RF-EMF risk perception (Freudenstein et al. 2015). Similarly, MacGregor and colleagues (MacGregor et al. 1999) demonstrated that perceived exposure and perceived health consequences were related, and that a perceived high risk of health effects was associated with higher exposure perception.

Improving public's knowledge about actual daily RF-EMF exposure can also be relevant for risk perception and communication strategies. Lay people have problems with understanding accurate exposure perception, i.e., identifying exposure sources and their radiation properties. Freudenstein et al (Freudenstein et al. 2015) demonstrated that perceived exposure from various RF-EMF devices and actual exposure differed. This is of special relevance with respect to the overestimation of far-field exposure, e.g., base stations' exposure levels and an underestimation of exposure emitted from near-field exposure (e.g. mobile phones). In line with this, previous research also reported (Baliatsas et al. 2015) a poor correlation between perceived exposure and actual exposure estimates in their research investigating possible associations between exposure and physical health symptoms. Therefore, providing information about actual exposure levels in everyday life situations, which was done in our study, seems to be a promising approach to evaluate exposure perception, risk perception and risk communication regarding telecommunication technologies.

The current study has a number of strengths. Firstly, objective measurement of personal RF-EMF exposure, which allowed the effect of knowledge of exposure on a range of variables to be assessed. Furthermore, this study also provided a basis for a more comprehensive investigation of the effects of providing personal RF-EMF exposure measurement information on risk perception. However, the findings were limited by a relatively small sample size, specifically in the personal measurement group, making it difficult to investigate dose-response associations or make generalisations. Since all measured exposure levels were classified as very low, participants might have under-estimated the risk since measured RF-EMF exposure levels were very low. RF-EMF exposure levels are reported to vary over the days of the week and hours of the day in general (Zeleke et al. 2018), and to have peaks for a short time resulting in immediate symptoms in electro-hypersensitive people (Bogers et al. 2018). However, the impact of such variations on risk perception and symptom reporting of people were not assessed in this study. In the current study, solutions previously proposed to minimize the effect of personal RF-EMF exposure measurement uncertainties such as good wearing techniques, small sampling intervals, and measurements over sufficient length of time (Bolte 2016) have been employed. Although we instructed the participants in person and in detail about how to handle the exposimeter during the measurements, we were not able to control the positioning of the exposimeters during the personal measurements. This may lead to measurement uncertainty, and under-estimation of the actual average body exposure levels

(Bolte et al. 2011, Gajsek et al. 2015, Bolte 2016). Expanded uncertainty due to body shielding and body attenuation effects linked to the ExpoM-RF were not assessed in this study although previous findings reported a high level of uncertainty in this regard (Hwang et al. 2017) that could have been determined by calibration correction factors or software processing filters (Bolte et al. 2011). Owing to the cross-sectional nature of the measurements, controlling for day-to-day variations in personal RF-EMF exposure was not possible.

5. Conclusions

In conclusion, our study demonstrated that, compared to those provided with precautionary messages and basic information, people provided with personal RF-EMF exposure data did not have significantly different scores for their exposure or risk perception towards RF-EMF in general or that from MPBS, but had greater confidence in being able to protecting themselves from RF-EMF. As a strategy, providing software apps on mobile phones that measure actual exposure could be implemented with the intention of providing realistic exposure information. This may 'demystify' the relatively abstract notion of personal RF-EMF exposure, and ultimately boost confidence in protection. Future research, preferably from a larger and more diverse sample, should aim to investigate the impact of provision of objectively measured exposure information and the knowledge of personal, as well as environmental RF-EMF exposures from both near-field and far-field sources on peoples` risk perception and risk communication vis-a-vis telecommunication technologies.

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Declaration of interests

Michael Abramson holds a small parcel of shares in Telstra, which operates a mobile telephone network in Australia. He has held investigator initiated grants from Pfizer and Boehringer-Ingelheim for unrelated research. He has also received from Sanofi assistance with conference attendance and an honorarium for unrelated research. The other authors declare no conflicts of interest.

Figure Legends

Figure 1: Participant Flow

Figure 2*:* Perceived mean levels of exposure, risk, and confidence in protection from RF-EMF (question: on a scale of 1-7: 1 "not-at-all" to 7 "to a very high"; error bars represent 95% confidence intervals)

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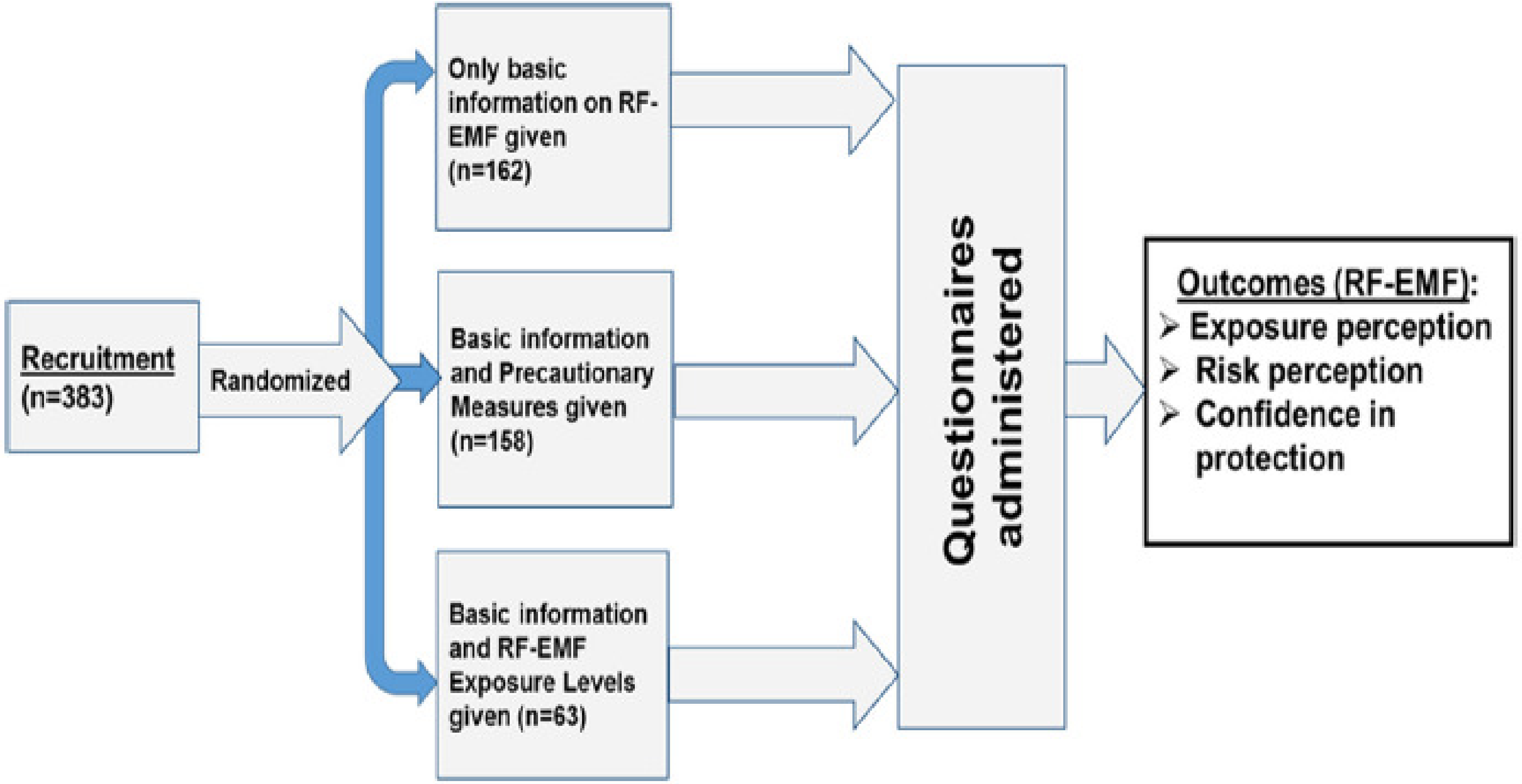

RF-EMF: Radiofrequency Electromagnetic Field

Fig. 1. Participant flow.

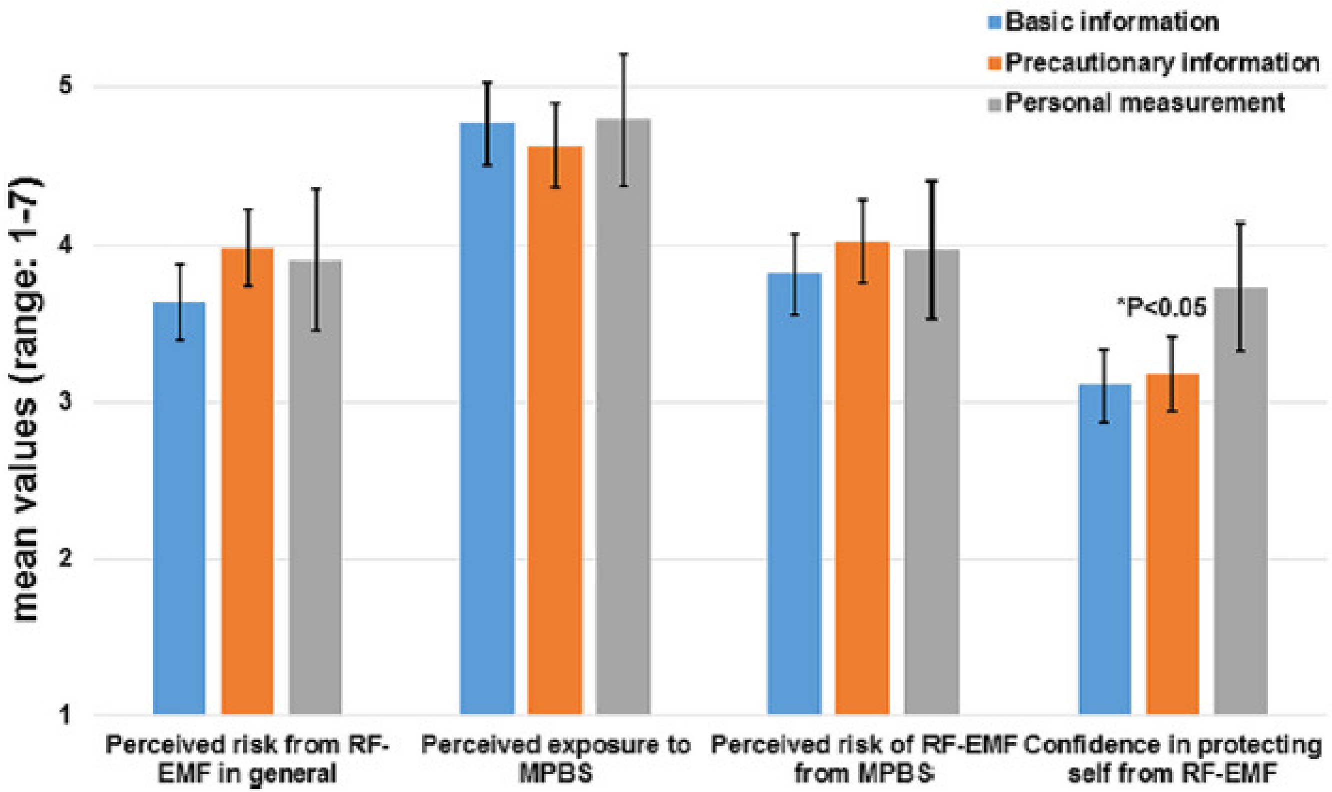

Fig. 2. Perceived mean levels of exposure, risk, and confidence in protection from RF-EMF (question: on a scale of 1–7: 1 "not-at-all" to 7 "to a very high"; error bars represent 95% confidence intervals).