The Federal Government's Electromagnetic Energy (EME) Program aims to promote health and safety and address misinformation about EME emissions. This Program will provide the public with clear, reliable, and reputable information on new EME based technologies like 5G, 6G and beyond, and advice on how to use this technology safely.

ARPANSA will support the Government's EME Program by delivering on its own EME Program Action Plan 2025 - 2028, which will help provide evidence-based scientific advice on EME and health. ARPANSA will report performance against this Action Plan through its corporate reporting and website. The Plan includes the below initiatives.

Assess EME exposure in the community

ARPANSA will conduct studies to assess EME exposure from existing and new telecommunications technologies, like 5G. The studies will separately consider EME exposure levels in the home, in the workplace, and in the wider community. The aims of the studies will include, but are not limited to:

- What is the typical EME exposure in the everyday environment?
- How does EME exposure change across different microenvironments?
- How does the EME exposure change over time?

ARPANSA will publish the results of these studies to inform the community on EME exposure levels.

Conduct research on EME and health

It is important to continue the research into EME and health to ensure that public health policies are based on the most up-to-date information as telecommunications and other technologies continue to develop.

ARPANSA will promote, co-ordinate, lead and support EME research. This research will focus on key research needs that underpin safety standards, and development of dosimetry research expertise which is a key gap in the Australian research sector. Our program will support gold standard research that considers the totality of science to ensure safety standards remain evidence-based and risk informed.

ARPANSA will also publish a new EME Research Agenda, following the publication of the WHO Environmental Health Criterion Monograph. The Research Agenda will make recommendations for specific areas of research where the body of knowledge can be expanded.

The EME Program of research will also be aimed at addressing areas of public concern that can benefit from additional evidence, with a particular focus on developing further risk communication expertise.

Engage with international health authorities

The World Health Organization (WHO) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) are leading the international effort to assess the health and environmental effects of EME exposure.

ARPANSA will continue to engage with the WHO, ICNIRP, other international bodies and experts to build new knowledge and contribute to research outcomes and international safety standards. Specific international engagement during 2025-2028 will include:

- Participation in the WHO health risk assessment of EME exposure, and WHO Collaborating Centre on RF EMF to help guide international policy and advice.
- Participation in the ICNIRP development of exposure guidelines to ensure they are fit for implementation in Australia.
- Attendance at international workshops and conferences which present advances in EME research and protection policies.

Develop national EME safety standards

In order to protect people from harmful effects of EME exposure, ARPANSA maintains a safety standard, which sets the limits for exposure from all EME sources, including 5G and other telecommunications. During 2025-2028 ARPANSA will continue to:

- Review, revise and maintain the ARPANSA EME Safety Standard based on international best practice and will consult all stakeholders on changes to the EME safety standard.
- Support the development of national standards related to EME measurement and safety compliance to reflect a rapidly changing environment and align with international best practice.

Provide information on EME and health

ARPANSA will provide information to the community through a range of mediums that translates scientific content on EME and health for a general audience. This includes the provision of the Talk to a Scientist Program, which will continue to be reviewed to ensure that it remains fit for purpose.

ARPANSA will also focus on key principles for effective risk communication to ensure that the information provided remains high quality and evidence-based.

EME RESEARCH, MEASUREMENT, AND RISK COMMUNICATION: HIGHLIGHTING BIOELECTROMAGNETICS IN AUSTRALIA

INTRODUCTION

The question of whether exposure to low-level electromagnetic energy (EME), particularly radiofrequency (RF) fields, is associated with health effects in humans is a long-standing question that still awaits a more definitive answer. As technologies evolve and exposures change, it is imperative that work continues to protect people and the environment from the harmful effects of radiation, through understanding risks, best practice regulation, research, policy, and engaging with the community.

Australia contributes significantly to research, knowledge, protection policies, and risk communication related to EME, and through the Australian Government's EME program, has a unique collaborative approach that encompasses government, academia and industry. This workshop aims to highlight some of the research and communications activities in Australia, the host country of BioEM 2026.

Research on EME and Health

Across academia and the Australian Governments EME Program, Australia has a focus on key research needs that form the basis for safety standards, specific areas of research where there are gaps in knowledge that require further investigation, as well as addressing areas of public concern that may benefit from additional evidence. Three streams of research currently being focused on are Human Experimental, Epidemiology, and In Vivo.

Human Experimental

A series of studies have examined the potential mechanisms underlying electromagnetic hypersensitivity (EHS), a condition characterised by the attribution of diverse symptoms to EME exposure. This research has found no evidence that EME exposure elicits the reported symptoms. Instead, the results suggest that the nocebo effect is more closely associated with symptom perception in EHS [1]. To address methodological limitations and further explore the potential contributing factors underlying the nocebo response, this series of studies also examined the role of alarmist media and physiological stress response in symptom perception [2-4]. Although awareness and belief of exposure status were found to be associated with symptom perception [2, 3], consistent with a nocebo effect, the studies found mixed evidence for the role of alarmist media in driving this response [2, 3], and no evidence that symptom perception is associated with a physiological stress response [3, 4]. Work is continuing to address whether anticipatory anxiety may be masking any potential physiological stress response being detected.

Epidemiology

Cosmetic treatments using non-ionising radiation — including RF and low-frequency EMF—are widely available and increasingly popular in Australia, though there is limited high-quality evidence on their adverse effects. While most reported effects are minor, serious injuries — including burns, pigment damage and scarring— can occur without proper care. Regulation of cosmetic NIR in Australia is limited and inconsistent, and varies by jurisdiction, device type and treatment setting. However, regulators have been reluctant to enact regulatory change due to a lack of evidence of an associated health burden.

This research seeks to provide the evidence needed to shape regulation of cosmetic NIR in Australia [5]. This multi-method research encompasses information from media, healthcare records, and regulatory sources, along with a retrospective consumer survey. Using a structured Evidence-to-Decision process, this research will produce evidence-based recommendations to support nationally consistent regulations with the aim of enhancing consumer protections and reducing preventable injury.

In Vivo

Although numerous studies have investigated the potential for adverse effects of RF-EME exposure, current evidence remains inconclusive due to limited human experimental data, inconsistent findings, and methodological differences that hinder comparison and replication. A major gap in the literature exists regarding the effects of RF-EME exposure during sensitive periods of brain development, particularly neurotransmission, behaviour, and physiological regulation. To address this, a large animal study is being performed that aims to: 1. Investigate the degree to which RF-EME exposure affects core body temperature (CBT) in rats [6]; 2. Investigate whether RF-EME exposure can affect behaviour in juvenile rats; 3. Investigate whether juvenile RF-EME exposure can affect neurotransmission of key developmental markers in the brain. The use of animal models allows for simulation of the human juvenile period in a much shorter time frame, which also allows the project to have a larger sample size and addresses issues from previous studies. To expose the rats to RF-EME, custom built reverberation chambers have been designed to ensure long-term uniform dose of RF-EME to rodents in an unrestrained setting [7]. By taking these measures this study aims to provide improvements over previous research, and robust biological evidence to clarify whether RF-EME exposure in juvenile rats has any impact on body temperature, behaviour, and neurotransmission. The findings will contribute to resolving ongoing scientific debate and may help guide future safety standards and public health recommendations.

Assessment of EME Exposure in the Community

To address the ongoing concern in the community regarding exposure to EME, the Australian Government agencies ARPANSA (Australian Radiation Protection and Nuclear Safety Agency) and ACMA (Australian Communications and Media Authority) conduct studies to assess EME exposure from both established and new technologies. Measurements are undertaken in various environments, such as the home, workplace, and wider community, and address a number of endpoints including:

- Assessing the typical EME exposure in everyday environments [8]
- Assessing whether EME exposure changes over time, particularly as new technologies are developed and deployed
- Providing information to the public on average EME from base stations, including how these measurements compare with safety limits

Risk Communication and Providing Information on EME and Health

The EME Program aims to promote health and safety and address misinformation about EME emissions. It encompasses three Australian Governmental agencies (ARPANSA, ACMA, and the Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts) that also collaborate with academia and work closely with key stakeholders. A key part of this is to provide the public with clear, reliable and reputable information on new EME based technologies like 5G, and advice on how to use this technology safely. ARPANSA in particular supports this vision by delivering evidence-based scientific advice on EME and health via various communications channels including the ARPANSA website, news items, social media, multimedia material, and media spokespersons. Another unique aspect of Australia's community engagement is ARPANSA's 'Talk to a Scientist' program, which provides the public with the opportunity to communicate directly with ARPANSA scientists on issues about radiation exposure, health, and radiation protection and safety in Australia. Addressing community concerns, tackling misinformation, and appropriate risk communication are all key elements for promoting the health and safety of the public, workers, and the environment in Australia.

CONCLUSIONS

Australia has a comprehensive program across government, academia and industry that contributes to research, knowledge, protection policies, and risk communication related to EME.

REFERENCES

[1] Verrender A, Loughran SP, Anderson V, Hillert L, Rubin GJ, Oftedal G, Croft RJ. IEI-EMF provocation case studies: A novel approach to testing sensitive individuals. *Bioelectromagnetics,* 39(2):132-143. doi: 10.1002/bem.22095.

[2] Verrender A, Loughran SP, Dalecki A, Freudenstein F, Croft RJ. Can explicit suggestions about the harmfulness of EMF exposure exacerbate a nocebo response in healthy controls? E*nviron Res.* 166:409-417. doi: 10.1016/j.envres.2018.06.032.

[3] Verrender, A., Wallace, N.K., Loughran, S.P., Wallace, C., Beange, J.,Croft, R. J. (2025). What is the effect of alarmist media and radiofrequency electromagnetic field (RF-EMF) exposure on salivary cortisol and non-specific symptoms? *Applied Psychology: Health and Well-Being*, 17(3), e70044. https://doi.org/10.1111/aphw.70044

[4] Verrender A, Manley J, Wallace NK, Loughran SP, Croft RJ. Looking for Biomarkers Which May Explain Idiopathic Environmental Intolerance Attributed to Electromagnetic Fields (IEI-EMF): Does RF-EMF Exposure Influence Salivary Cortisol Response? *Bioelectromagnetics*46(6):e70021. doi: 10.1002/bem.70021.

[5] Thomas Z, Berecki-Gisolf J, Grant G, Karipidis K. Burned in Pursuit of Beauty: Injuries From Cosmetic Use of Non-Ionizing Radiation and Associated Regulatory Gaps. *Bioethical Inquiry* (2025). https://doi.org/10.1007/s11673-025-10475-y

[6] Bala N, Croft RJ, McIntosh RL, Iskra S, Frankland JV, McKenzie RJ, Deng C. Characterization of the Core Temperature Response of Free-Moving Rats to 1.95 GHz Electromagnetic Fields. *Bioelectromagnetics 46 (5), 2025. doi: 10.1002/bem.70013*

[7] Iskra S, McIntosh RL, McKenzie RJ, Frankland JV, Deng C, Sylvester E, Wood AW, Croft RJ. The Development of a Reverberation Chamber for the Assessment of Biological Effects of Electromagnetic Energy Absorption in Mice. *Bioelectromagnetics* 46 (1), 2025. doi: 10.1002/bem.22539.

[8] Bhatt CR, Henderson S, Sanagou M, Brzozek C, Thielens A, Benke G, Loughran S. Micro-Environmental Personal Radio-Frequency Electromagnetic Field Exposures in Melbourne: A longitudinal Trend Analysis. Environmental Research 251 (Pt 2), 2024. https://doi.org/10.1016/j.envres.2024.118629

Document 3

Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

Measuring RF exposure in public spaces:

Investigating the influence of crowds

Stuart Henderson

ARPANSA EME Program

General public exposure to RF in different contexts

At home, at work, in public spaces

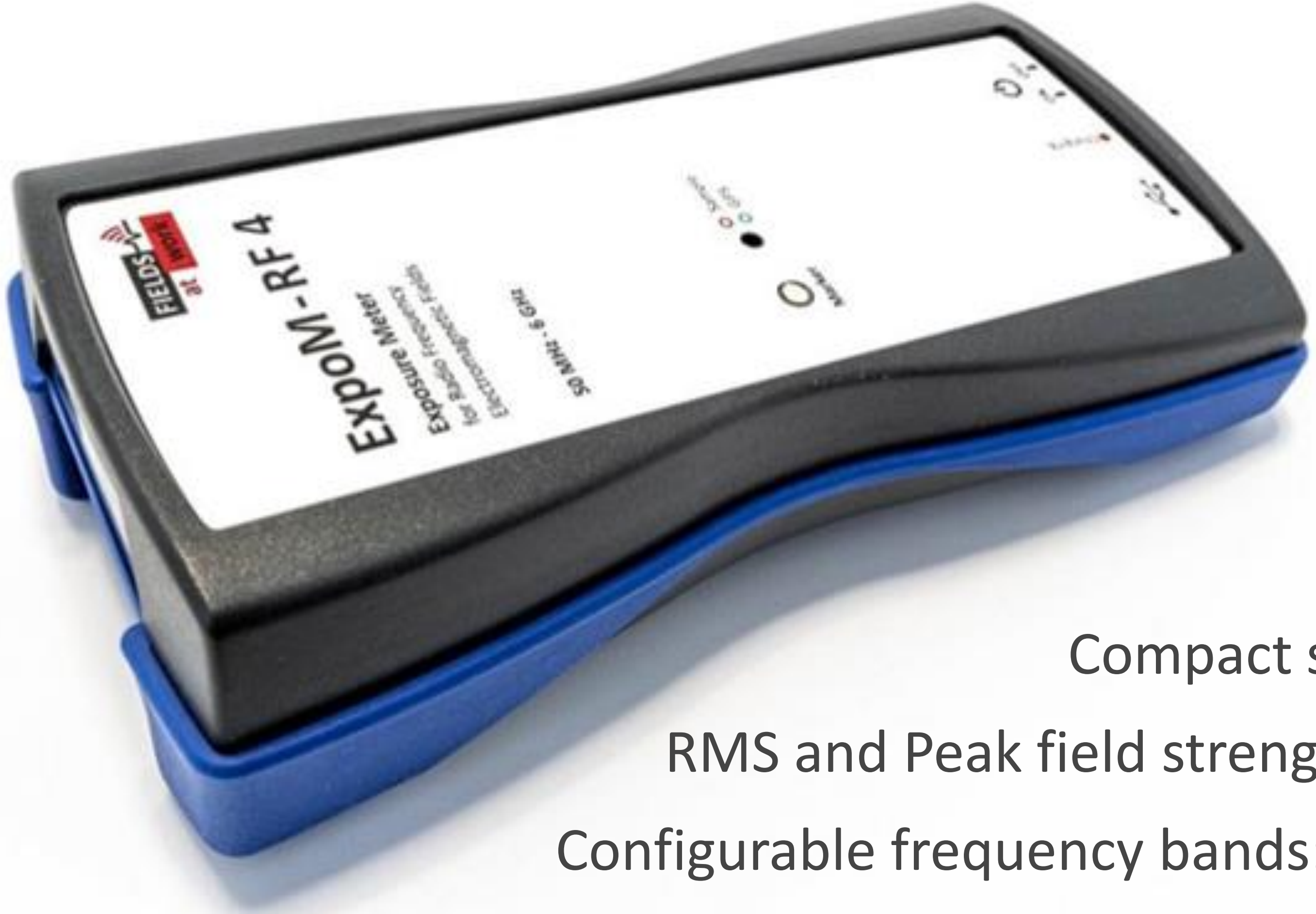
Spot measurements on grid across city

Walking through different microenvironments

Measurements on public transport

Targeting special events

Equipment



GPS receiver

Compact size: 16 × 8 × 5 cm

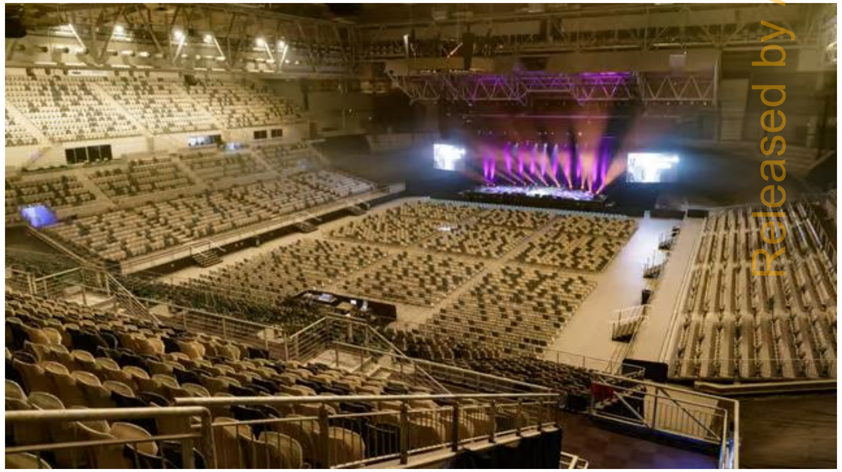
RMS and Peak field strength measurements

Configurable frequency bands: 50 MHz to 6 GHz

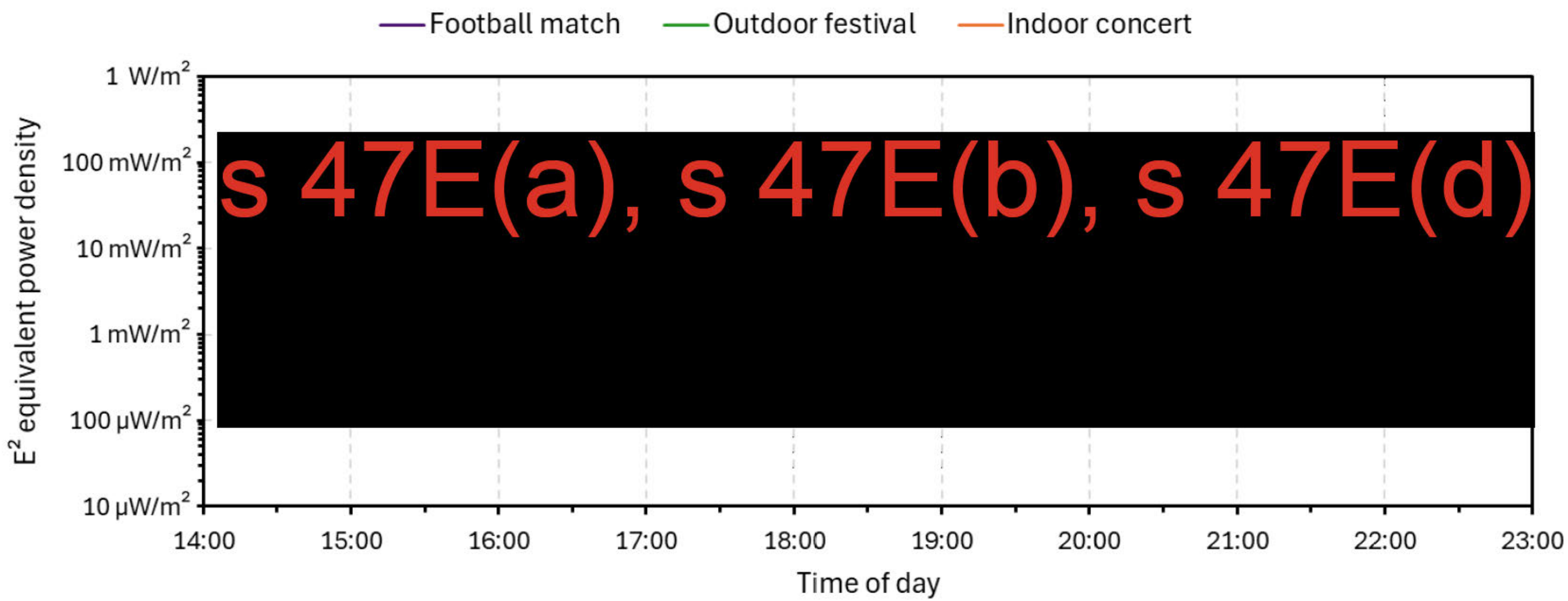
50 ms observation time per band, data recorded every 6 s

Measurement locations

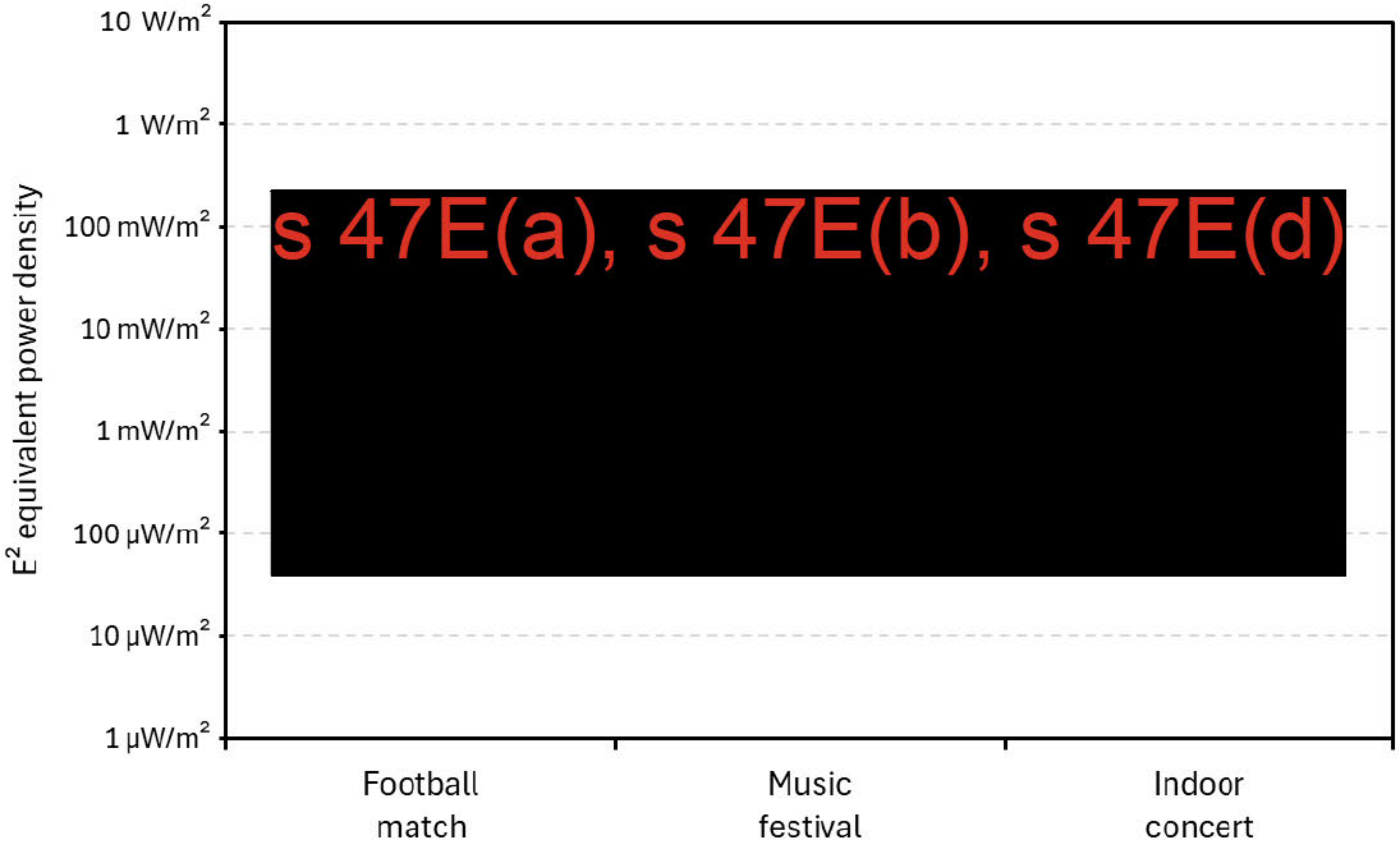
Sporting events, MCG	Outdoor stadium capacity 100,000
Festival, Flemington Racecourse	Outdoor venue capacity 30,000
Music concert, John Cain Arena	Indoor arena capacity 15,000



Time series – raw data



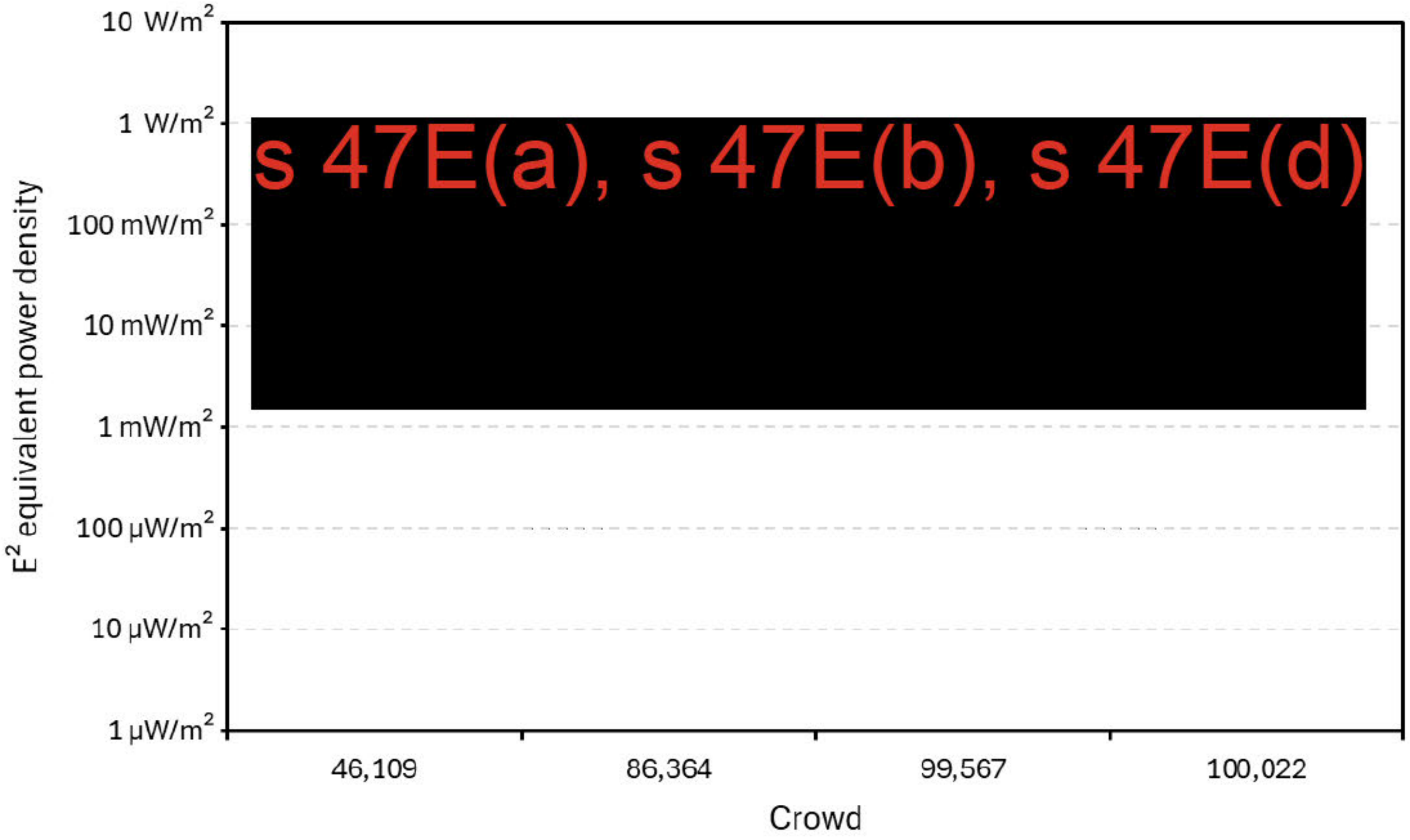
Event type

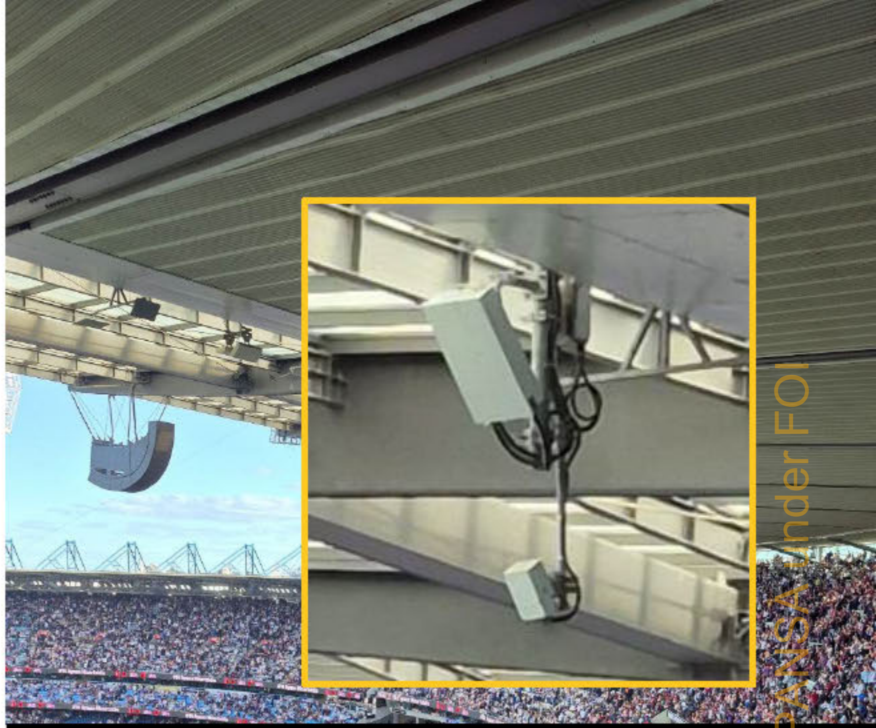


[redacted]

s 47F

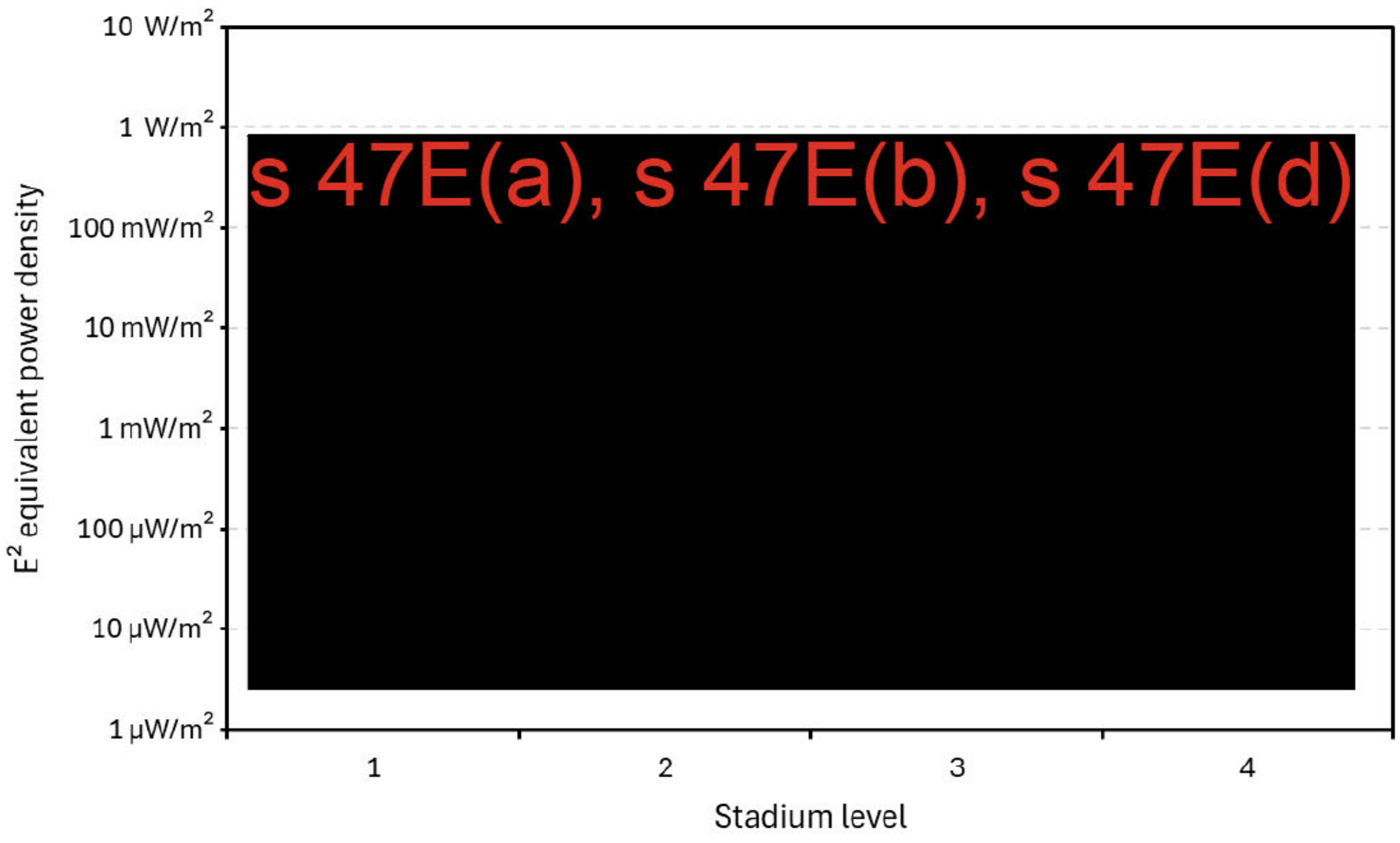
Crowd size





[redacted] s 47F

Seat location



s 47F
[redacted]

Discussion

- ✓ Crowd provides network traffic
- ✗ Body shielding is an issue
- ✓ Realistic exposure scenarios
- ✗ Lose some control over locations
- ✗ Many unconstrained variables
- ✗✓ Lots of ~~hard work~~ ~~long hours~~ fun!

Summary

Measured RF levels well below limits

Much more analysis possible

More events to be attended!

[redacted] s 47F

Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

Thank you

e. [redacted]@arpansa.gov.au
w. arpansa.gov.au

ARPANSANews
ARPANSAGovernment
ARPANSA
ARPANSA

THE IMPACT OF RADIOFREQUENCY ELECTROMAGNETIC FIELDS ON HUMANS, ANIMALS AND PLANTS

Ken Karipidis

INTRODUCTION

Exposure to radiofrequency (RF) electromagnetic fields (EMF) is one of the most common and fastest growing anthropogenic factors on the environment. RF EMF is mainly produced by telecommunications sources such as radio and television broadcasting, satellite transmissions, Wi-Fi and mobile telephony including the latest 5G network.

Exposure to sufficiently high levels of RF EMF can excessively heat biological tissue and potentially cause tissue damage [1]. In order to protect humans from excessive exposure to RF EMF, guidelines have been developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) that recommend limits on exposure to RF fields [2]. Exposure to RF EMF in the environment from various (mainly telecommunications) sources is generally low and much lower than the ICNIRP exposure limits [3].

Notwithstanding the large body of research underpinning the existing exposure limits in the ICNIRP guidelines, the issue of whether they are adequate to provide complete protection to both humans and to the environment from harmful effects of exposure to RF EMF remains a subject of research and active debate within the scientific and wider community.

METHODS

The World Health Organization (WHO) recently commissioned a series of systematic reviews investigating the effects of RF EMF on a number of outcomes related to human health [4]. The results from the systematic reviews will form part of the WHO updated monograph on RF EMF.

A relatively smaller number of studies and reviews have been published on the impact of anthropogenic RF EMF on animals and plants in the environment. A recent systematic search and analyses was conducted investigating the results of all the studies investigating the effects of RF EMF exposure on animals and plants [5][6].

RESULTS

The results from the WHO commissioned systematic reviews generally did not change previous mainstream conclusions that there is no substantiated evidence of health effects from RF EMF exposure below the ICNIRP guidelines.

The analysis of studies investigating the impact of RF EMF on animals and plants showed variable results. Notably the majority of the studies were of poor quality with numerous methodological shortcomings. The analysis further showed an inverse relationship between effect size and study quality meaning that poor quality studies were more likely to show an effect compared to good quality studies.

CONCLUSION

Regarding the effect of RF EMF on human health research to date indicates that the ICNIRP guidelines are appropriate in protecting humans. However, there are still certain gaps in the knowledge and research should continue especially as wireless technology is evolving with the upcoming 6G network and beyond. Regarding the effect of RF EMF on animals and plants it is clear that we need further high quality research.

REFERENCES

[1] International Commission on Non-Ionizing Radiation Protection. Exposure to high frequency electromagnetic fields, biological effects and health consequences (100 kHz-300 GHz). 2009.

[2] International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP guidelines for limiting exposure to electromagnetic fields (100 KHz to 300 GHz). Health Phys. 2020; 118:483–524.

[3] Henderson S, Bhatt C, Loughran S. A survey of the radiofrequency electromagnetic energy environment in Melbourne, Australia. Radiat Prot Dosimetry. 2022;199(6):519-26.

[4] Verbeek J, Zeeb H, van Deventer E, Ijaz S, Doré JF, Driessen S, Roth N, Whaley P. Systematic reviews and meta-analyses for the WHO assessment of health effects of exposure to radiofrequency electromagnetic fields, an introduction. Environ Int. 2025 Sep;203:109751.

[5] Karipidis K, Brzozek C, Mate R, Bhatt CR, Loughran S, Wood AW. What evidence exists on the impact of anthropogenic radiofrequency electromagnetic fields on animals and plants in the environment: a systematic map. Environ Evid. 2023 May 11;12(1):9.

[6] Brzozek, C., Mate, R., Bhatt, C. R., Loughran, S., Wood, A. W., & Karipidis, K. (2024). Investigating the impact of anthropogenic radiofrequency electromagnetic fields on animals and plants in the environment: analysis from a systematic map. International Journal of Environmental Studies, 81(5), 2343–2358.

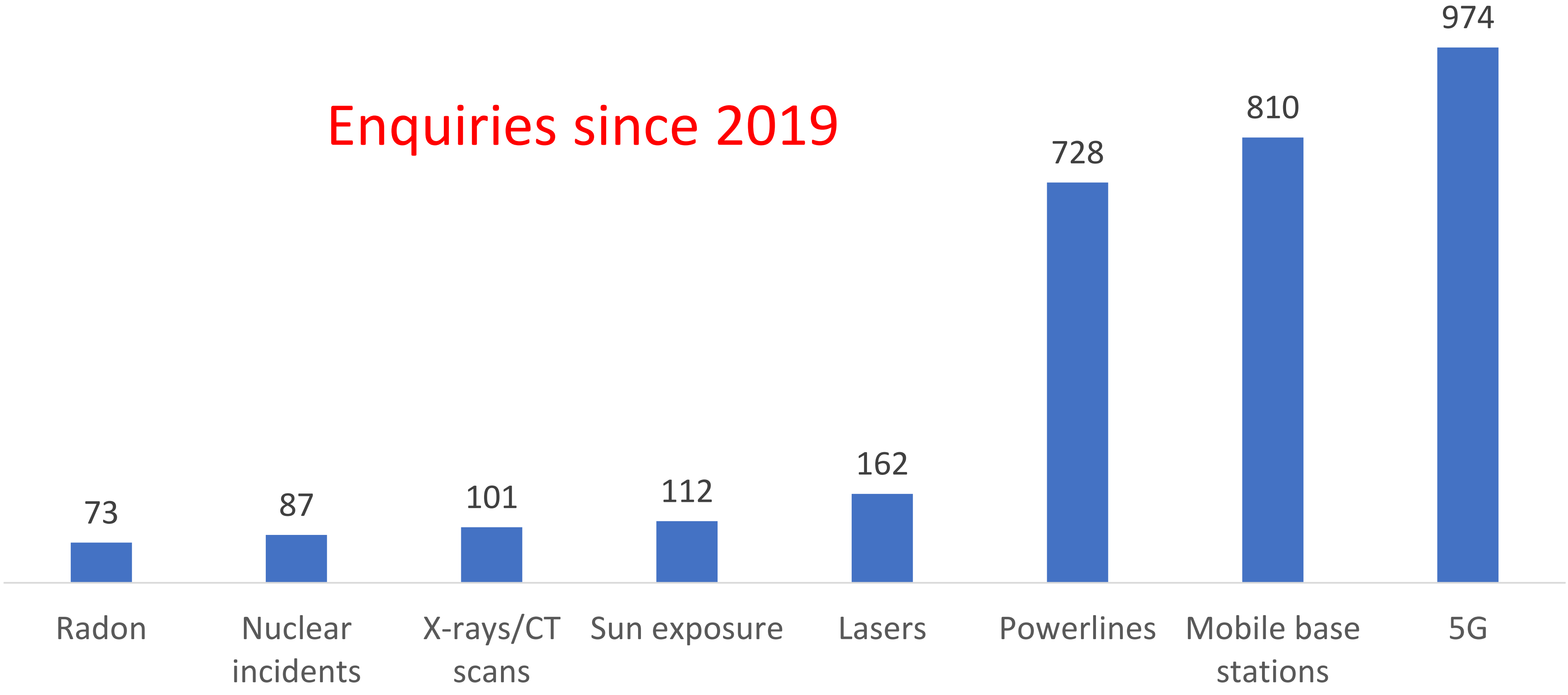
Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

The impact of radiofrequency electromagnetic fields on humans, animals and plants

Ken Karipidis

ARPANSA's Talk-to-a-Scientist Program



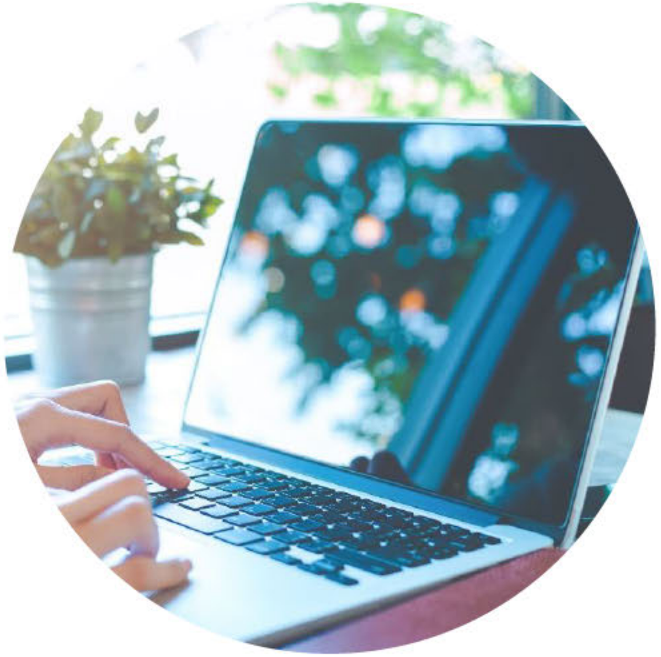
What some people tell us

5G has been proven to be hazardous to human health, 6G will be the same

?

Is this true?

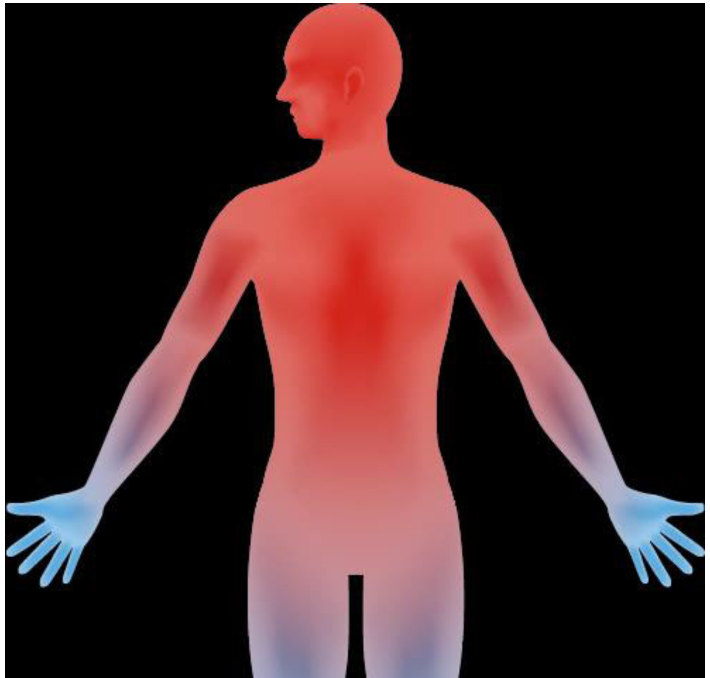
5G and other wireless telecommunications such as radio, television and Wi-fi emit **radiofrequency electromagnetic fields**



Are radiofrequency fields hazardous?

They can be

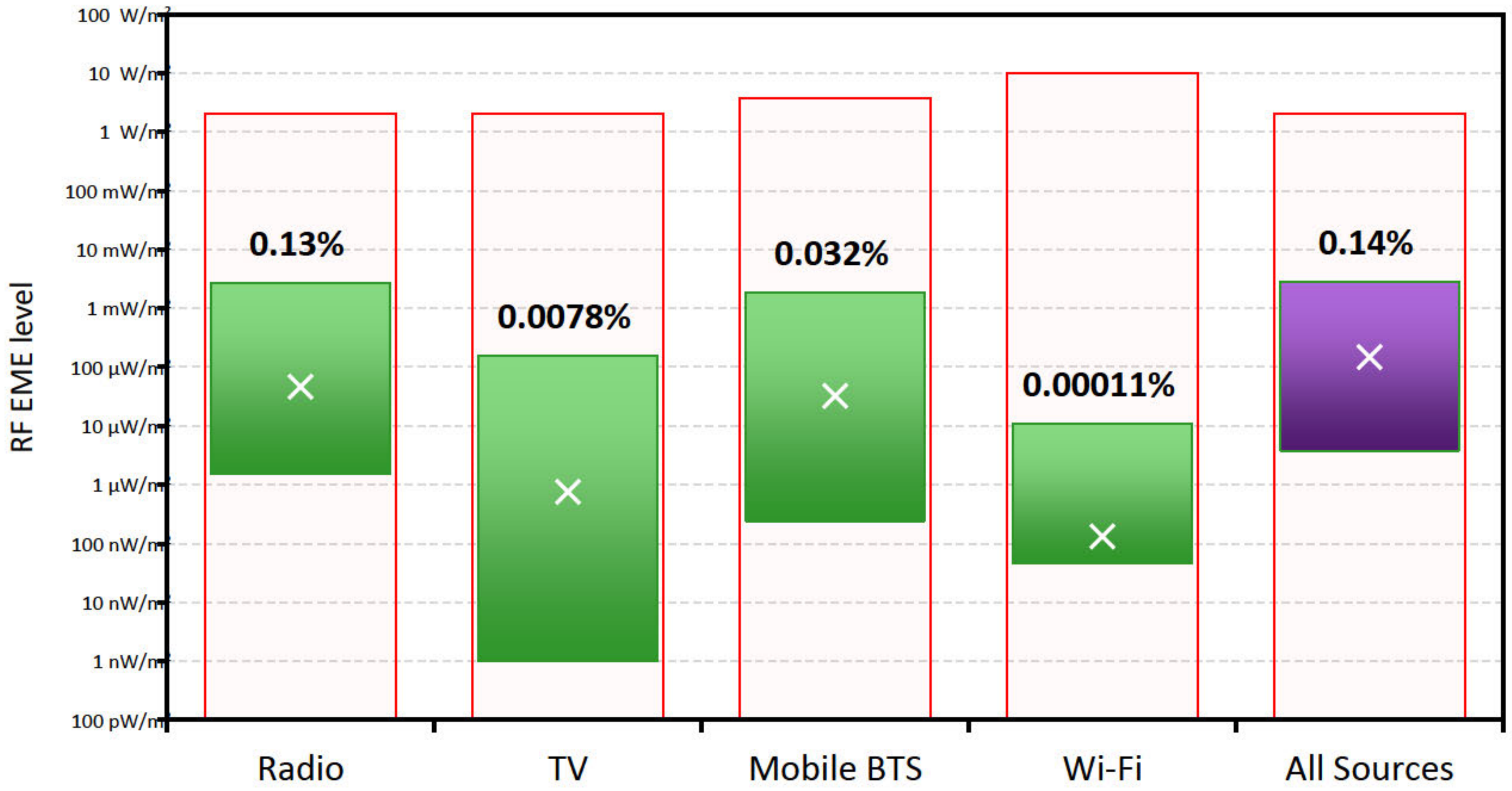
RF fields at sufficiently high levels can **heat biological tissue** and potentially cause tissue damage



But

The RF fields that the public is exposed to from telecommunications are **too low to produce significant heating** or increased body temperature

RF measurements in Australia



Do radiofrequency fields cause health effects at low levels?

Thousands of different types of studies (in vitro, animal, epidemiological) have looked at whether low level RF exposure causes long-term health effects, especially cancer

World Health Organization

Environmental Health Criteria monograph on RF fields

Does exposure to radiofrequency electromagnetic fields cause harm to humans?

WHO systematic reviews

Cancer	1. Human observational studies 2. Animal studies
Adverse reproductive outcomes	3. Human observational studies 4. Animal and cellular studies
Cognitive impairment	5. Human observational studies 6. Human experimental studies
Self-reported symptoms	7. Human observational studies 8. Human experimental studies
Oxidative stress	9. Animal and cellular studies

WHO systematic reviews

Cancer

1. Human observational studies

2. Animal studies

Human observational studies on cancer

Confidence in the combined result

Moderate certainty evidence that RF exposure from mobile phone use **does not increase** the risk of brain cancer in humans

Combined result from all the evidence

Human observational studies on cancer

Moderate certainty evidence that RF exposure from mobile phone use **does not increase** the risk of brain cancer in humans

Moderate to low certainty evidence that RF exposure **does not increase** the risk of any other cancers in humans

Animal experimental studies on cancer

High certainty evidence that RF exposure **does increase** the risk of brain cancer in rats

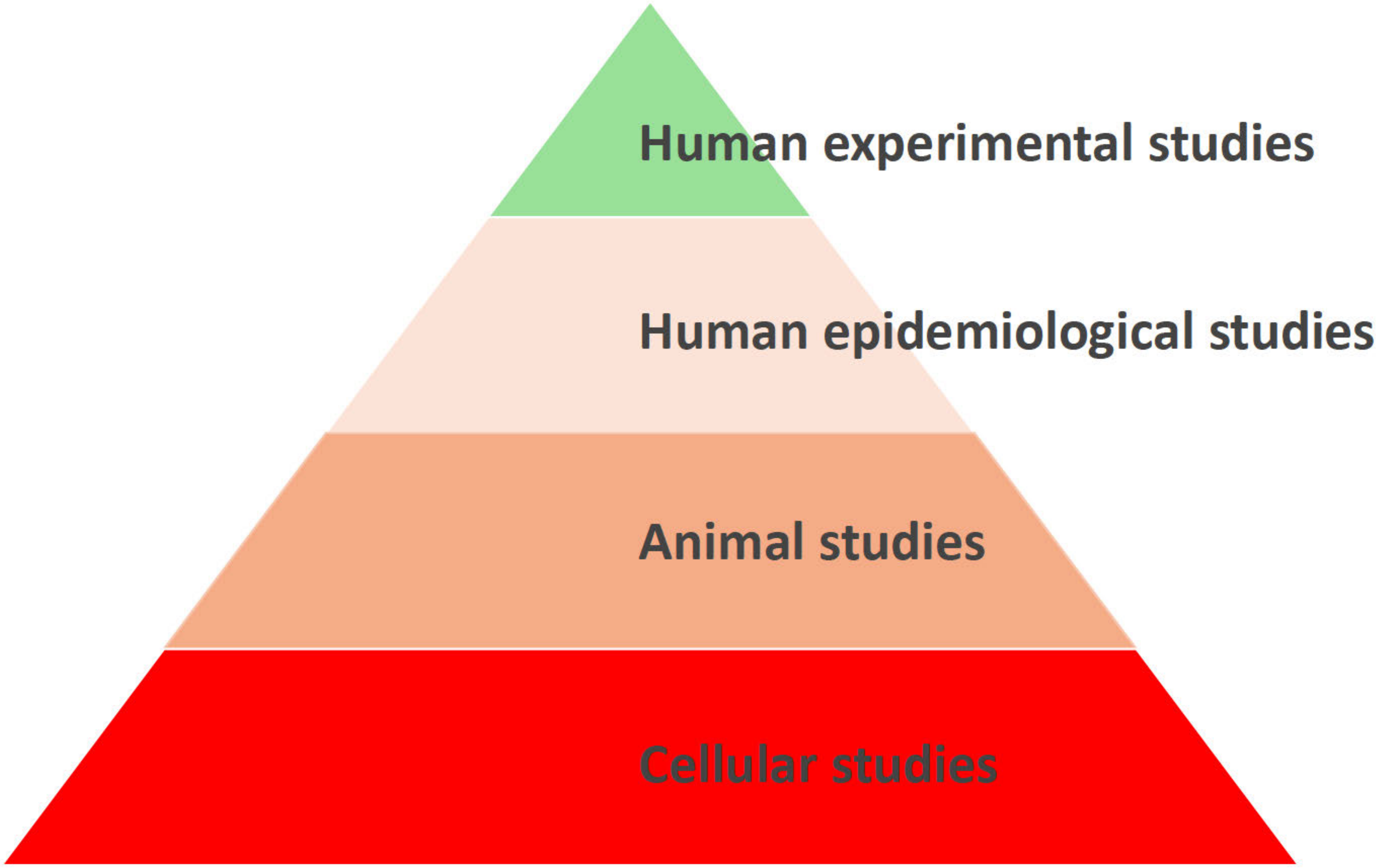
High to moderate certainty evidence that RF exposure **does increase** the risk of other cancers in rats

Vs

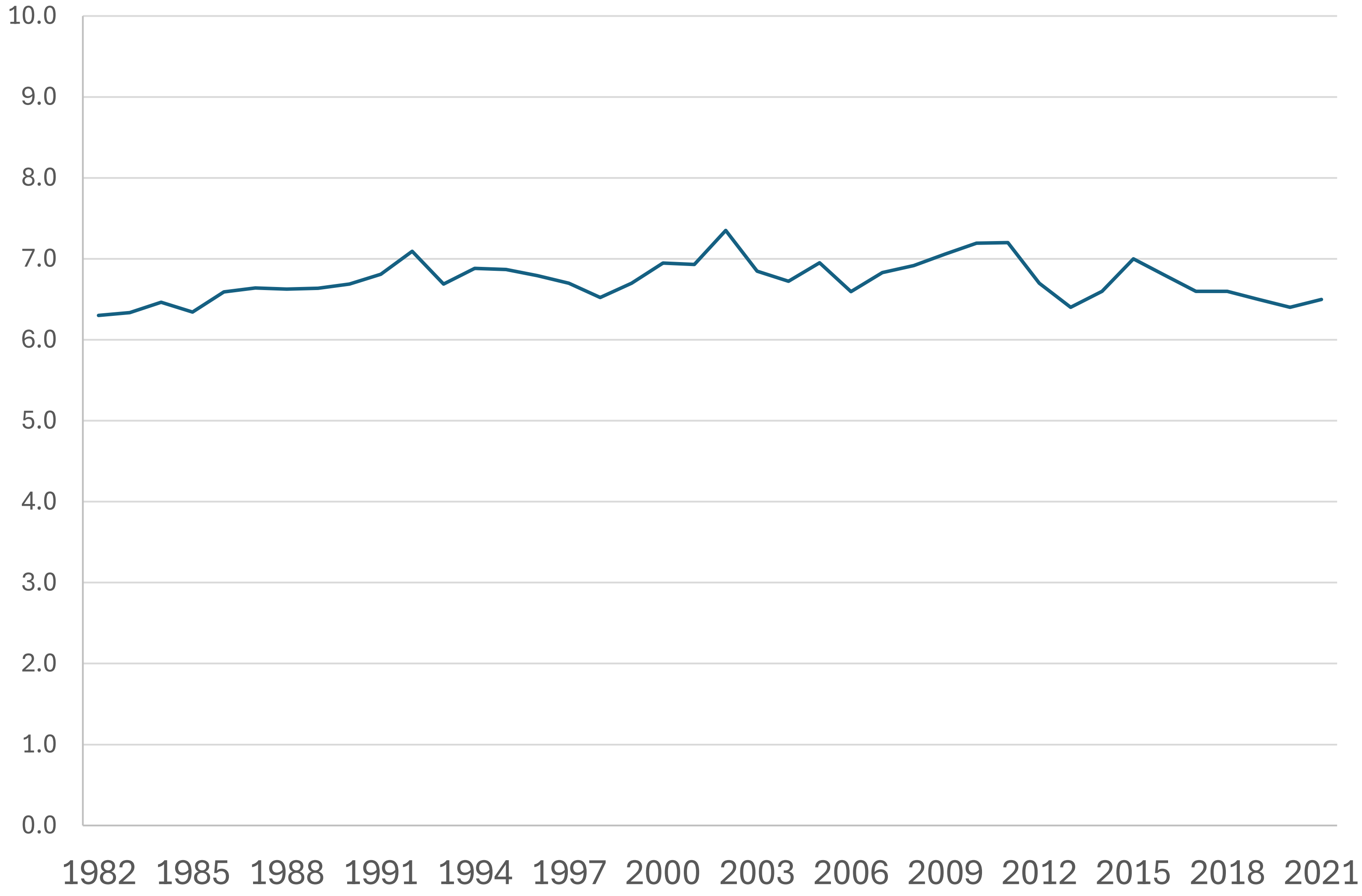
The results of the animal systematic review have been questioned:

- It did not combine results from different studies
- Questions on the assessment of the quality of individual studies
- Questions on the assessment of the certainty of the evidence

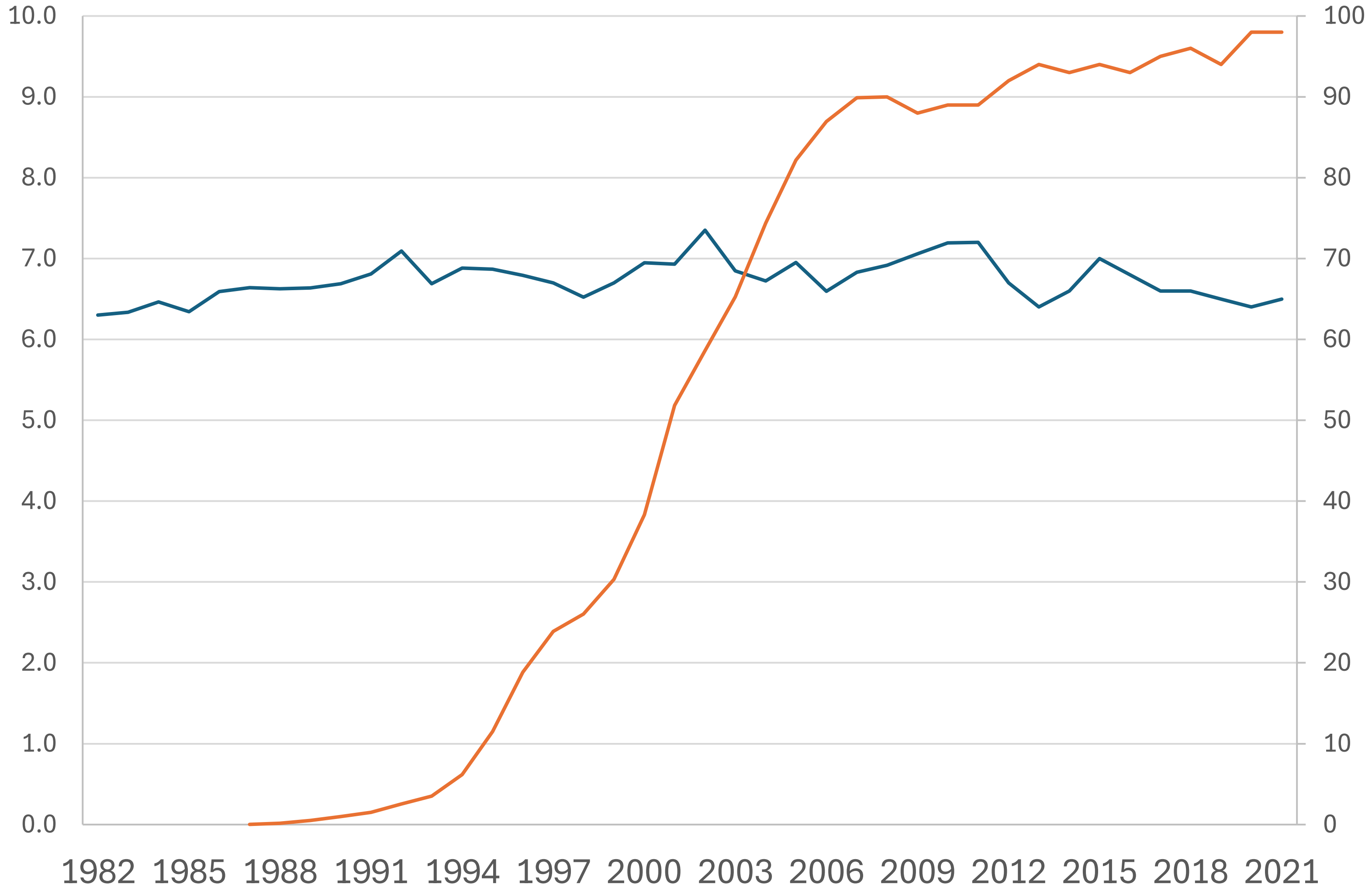
Hierarchy of evidence



Brain cancer rates in Australia



Brain cancer rates in Australia



What about other health effects?

Effect	Type of study	Result	Certainty	Comments
Cognitive impairment	Observational	No effect	Low to very low	
	Animal/cellular	No effect	High to low	
Non-specific symptoms	Observational	No effect	Very low	
	Human experimental	No effect	High to very low	
Adverse reproductive outcomes	Observational	No effect	Very low	
	Animal/cellular	Some effects	High to very low	Effects generally shown at very high exposure levels
Oxidative stress	Animal/cellular	Some effects	Very low	Uncertainty on the significance on human health

We need more research

For some things

But we need quality research

"**Birds disappearing mysteriously. . . bees under threat.**

Electromagnetic Fields A 'Credible Threat' To Wildlife

EMFSAFETYNETWORK.ORG

Does environmental exposure to radiofrequency fields have a negative impact on animals and plants?

Karipidis *et al. Environmental Evidence* (2023) 12:9
https://doi.org/10.1186/s13750-023-00304-3

Environmental Evidence

SYSTEMATIC MAP Open Access

What evidence exists on the impact of anthropogenic radiofrequency electromagnetic fields on animals and plants in the environment: a systematic map

Ken Karipidis[1,2*], Chris Brzozek[1,3], Rohan Mate[1], Chhavi Raj Bhatt[1], Sarah Loughran[1] and Andrew W Wood[2]

We found eligible

334 studies

Animals 71%

Plants 29%

INTERNATIONAL JOURNAL OF ENVIRONMENTAL STUDIES
2024, VOL. 81, NO. 5, 2343–2358
https://doi.org/10.1080/00207233.2024.2375861

Routledge
Taylor & Francis Group

ARTICLE

OPEN ACCESS Check for updates

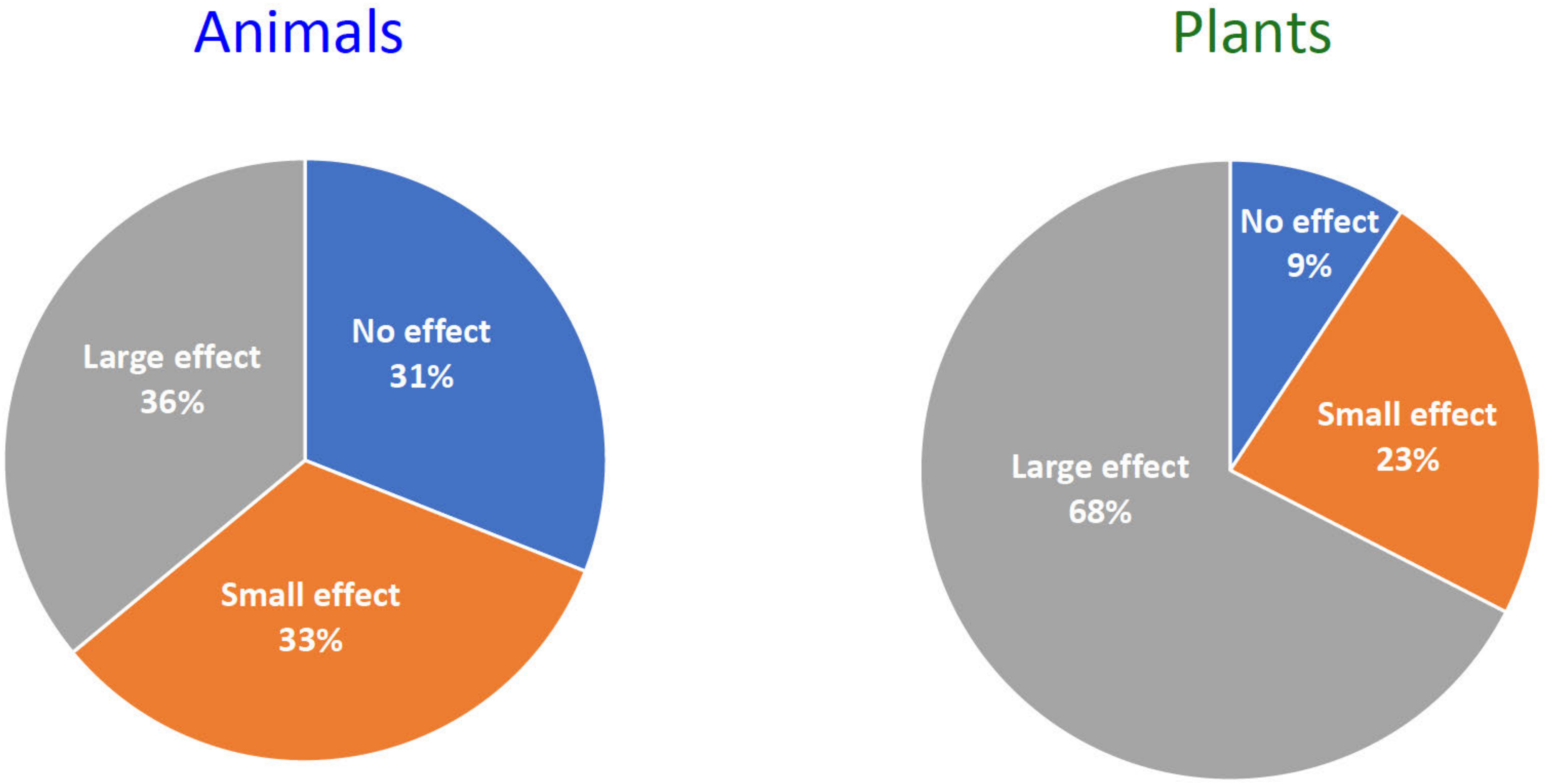
Investigating the impact of anthropogenic radiofrequency electromagnetic fields on animals and plants in the environment: analysis from a systematic map

Chris Brzozek[a,b], Rohan Mate[a], Chhavi Raj Bhatt[a], Sarah Loughran[a], Andrew W. Wood[c] and Ken Karipidis[a,c]

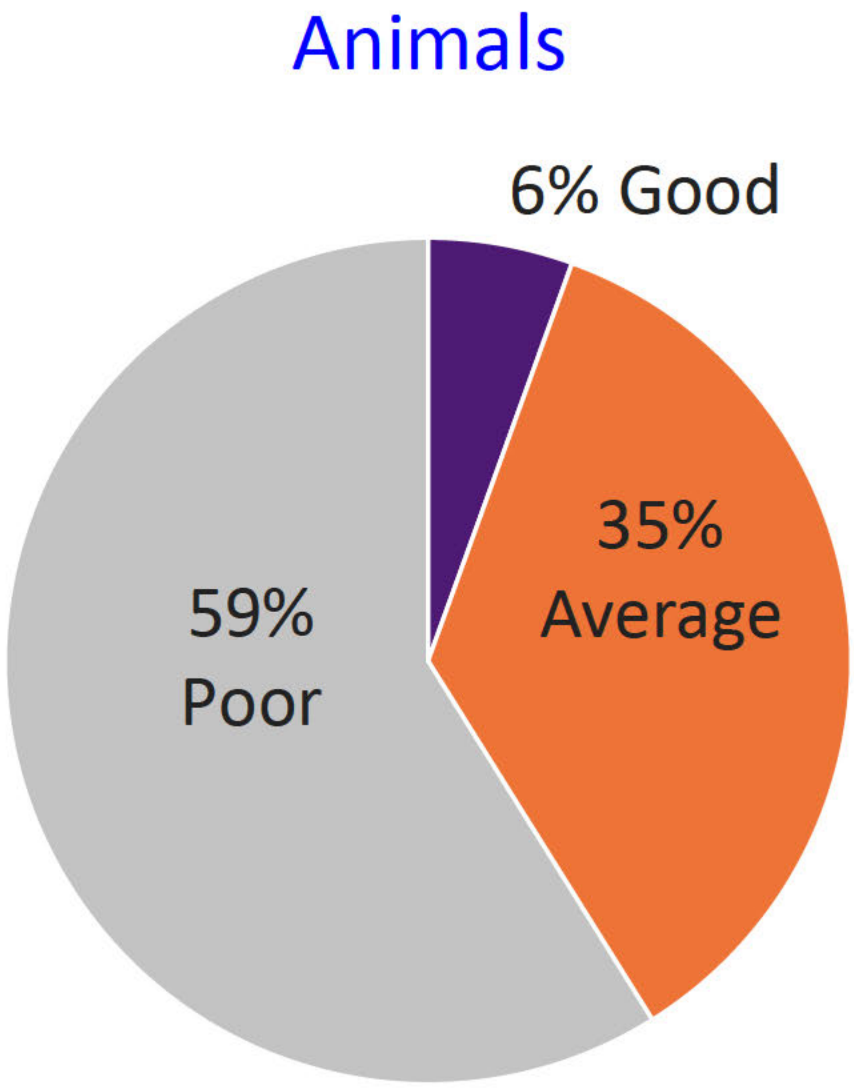
For each study we assessed

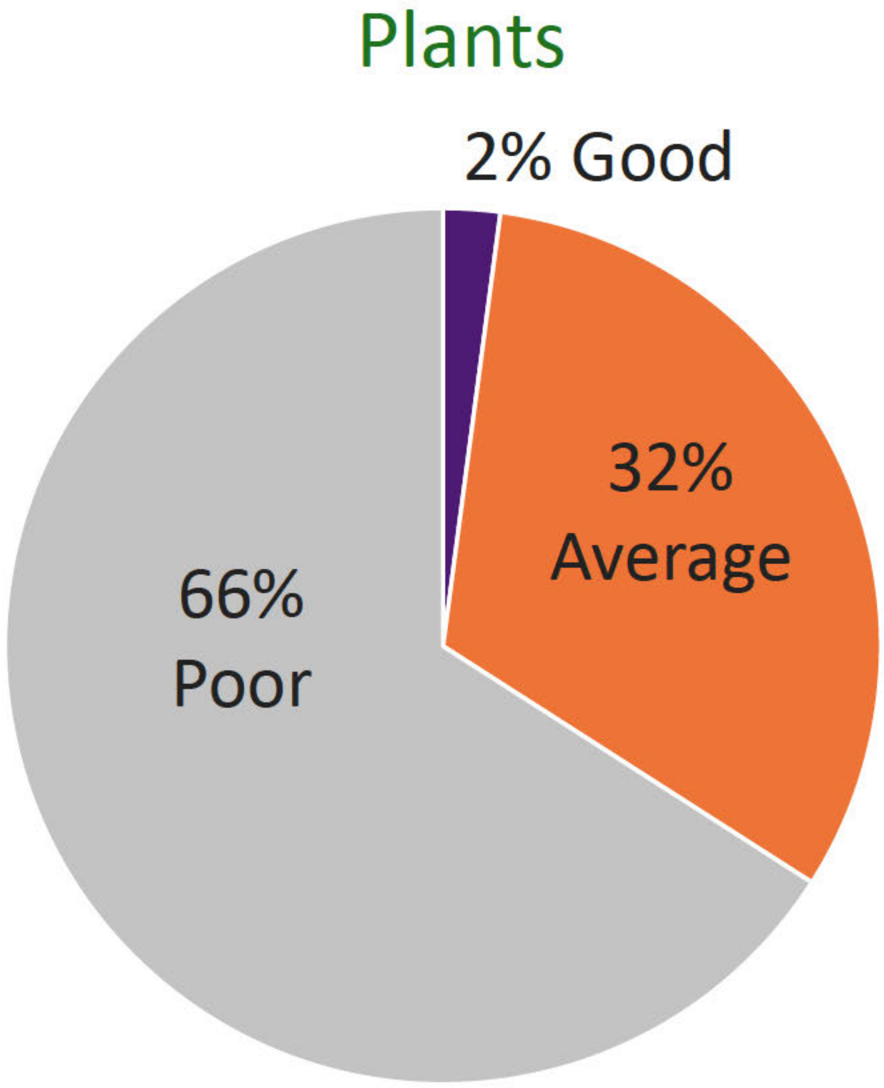
- Effect size
- The quality

Have studies found an effect?

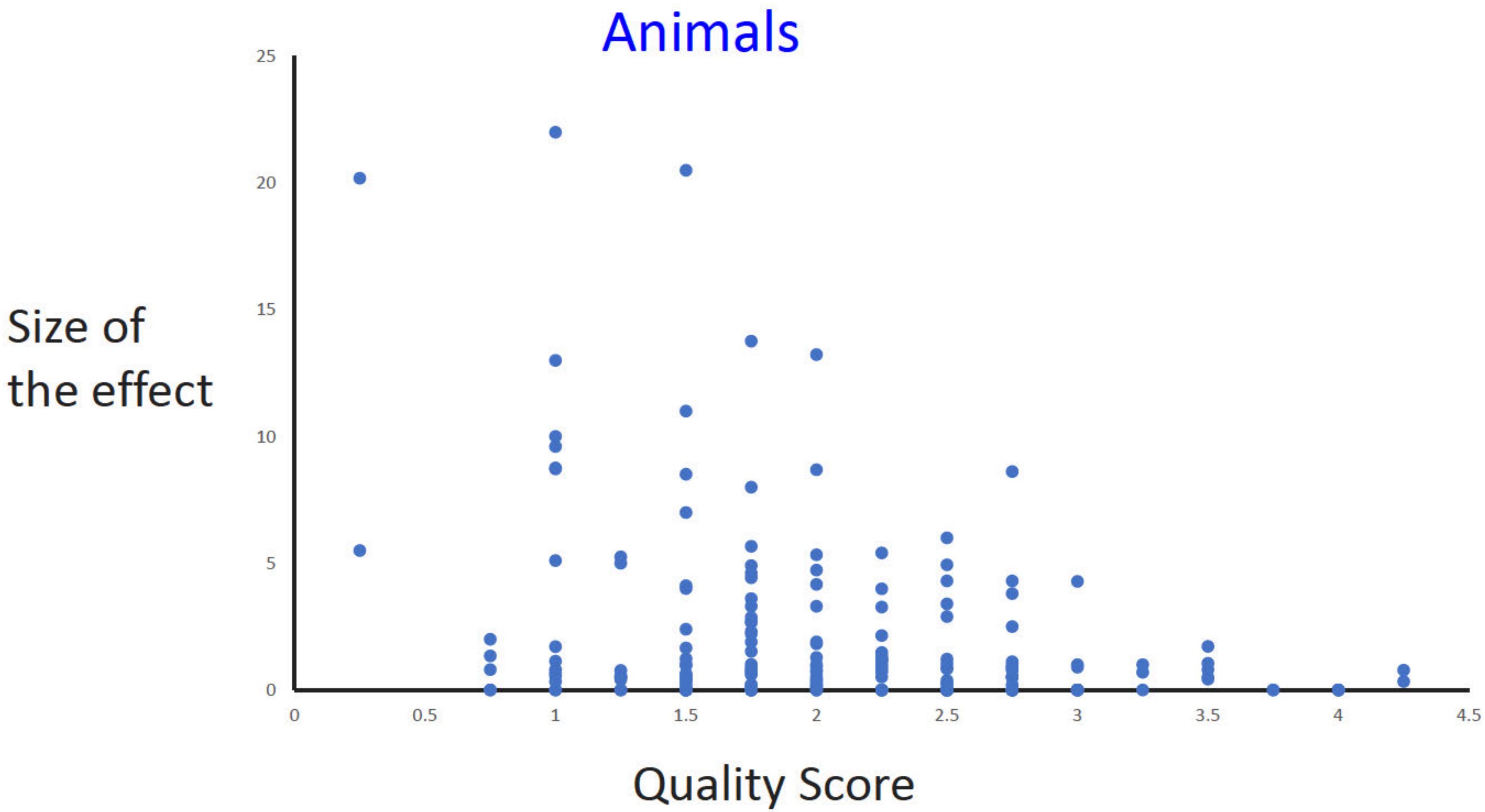


What was the quality of the studies?

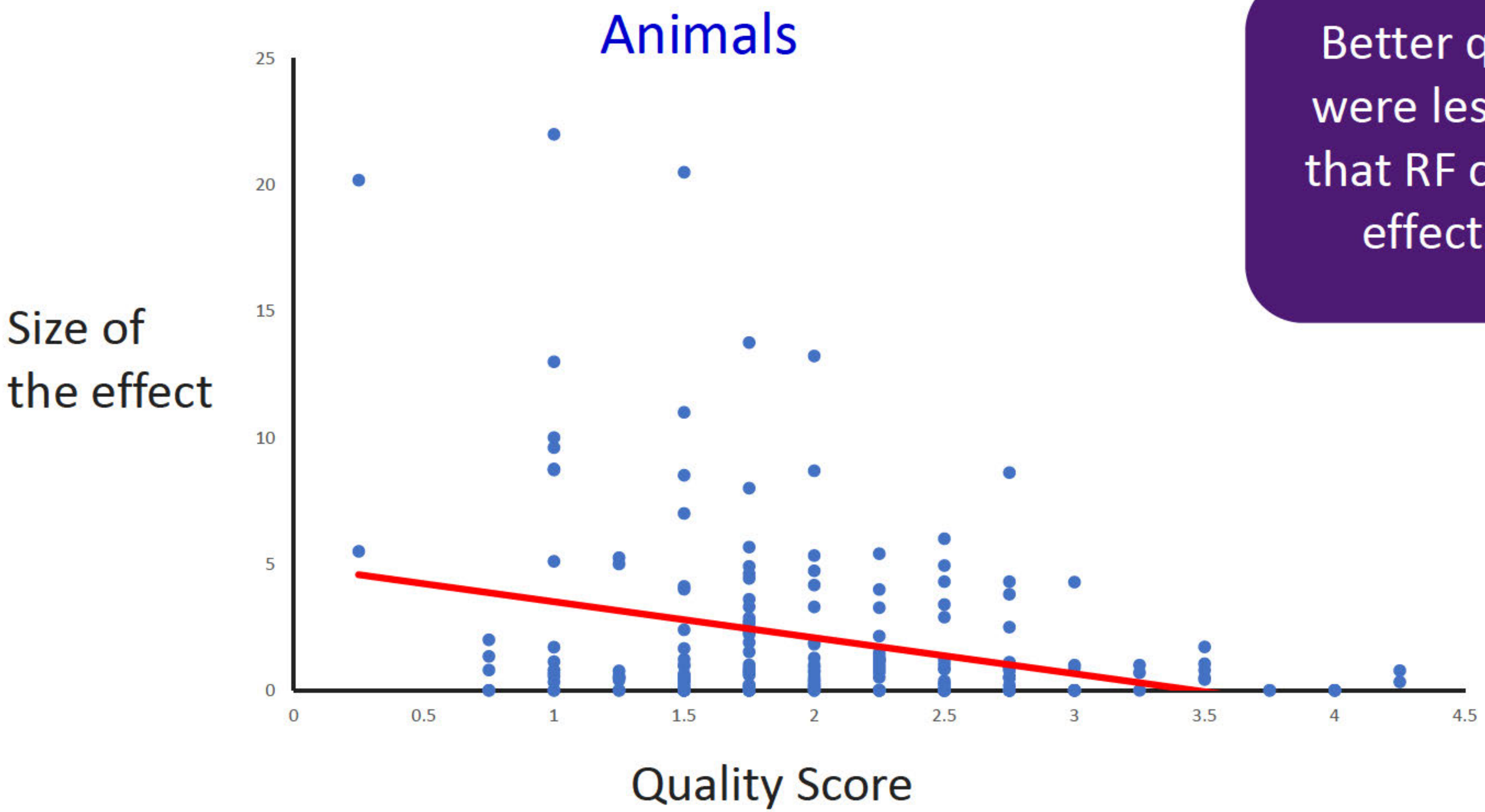




How is the quality of the studies related to what they found?



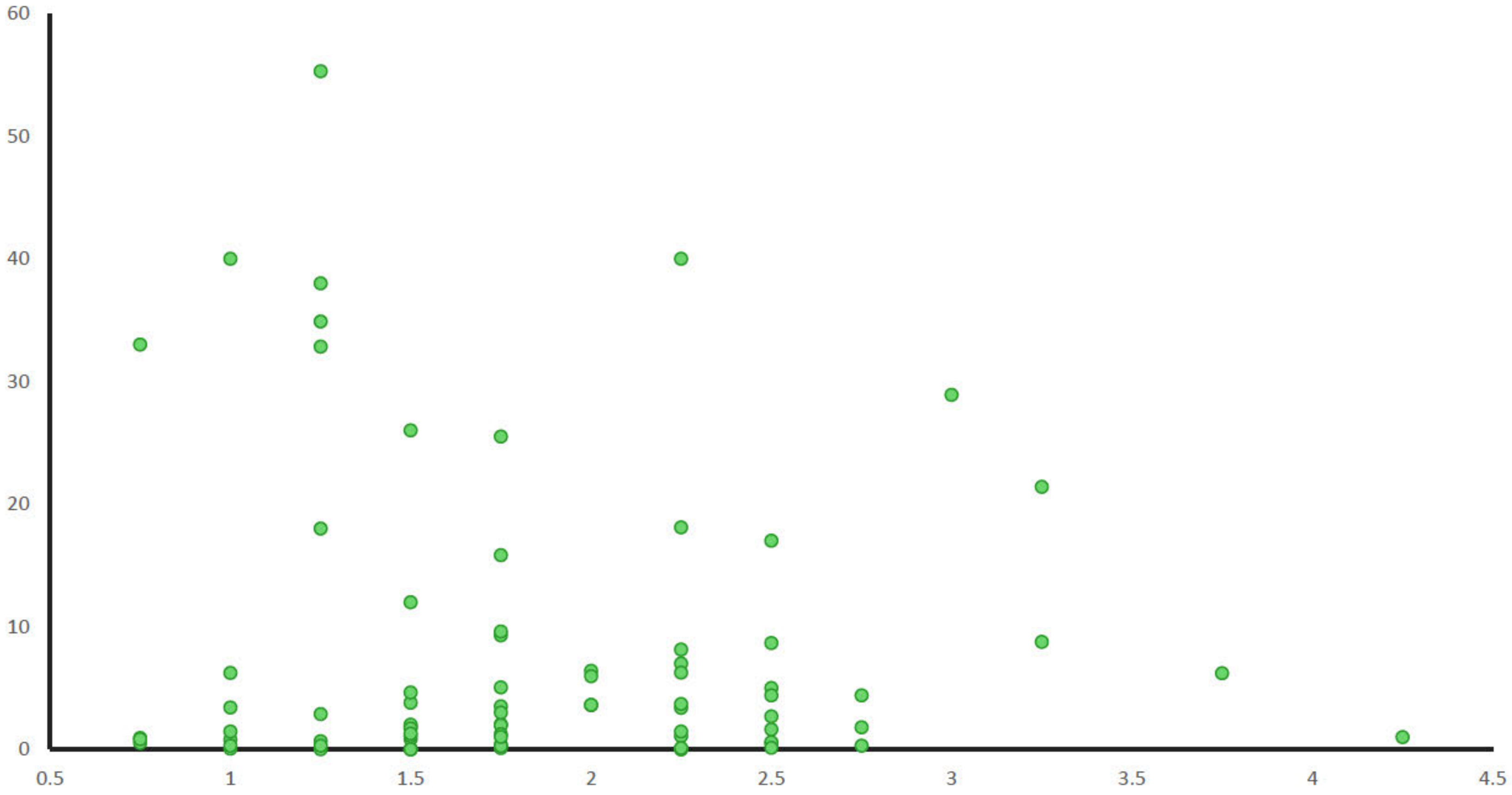
How is the quality of the studies related to what they found?



Better quality studies were less likely to find that RF causes adverse effects in animals

What about for plants?

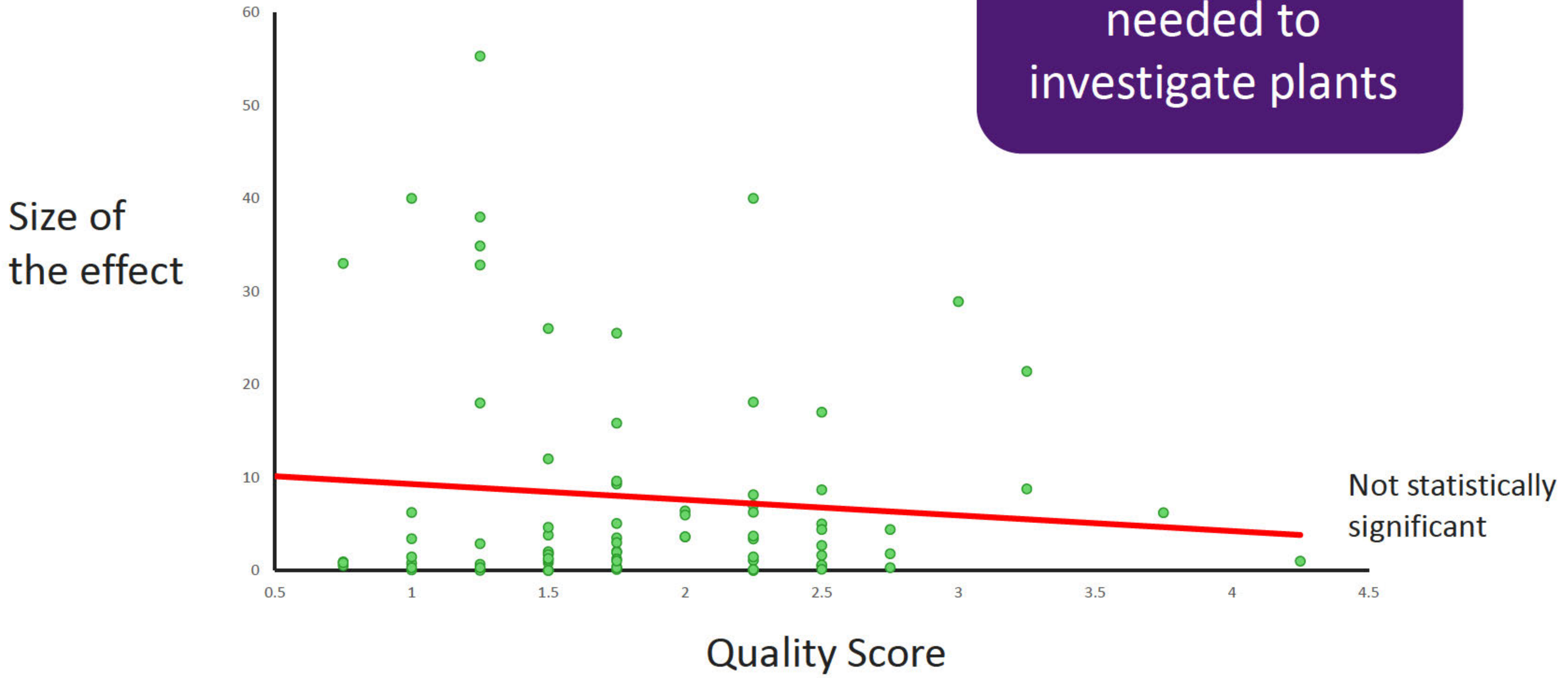
Size of the effect



Quality Score

What about for plants?

More studies are needed to investigate plants



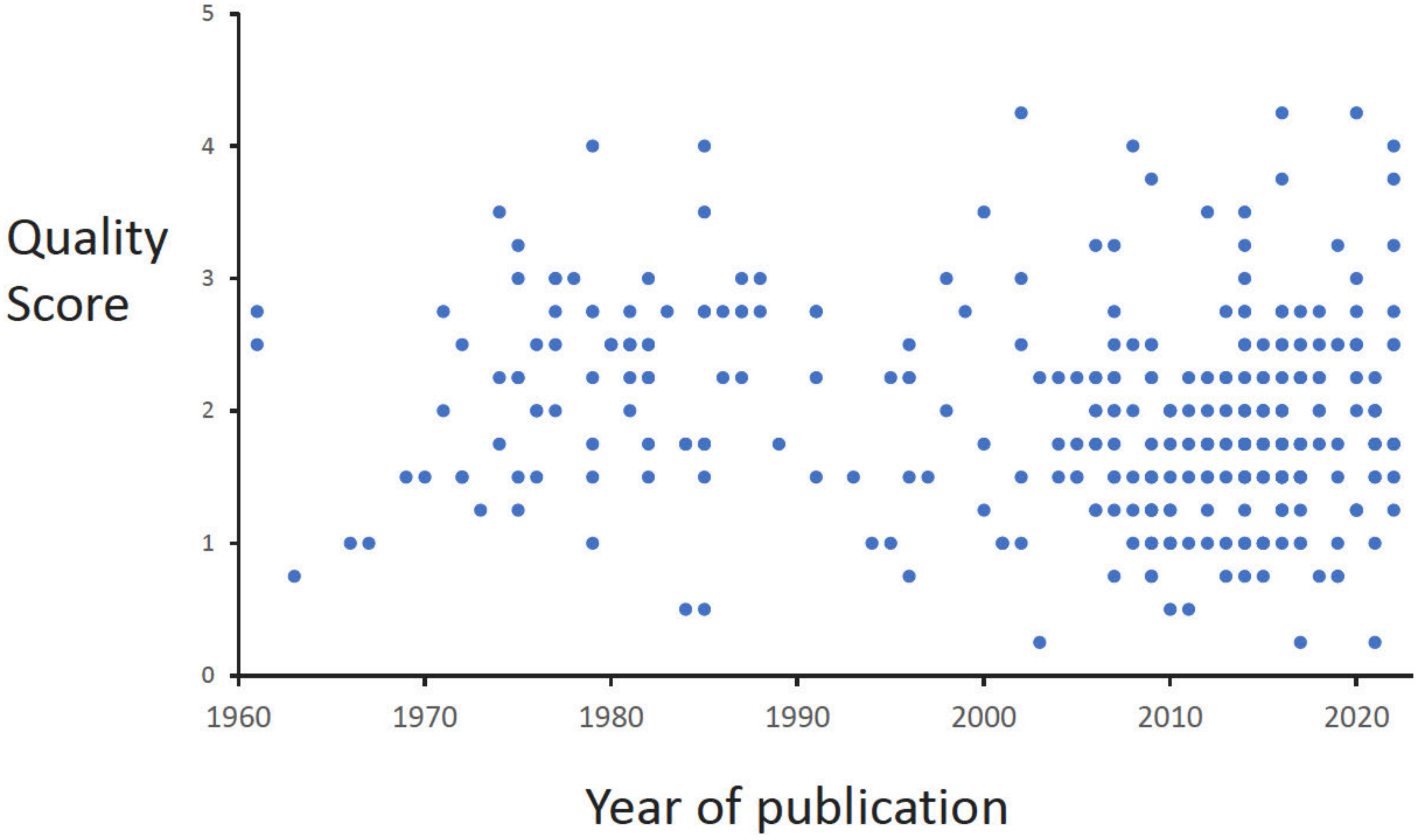
<u>Based on our “crude” analysis</u>

No substantiated evidence that animals and plants are affected from RF exposure in the environment

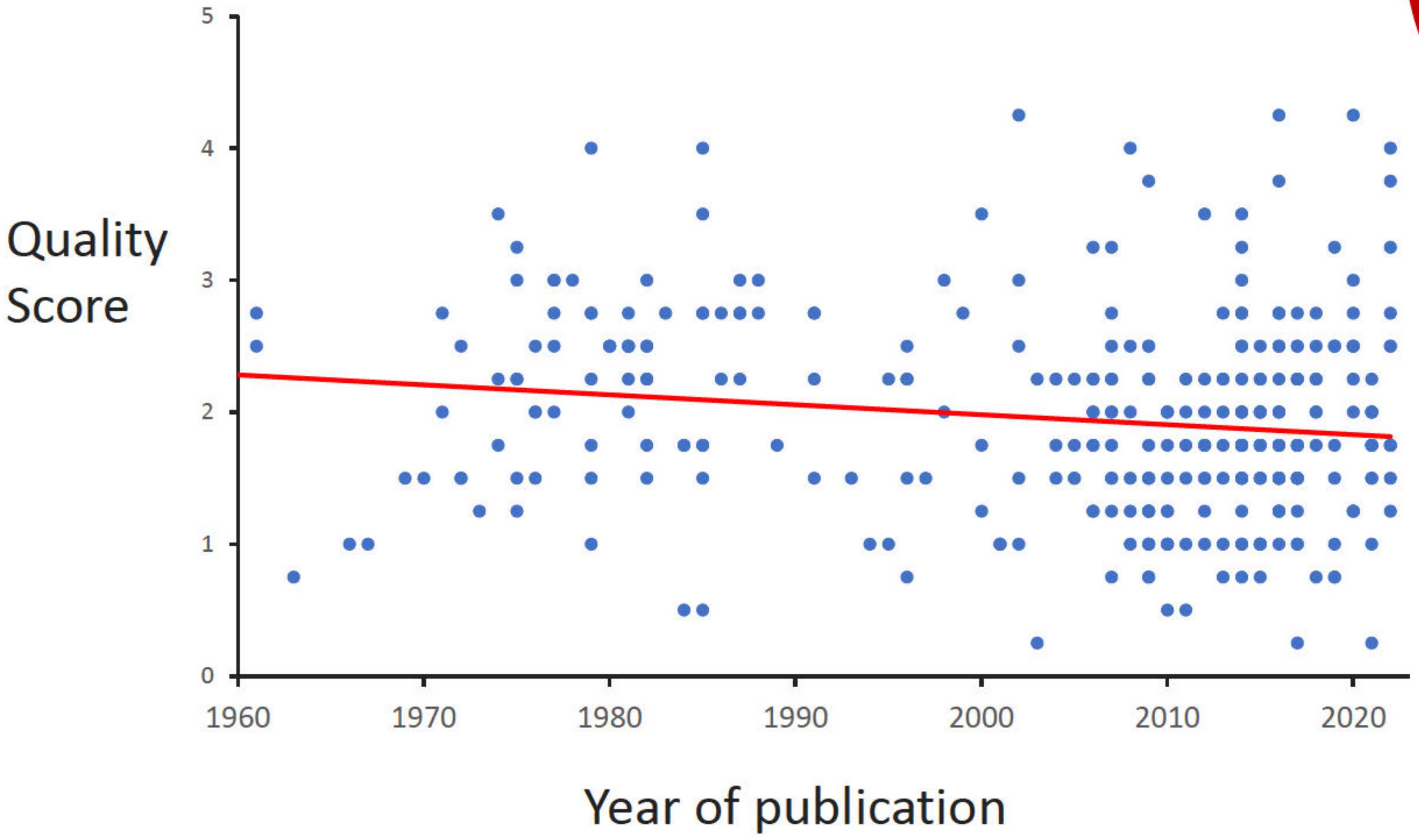
We clearly need more research

But we need more than just
MORE PUBLICATIONS!!!

We also analysed the quality of studies over the years



We also analysed the quality of studies over the years



The quality of the studies has been steadily getting worst

Public plea
No more trash research

Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

Thank you

e. [redacted]@arpansa.gov.au
w. arpansa.gov.au

ARPANSANews ARPANSAGovernment ARPANSA ARPANSA

Classification

Characterising personal RF-EMF exposures on trains in Australia

[1]Chhavi Raj Bhatt*, [1]Stuart Henderson, [1]Masoumeh Sanagou, [1]Sarah Loughran

[1]Australian Radiation Protection and Nuclear Safety Agency, 619 Lower Plenty Road, Yallambie 3085 VIC, Australia

**Correspondence:* s 22(1)(a)(ii) [redacted]@arpansa.gov.au

Summary of abstract

We characterised personal far-field radio-frequency electromagnetic field (RF-EMF) exposure on trains in Melbourne, Australia. RF-EMF exposure measurements were conducted during 32 train rides along eight routes, with measurements undertaken for 50 minutes on average per train ride at different times of day. The RF-EMF exposures (88 MHz – 6 GHz) were measured by using an ExpoM-RF4™ dosimeter carried across the researcher's chest while seated inside the trains. Data on geographic zones of train travel (inner, middle or outer suburb zones), travel direction, measurement time, approximate number of travellers in train carriage, proportion of travellers on phone calls or other phone activity were recorded. Median total exposures over the entire travel or geographic zones were evaluated. Association between exposure levels and geographical zones or time of day, following the adjustment of above-mentioned covariates and train speed, were also explored using quantile regression analysis. Median total exposure during the entire train rides was [redacted] V/m. The exposures in the inner, middle and outer zones were [redacted] V/m, [redacted] V/m, and [redacted] V/m, respectively. The exposures in morning, early afternoon and late afternoon were [redacted] V/m, [redacted] V/m, and [redacted] V/m, respectively. s 47E(a), s 47E(b), s 47E(d) [redacted]

Keywords: RF-EMF, personal exposure trains, Australia

Background

Train travel presents a distinctive RF-EMF exposure environment shaped by several interacting factors. The rapid movement of the train forces mobile devices to undergo frequent signal handovers, during which transmission power typically increases to maintain network connectivity.[1] The metallic structure of the carriage further contributes to elevated exposure by acting as a partial Faraday cage, weakening external signals and prompting handsets to boost their output.[2] High passenger density in a confined space adds another layer of complexity, as numerous devices simultaneously compete for network resources and generate additional emissions.[1] Further, the activity of passengers in terms of mobile phone use, travel zone, travel time, train speed, etc. are likely to influence RF-EMF exposure.

Personal RF-EMF exposure during train travel has mostly been examined within broader micro-environmental exposure studies,[3] providing only descriptive information and has generally not addressed how journey characteristics, particularly travel zone and travel time, relate to RF-EMF exposure. This leaves a notable knowledge gap to systematically understand the influence of journey related factors in RF-EMF exposure. This study aims to characterise RF-EMF exposure on trains and evaluate the association between RF-EMF exposure and travel zone or travel time.

Methods

Measurements were collected using an ExpoM-RF4™ device, which recorded E-field intensity (V/m) across 32 frequency bands (88 MHz–6 GHz) and GPS location every six seconds. During data collection, the device was carried in a chest-worn bag while the researcher sat away from the train window. All personal RF-EMF–emitting devices were switched to aeroplane mode with Wi-Fi and Bluetooth disabled. Data collection occurred on weekdays.

Measurements were conducted on eight Melbourne train lines (Fig. 1) — Sandringham, Cranbourne, Glen Waverley, Belgrave, Hurstbridge, Upfield, Sunbury, and Werribee — covering ~50-minute journeys between Flinders Street Station in the central business district (CBD) of the city and suburban terminal stations. Each journey included six measurements: four on-train (throughout the full trip) and two at stations (origin and destination). For each line, four on-train measurements were taken: (1) suburban terminal to Flinders Street (morning), (2) Flinders Street to suburban terminal (early afternoon), (3) suburban terminal to Flinders Street (early afternoon), and (4) Flinders Street to suburban terminal (late afternoon).

Additional contextual information on covariates was recorded, including travel zones (inner: <10 km from CBD, middle: 10-20 km from CBD, and outer: >20 km from CBD), direction (city- or suburban-bound), timeslot (morning 8:00–9:30, early afternoon 11:30–15:30, late afternoon 16:00–17:30), estimated number of passengers per zone, and the proportion of passengers using mobile phones (calling or non-calling use).

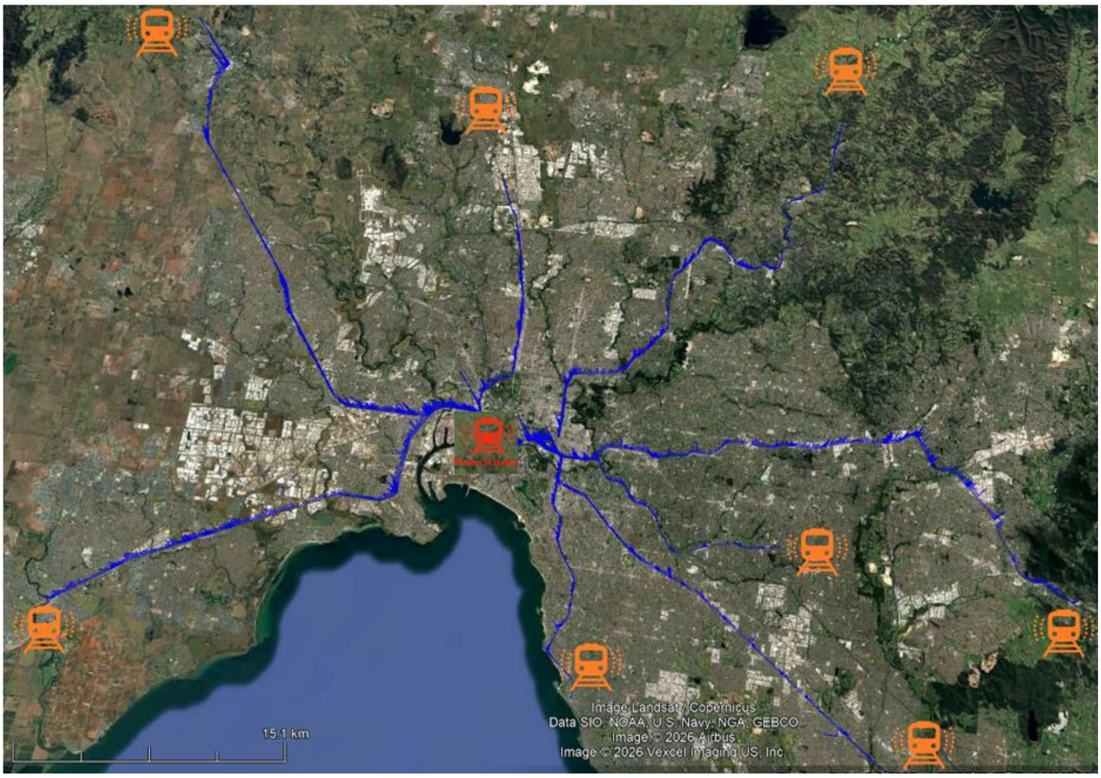


Fig.1. A geographic map of Melbourne showing the GPS tracks of the eight measured train routes. The red train denotes the final destination (Flinder St Station) of all city-bound trains

Data analysis only included on-train measurements (n=32 journeys) of root-mean square (rms) exposure. Total exposure was estimated across different quantiles from rms sum of all measured frequency-specific exposures. Quantile regression (QR) analysis, adjusted for geographic zones of train travel (inner, middle or outer suburb), travel direction, measurement time, approximate number of travellers in train carriage, proportion of travellers on phone calls or other phone activity, was used to evaluate quantile-specific associations between the zones or timeslots and total exposure levels across the distribution of the exposure.[4] The analyses were conducted using STATA 17.0 (significance level at $p<0.05$), which adjusted for the above-mentioned covariates and train speed.

Results

s 47E(a), s 47E(b), s 47E(d) [redacted]

[redacted]

s 47E(a), s 47E(b), s 47E(d) [redacted]

Figs. 2a (left) and 2b (right). Trend of quantile regression-based estimated coefficients (β_τ, y-axis) by total exposure quantiles (x-axis) [baseline group = inner zone].

s 47E(a), s 47E(b), s 47E(d)

[redacted]

Figs. 3a (left) and 3b (right). Trend of quantile regression-based estimated coefficients (β_τ, y-axis) by total exposure quantiles (x-axis) [baseline group = early afternoon].

Conclusion

s 47E(a), s 47E(b), s 47E(d)

[redacted]

References

1. Wiart J, Dale C; Bosisio AV, le Cornec A. Analysis of the influence of the power control and discontinuous transmission on RF exposure with GSM mobile phones. IEEE Trans. Electromagn Compat 2000, 42, 376–385.
2. Aerts S, Plets D, Thielens A, Martens L, Joseph W. Impact of a small cell on the RF-EMF exposure in a train. Int J Environ Res Public Health 2015, 12, 2639–52.
3. Chiaramello E, Bonato M, Fiocchi S, et al. Radio Frequency Electromagnetic Fields Exposure Assessment in Indoor Environments: A Review. Int J Environ Res Public Health 2019, 16, 955.
4. Khadka A, Hebert JL, Glymour MM, et al. Quantile regressions as a tool to evaluate how an exposure shifts and reshapes the outcome distribution: a primer for epidemiologists. Am J Epidemiol 2025, 194, 2075–2084.

Calibration of an RF-EMF Exposimeter and Application to Historical Exposure

Chhavi Raj Bhatt*, [redacted] Stuart Henderson, Don Wijayasinghe, Sarah Loughran

Australian Radiation Protection and Nuclear Safety Agency, 619 Lower Plenty Road, Yallambie 3085 VIC, Australia

**Correspondence:* [redacted] *@arpansa.gov.au*

Summary of Abstract

Accurate assessment of radiofrequency electromagnetic field (RF-EMF) exposure is essential for evaluating potential health effects and ensuring compliance with local and international safety guidelines. To achieve reliable exposure monitoring, RF-EMF measurement devices should be routinely calibrated, and reported exposure levels should incorporate calibration results to minimise systematic measurement bias. This study aims to (i) derive calibration factors for a RF-EMF exposimeter and (ii) apply these factors to assess the variability between calibration-adjusted and non-adjusted historical RF-EMF exposure data. An ExpoM-RF4™ exposimeter was calibrated in a fully anechoic chamber. Transfer standard calibration was performed using an RF-EMF signal generator at mobile phone frequencies (viz., 900, 1800, 2100, 2600, and 3500 MHz) and a transmitted electric field strength of 10 V/m. For each frequency, E-field measurements were collected at multiple angular positions (0 to 360 degrees in 30-degree increments) in vertical and horizontal orientations. Calibration factors (CF) for each frequency and orientation were subsequently derived. These factors were then applied to estimate calibration-adjusted exposure levels in each frequency band using historical exposure data. The variability of frequency-specific exposure (in dB) between CF-adjusted exposure and non-adjusted exposure and its impact on historically reported RF-EMF exposure were evaluated. [redacted]

Keywords: RF-EMF exposure, anechoic chamber, calibration

Full length abstract

Background

Accurate assessment of radiofrequency electromagnetic field (RF-EMF) exposure is essential for evaluating potential health effects, characterising population-level exposure patterns, and ensuring compliance with local and international safety guidelines. Reliable exposure monitoring depends not only on appropriate measurement protocols but also on the performance and response characteristics of the measurement instruments themselves.[1] Because RF-EMF exposimeters can exhibit frequency-, orientation-, and angle-dependent variability; routine calibration is required to verify their accuracy and stability.[1,2]. Incorporating calibration results into reported exposure levels is therefore critical for reducing systematic measurement bias and enhancing the validity of exposure estimates. Despite this, RF-EMF exposure assessments often rely solely on raw measurements obtained directly from exposimeters without adjusting for their frequency-dependent calibration factors (CFs), which may introduce bias when reporting exposure levels in real-world environments.[3] This study aims to derive CFs for an RF-EMF exposimeter (ExpoM-RF4™) and apply them to evaluate the difference between calibration-adjusted and non-adjusted historical RF-EMF exposure data.

Methods

Calibration procedure

s 47E(a), s 47E(b), s 47E(d) [redacted]

[redacted]

s 47E(a), s 47E(b), s 47E(d) [redacted]

Fig.1. Calibration set up (left) with an exposimeter device (right) placed in the vertical orientation on top of the calibration stand

Derivation of CFs

s 47E(a), s 47E(b), s 47E(d) [redacted]

[redacted]

[redacted]

Application of CFs to historical measurements

The frequency-specific mean values of CFs will be applied to aforementioned mobile phone frequency bands and their impact on reported median total RF-EMF exposure level (e.g., historical data[3]) will be reported.

Results

The calibration component of this study is currently underway. s 47E(a), s 47E(b), s 47E(d) [redacted]

Conclusion

s 47E(a), s 47E(b), s 47E(d) [redacted]

References

1. Eeftens M, Dongus S, Bürgler A, Röösli M; ACCEDERA team. A real-world quality assessment study in six ExpoM-RF measurement devices. Environ Res 2020, 182, 109049.
2. Bolte JF, van der Zande G, Kamer J. Calibration and uncertainties in personal exposure measurements of radiofrequency electromagnetic fields. Bioelectromagnetics 2011, 32(8), 652-63.
3. Bhatt CR, Henderson S, Sanagou M, Brzozek C, Thielens A, Benke G, Loughran S. Micro-environmental personal radio-frequency electromagnetic field exposures in Melbourne: A longitudinal trend analysis. Environ Res 2024, 251(Pt 2), 118629.

Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

Characterising personal RF-EMF exposures on trains in Australia

*Chhavi Raj Bhatt, Stuart Henderson, Masoumeh Sanagou, Sarah Loughran

Overview

- ❑ Background
- ❑ Methods
- ❑ Results
- ❑ Conclusion

Background

- ❑ Train: A unique RF-EMF exposure environment due to:
  - ❖ ***Metallic structure***
    - → *Partial Faraday cage*
    - → *Mobile handsets boost Tx*
  - ❖ ***Passenger density***
    - → *Enhanced RF-EMF exposure*
  - ❖ ***Signal handovers***
    - → *Tx power increase*

[redacted] s 47F

Sources: *ABC News; Rail Express Australia, RACV*

- RF-EMF exposure on trains (higher than outdoor environments) are descriptively reported[1,2,3]

- Limited evidence investigating exposure across:
  - *Travel zones (urbanicity)*
  - *Travel times ('time-of-day')*

- Study purpose:
  - *Better characterise RF-EMF exposure on trains*
  - *Evaluate association between RF-EMF exposure and travel time or travel zone*

1. Loizeau et al. *J Expo Sci Environ Epidemiol*, 2026
2. Jalilian et al. *Environ Res*, 2019
3. Jalilian et al. *Environ Res*, 2026

Methods

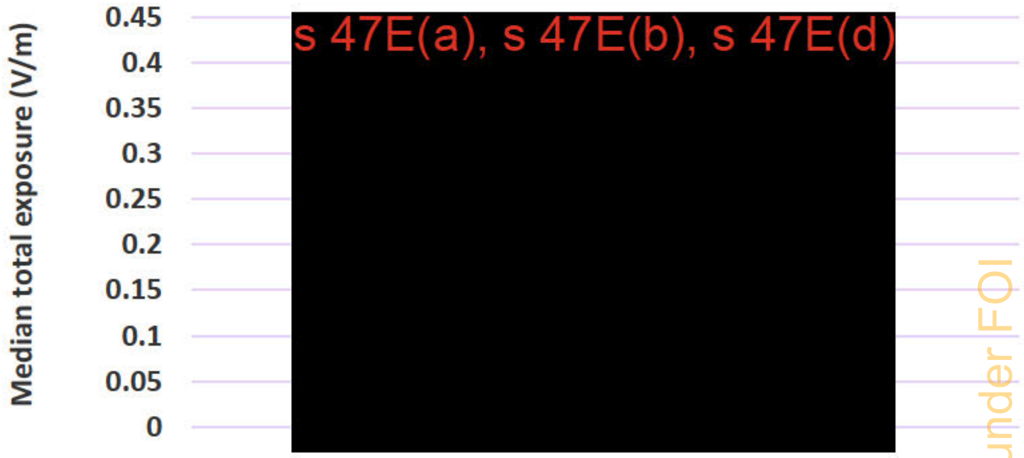
- Half of Melbourne train lines (n=8) measured
- 32 full journeys (4 on each train line): city- and suburban-bound trains at different times-of-day
- Mean journey duration: ~50 min (30 to 70 min)
- Data (exposure, GPS, speed) logged every 6 s
- 32 frequency bands (88 MHz – 6 GHz)

s 47F
[redacted]

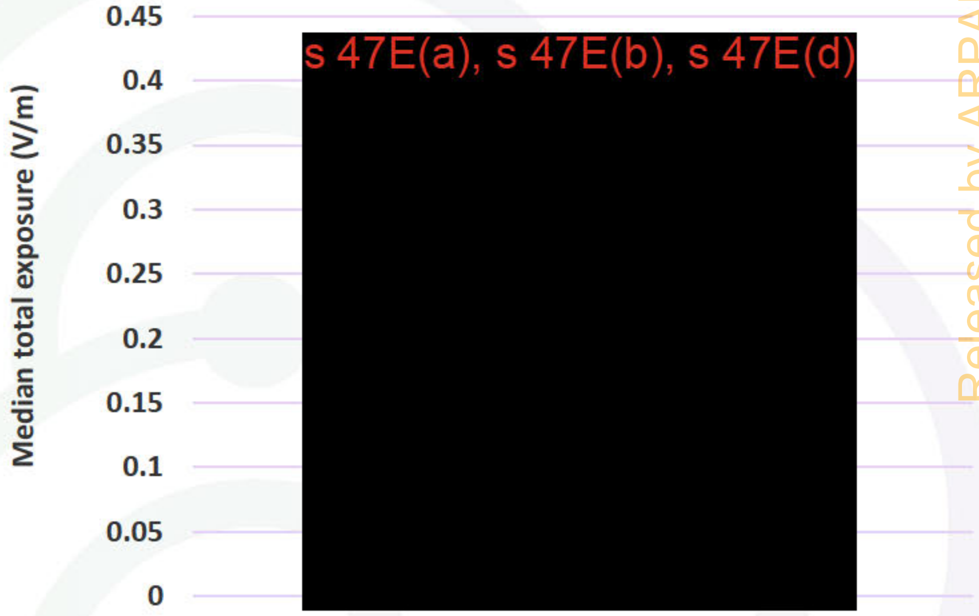
Results

Median total exposure

- s 47E(a), s 47E(b), s 47E(d) [redacted] V/m (all journeys)
- Times-of-day
  - *Early afternoon: non-busy hours*
  - *Morning/Late afternoon: busy hours*
- Travelling zones (urbanity)*
  - *Inner: <10 km*
  - *Middle: 10-20 km*
  - *Outer: >20 km*



[redacted]



[redacted]

* From city centre

Association: median total exposure and 'time-of-day'

Compared to '*early afternoon*', the median total exposure in '*morning*' and '*late afternoon*' were [redacted] (Figs. 1 & 2)

**Adjusted for no. of travellers in train carriage, proportion of travellers on phone calls or other phone activity, and train speed*

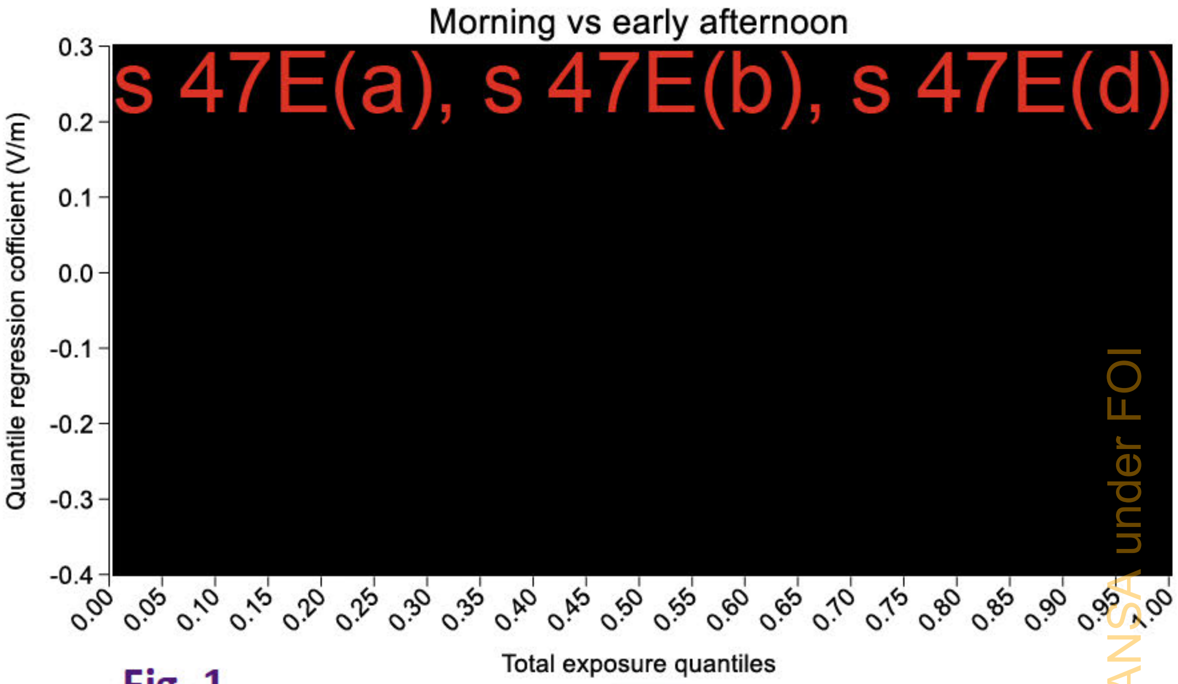


Fig. 1

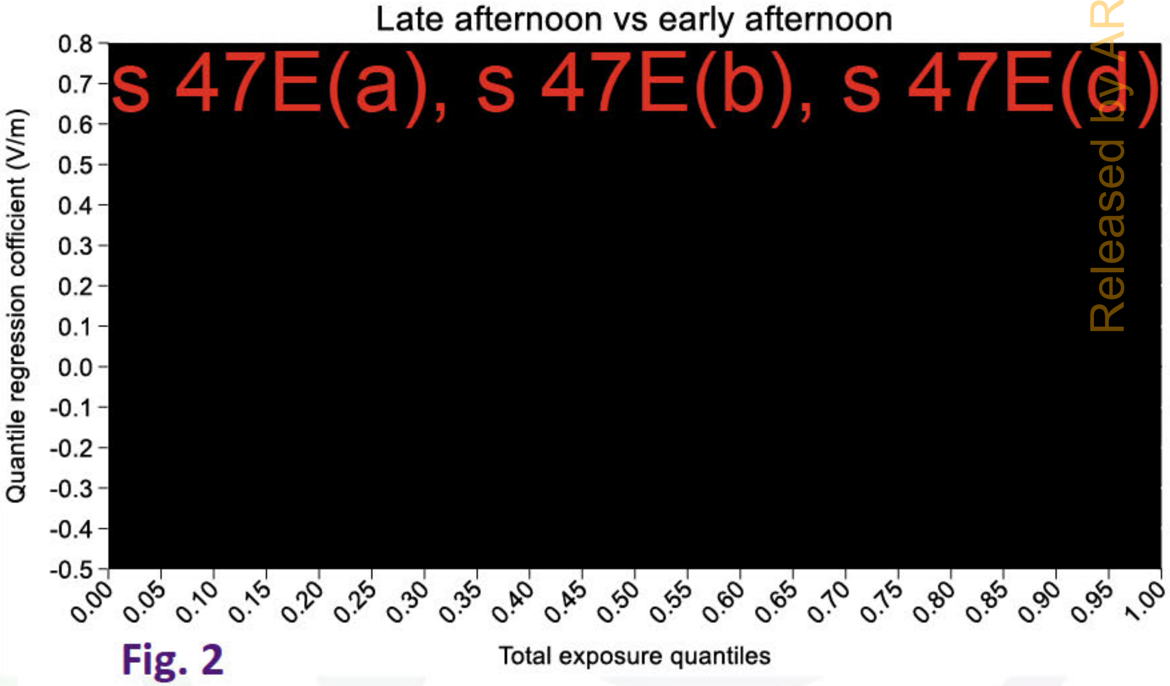


Fig. 2

Association: median total exposure and travel zone

Compared to inner zone, median total exposure:

- *Outer zone:* [redacted] *(Fig. 3)*
- *Middle zone:* [redacted] *(Fig. 4)*

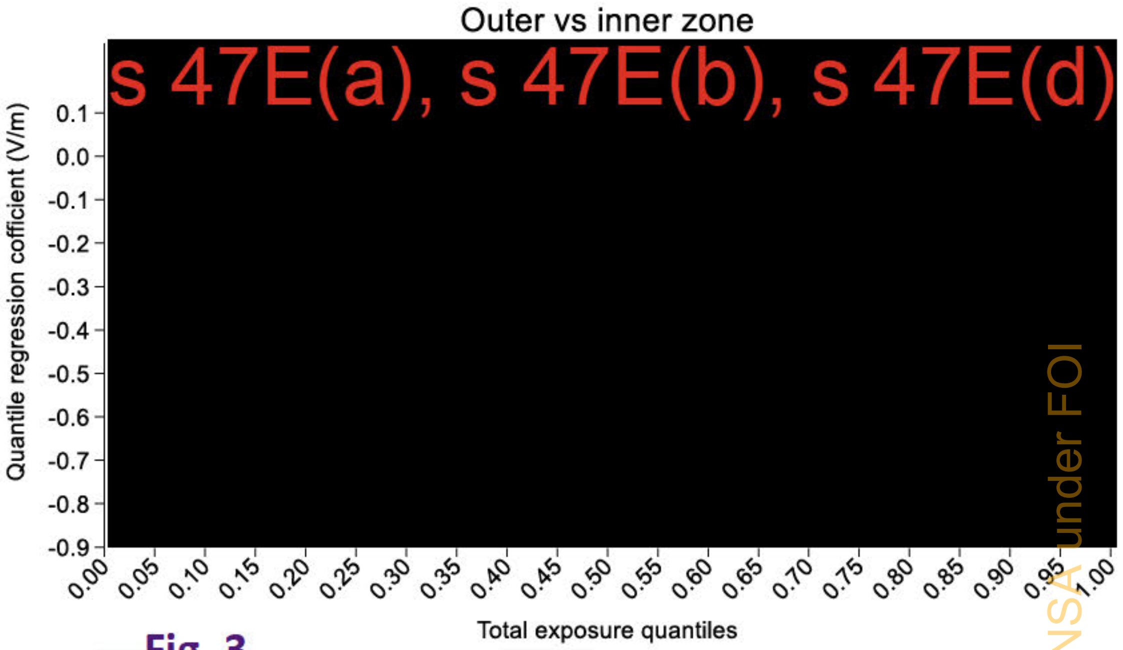


Fig. 3

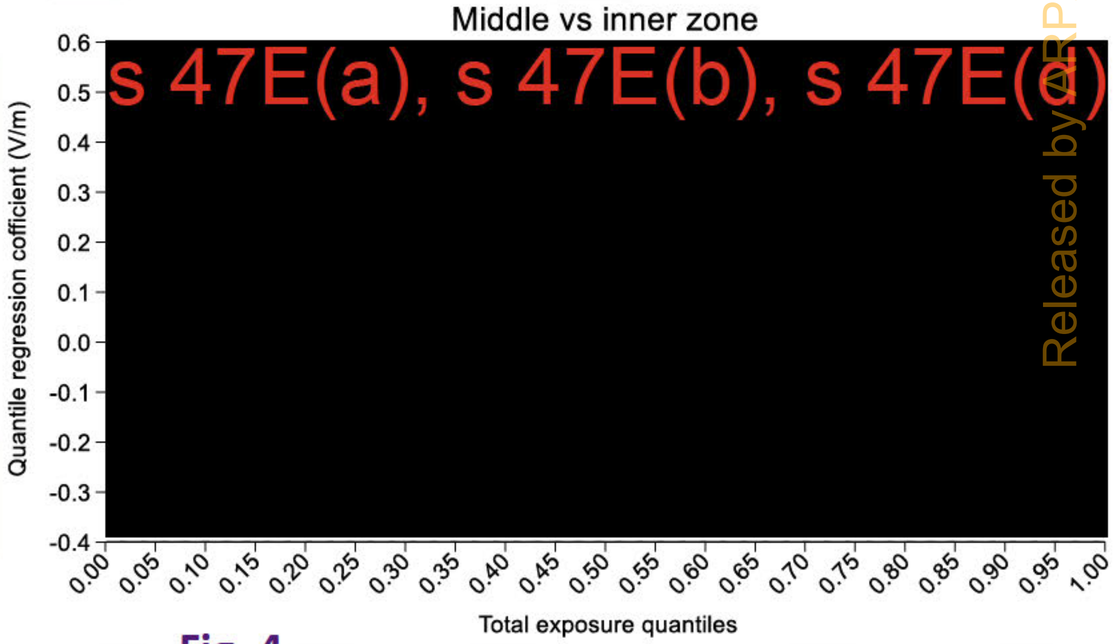


Fig. 4

Conclusion

- s 47E(a), s 47E(b), s 47E(d) [redacted]
- s 47E(a), s 47E(b), s 47E(d) [redacted]
- s 47E(a), s 47E(b), s 47E(d) [redacted]

Australian Government

Australian Radiation Protection and Nuclear Safety Agency

arpansa

Thank you

Email: [redacted]@arpansa.gov.au

ARPANSANews

ARPANSAGovernment

ARPANSA

ARPANSA

Occupational Exposure to Radiofrequency Electromagnetic fields (RF EMF) and the Risk of Cancer

Rohan Mate
PhD Student
Monash University

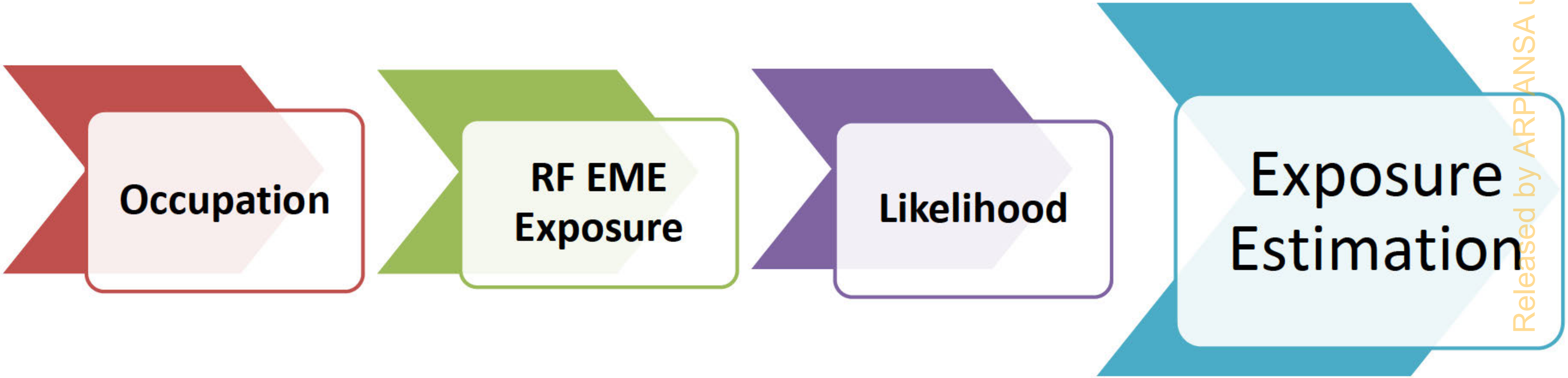
We’re all exposed to RF-EMF

Epidemiological research

Epidemiological

Exposure assessment

Job Exposure Matrix (JEM)



The job exposure matrix

INTEROCC RF JEM

Interphone Occupational case-control study

- Exposure intensity rating

- Measurement based
- 289 RF EME jobs
- >9000 subjects
- Data from 1974 and 2013

CANJEM

Canadian job exposure matrix

- Exposure intensity rating

- Expert assessment
- 119 RF EME jobs
- >8500 subjects
- Data from 1979 and 2004

Lucile Migault et al. 2019. Development of a job-exposure matrix for assessment of occupational exposure to high-frequency electromagnetic fields (3 kHz–300 GHz).

Jack Siemiatycki , Jérôme Lavoué. 2018. Availability of a New Job-Exposure Matrix (CANJEM) for Epidemiologic and Occupational Medicine Purposes

Study aim

Assess the impact of occupational exposure to RF EMF on the incidence of glioma and follicular lymphoma.

Glioma

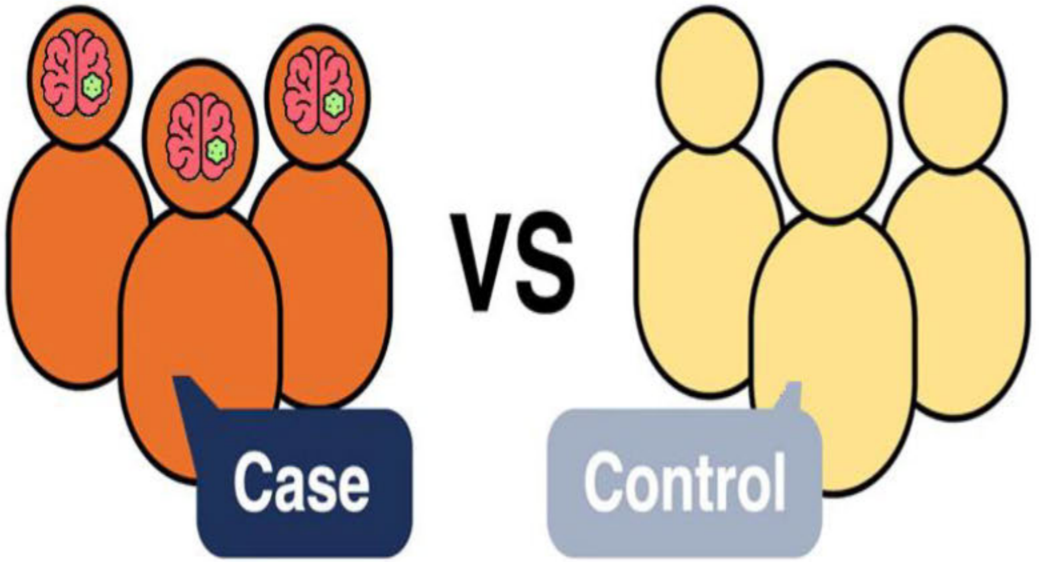
- Gliomas primary brain tumors from glial cells
  - 70–80% of malignant brain tumors
  - Incidence rates stable for last 30 years

- Is there an association with RF EMF?

Glioma case-control study

- **Glioma case-control study**
  Australian Genomics and Clinical Outcomes of Glioma study
- Family based case-case control study
- 467 cases
- 367 controls

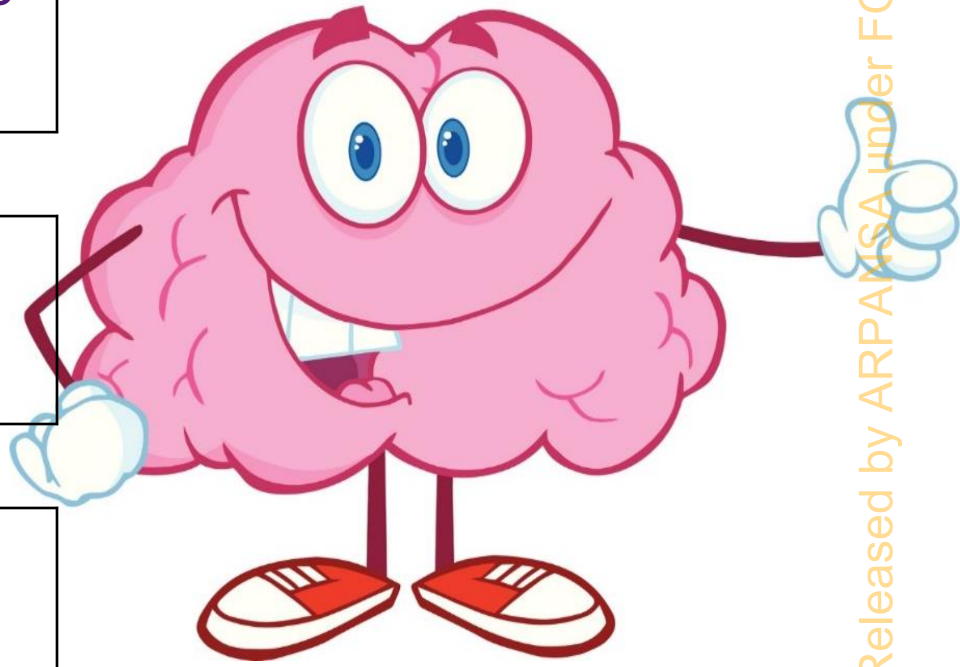
From Australian population



Controlled for: sex, age, ethnicity, education, smoking status, alcohol consumption and relationship of cases and controls

Glioma cancer analysis

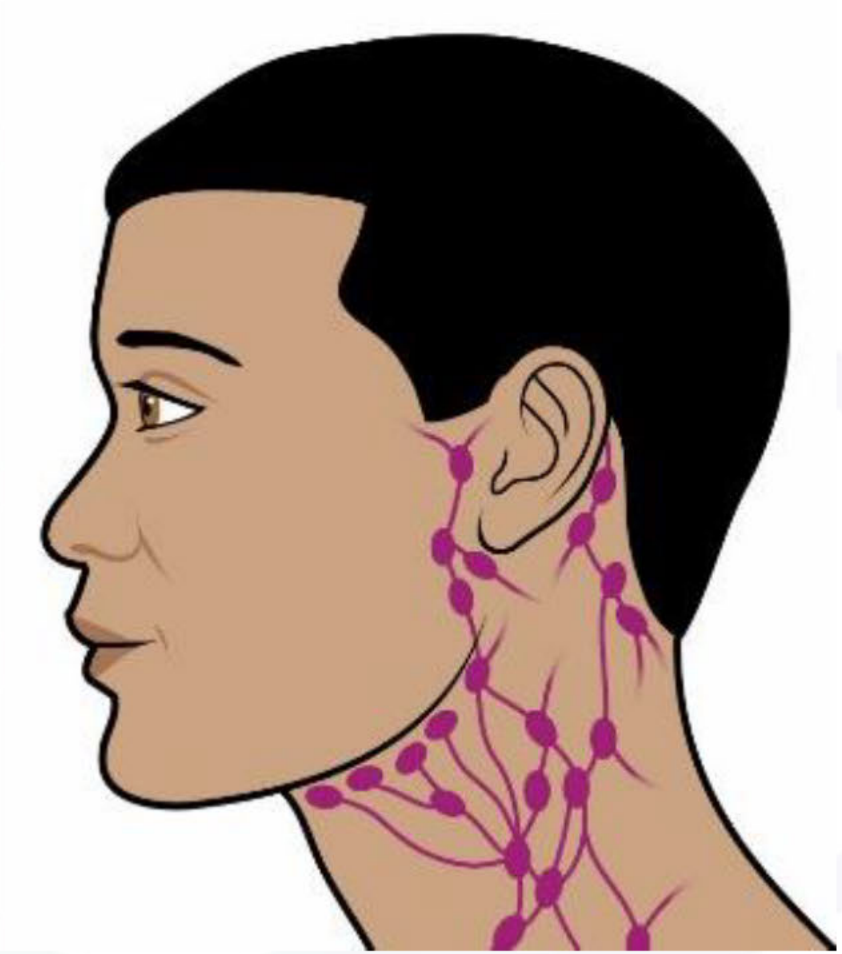
	Quartiles	OR	95% CI
INTEROCC RF JEM (electric field)	Lowest VS highest	0.74	0.47-1.15
INTEROCC RF JEM (magnetic field)	Lowest VS highest	0.92	0.58-1.45
CANJEM	Lowest VS highest	0.85	0.54-1.32



Controlled for: sex, age, ethnicity, education, smoking status, alcohol consumption and relationship of cases and controls

Follicular lymphoma (FL)

- Second most common non-Hodgkin lymphoma (NHL)
- From B lymphocytes and accounts for 20–30% of NHL
- Incidence rates has increased steadily since 1983 in Australia and globally
- Previous epidemiological studies grouped it with NHL
- Is there an association with RF EMF?

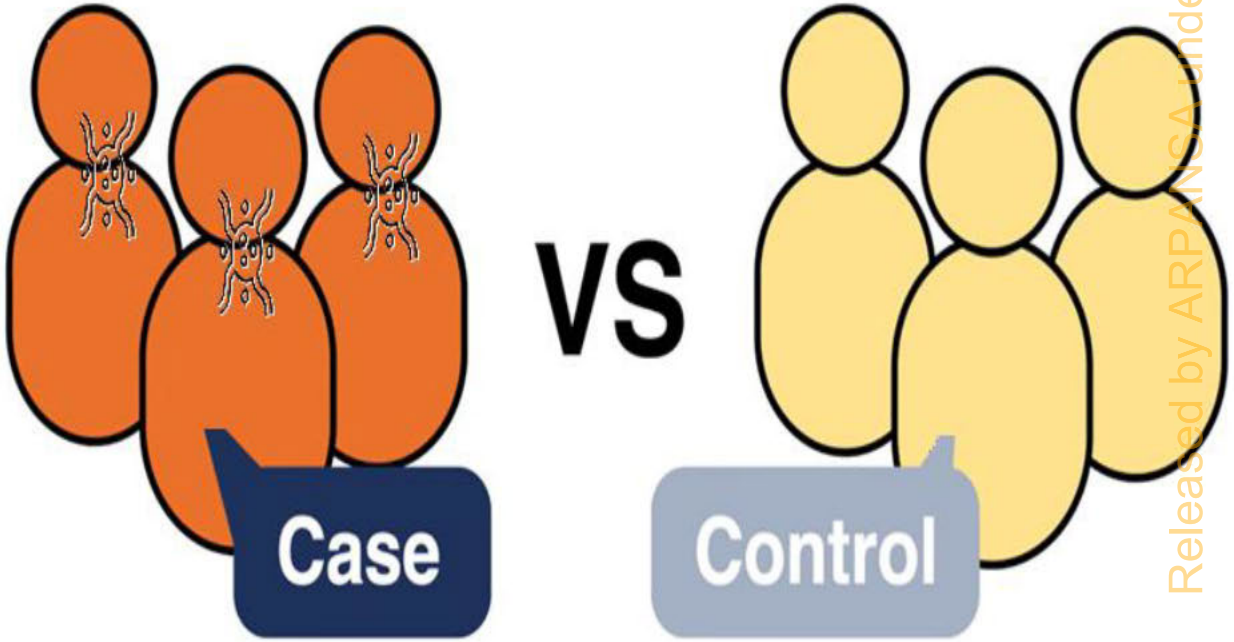


Follicular lymphoma case-control study

- **Follicular lymphoma case-control study**
  Lymphoma, lifestyle environment and family (LEAF) study

- Family based case-case control study
- 727 cases
- 484 controls

From Australian population



Follicular lymphoma analysis

	Quartiles	OR	95% CI
INTEROCC RF JEM (electric field)	Lowest VS highest	s 47E(a), s 47E(b), s 47E [redacted]	s 47E(a), s 47E(b), s 47E(d) [redacted]
INTEROCC RF JEM (magnetic field)	Lowest VS highest	s 47E(a), s 47E(b), s 47E [redacted]	s 47E(a), s 47E(b), s 47E(d) [redacted]
CANJEM	Lowest VS highest	s 47E(a), s 47E(b), s 47E [redacted]	s 47E(a), s 47E(b), s 47E(d) [redacted]

Controlled for: sex, age, ethnicity, smoking status, alcohol consumption and relationship of cases and controls

Results Overall

- s 47E(a), s 47E(b), s 47E(d) [redacted]
- s 47E(a), s 47E(b), s 47E(d) [redacted]
- s 47E(a), s 47E(b), s 47E(d) [redacted]

Acknowledgements

Supervisors

[redacted] s 22(1)(a)(ii), Ken Karipidis, Sarah Loughran and [redacted] s 22(1)(a)(ii)

Data providers

[redacted] s 22(1)(a)(ii)

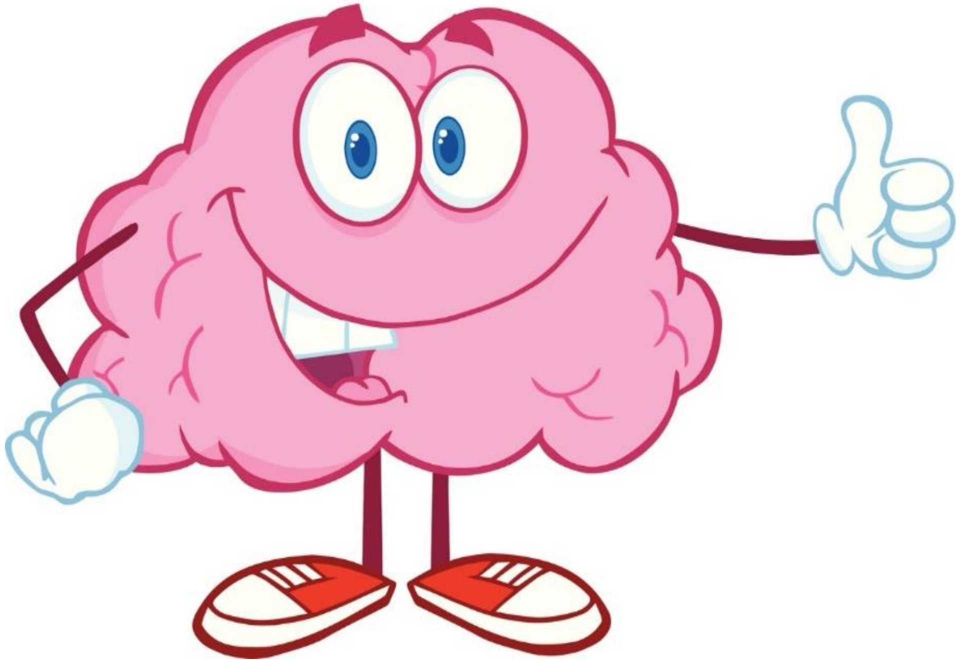
Additional collaborators

Masoumeh Sanagou and Stuart Henderson

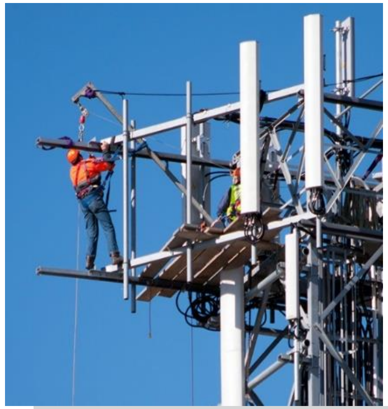
Monash University

Thank you

s 22(1)(a)(ii) [redacted]@monash.edu.au



Top ten exposed occupations



Occupations CANJEM	Occupations INTEROCC RF JEM
Aircraft pilots and associate professionals	Textile machine operators
Photographers and image and sound recording equipment operators	Shoemaking and related machine operators
Production and operations department managers not elsewhere classified	Production clerks
Broadcasting and telecommunications equipment operators	typesetters and related workers
Air traffic controllers	Civil engineering technicians
Electronics fitters	General mangers in transport, storage and communications
Electronics and telecommunications engineering technicians	Film, stage and related actors and directors
Undertakers and embalmers	Paper-products machine operators
Electrical mechanics and fitters	Construction and maintenance labourers: roads, dams and similar constructions
Ships' deck crews and related workers	Builders, traditional materials

Job exposure matrix

CANJEM	INTEROCC RF JEM
Aircraft pilots and associate professionals	Textile machine operators
Photographers and image and sound recording equipment operators	Shoemaking and related machine operators
Production and operations department managers not elsewhere classified	Production clerks
Broadcasting and telecommunications equipment operators	Typesetters and related workers
Air traffic controllers	Civil engineering technicians
Electronics fitters	General mangers in transport, storage and communications
Electronics and telecommunications engineering technicians	Film, stage and related actors and directors
Undertakers and embalmers	Paper-products machine operators
Electrical mechanics and fitters	Construction and maintenance labourers: roads, dams and similar constructions
Ships' deck crews and related workers	Builders, traditional materials

Cancer analysis

- Glioma case-control study

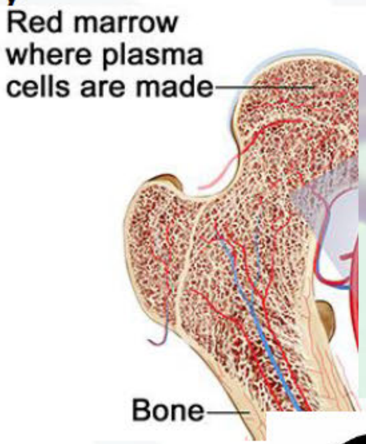
  Australian Genomics and Clinical Outcomes of Glioma (AGOG) study

- Multiple Myeloma case-control study

  Epidemiology of Multiple Myeloma in Australia (EMMA) study

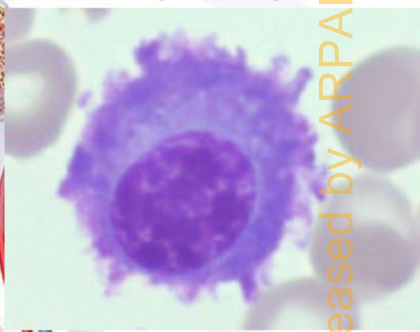
- Follicular lymphoma case-control study

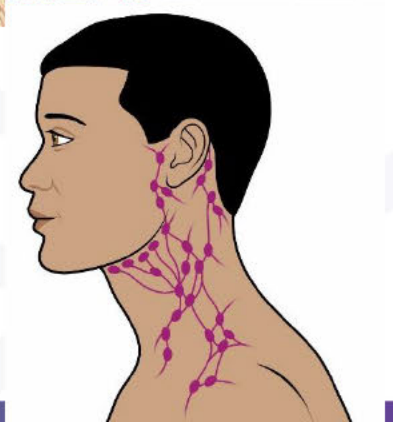
  Lymphoma, Lifestyle, Environment & Family (LEAF)



Plasma cell

Multiple Myeloma





Other studies on Occupational RF exposure and glioma

- Vila J, Turner MC, Gracia-Lavedan E, Figuerola J, Bowman JD, Kincl L, et al. Occupational exposure to high-frequency electromagnetic fields and brain tumor risk in the INTEROCC study: An individualized assessment approach. Environment international. 2018;119:353-65.
- Baldi I, Coureau G, Jaffré A, Gruber A, Ducamp S, Provost D, et al. Occupational and residential exposure to electromagnetic fields and risk of brain tumors in adults: a case–control study in Gironde, France. International journal of cancer. 2011;129(6):1477-84
- Karipidis KK, Benke G, Sim MR, Kauppinen T, Giles G. Occupational exposure to ionizing and non-ionizing radiation and risk of glioma. Occupational Medicine. 2007;57(7):518-24.
- Berg G, Spallek J, Schüz J, Schlehofer B, Böhler E, Schlaefer K, et al. Occupational exposure to radio frequency/microwave radiation and the risk of brain tumors: Interphone Study Group, Germany. American journal of epidemiology. 2006;164(6):538-48.

Calibration of an RF-EMF Exposimeter and Application to Historical Exposure

Chhavi Raj Bhatt*, s 22(1)(a)(ii) [redacted] Stuart Henderson, Don Wijayasinghe, Sarah Loughran

Australian Radiation Protection and Nuclear Safety Agency, Melbourne, Australia

*Correspondence: s 22(1)(a)(ii) [redacted]@arpansa.gov.au

Introduction

- RF-EMF exposimeter devices should be routinely calibrated to achieve reliable exposure monitoring and reported exposure levels should incorporate calibration results to minimise systematic measurement bias.
- RF-EMF exposimeters can exhibit frequency-, orientation-, and angle-dependent variability; routine calibration is required to verify their accuracy and stability.[1,2]

Aim

- To derive calibration factors (CFs) for an exposimeter and apply them to assess the variability in exposure between calibration-adjusted and non-adjusted total RF-EMF exposure.

Methods

s 47E(a), s 47E(b), s 47E(d) [redacted]

Results

- The CFs varied for different frequency bands and rotational angles (Table 1).
- Of all frequencies, the lowest and highest mean values of CFs were [redacted] (800 MHz) and [redacted] (2300 MHz).
- Median total RF-EMF exposure levels with and without CF-adjustment were [redacted] V/m and [redacted] V/m, respectively (Table 2)
- [redacted] variation between CF-adjusted and non-adjusted total exposure levels were noted; [redacted] dB at median total exposure level.

Discussion and conclusion

- This study derived CFs for different frequency bands and angular rotations to enable a comparison between total RF-EMF exposure derived from CF-adjusted and non-adjusted measurement data.
- s 47E(a), s 47E(b), s 47E(d) [redacted]
- s 47E(a), s 47E(b), s 47E(d) [redacted]
- Ongoing work includes the extension of calibration measurements to mobile uplink frequency bands as well as horizonal orientation.

s 47E(a), s 47E(b), s 47E(d) [redacted]

Fig 1. An illustration of calibration set-up of an Exposimeter (left) and the device undertaking the measurement in a fully anechoic chamber (right)

Note: The device is at 0°, which is defined as the front-face normal aligned with the RF antenna boresight

	Frequency (in MHz) band-specific CFs						
Azimuthal angle (φ)	**800**	**900**	**1800**	**2100**	**2300**	**2600**	**3500**
-90°	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
-60°	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
-30°	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
0°	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
30°	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
60°	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
90°	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Mean value of CF	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 1. Summary of derived calibration factors (CFs) for mobile frequency bands at different rotational angles (vertical orientation)

	Total exposure (V/m)		
Summary	**CF unadjusted**	**CF adjusted**	**Variability (in dB)**
Minimum	[redacted]	[redacted]	[redacted]
Maximum	[redacted]	[redacted]	[redacted]
Mean	[redacted]	[redacted]	[redacted]
Standard deviation	[redacted]	[redacted]	[redacted]
Median	[redacted]	[redacted]	[redacted]
Quartile 3	[redacted]	[redacted]	[redacted]
Quartile 1	[redacted]	[redacted]	[redacted]

Table 2. A summary of reported total RF-EMF exposure (with/without CF adjustment) and variability between unadjusted and adjusted total exposure

References

1. Eeftens M, Dongus S, Bürgler A, Röösli M; ACCEDERA team. A real-world quality assessment study in six ExpoM-RF measurement devices. *Environ Res 2020*, 182, 109049.
2. Bolte JF, van der Zande G, Kamer J. Calibration and uncertainties in personal exposure measurements of radiofrequency electromagnetic fields. *Bioelectromagnetics* 2011, 32(8), 652-63.

PB-18

Document 11

Is occupational exposure to radiofrequency electromagnetic fields associated with risk of glioma or follicular lymphoma?

Mate R[1,2], Benke G[1], Loughran SP[2], Abramson MJ[1], Karipidis K[2]

[1] *School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia*

[2] *Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), Yallambie, VIC, Australia*

Introduction

Previous epidemiological studies have investigated possible associations between occupational exposure to RF EMF and a range of cancers. Although the findings to date give no consistent evidence of a causal relation between occupational RF EMF exposure and cancer, previous studies could not rule out an association and further research was warranted(1, 2). A key concern across all previous studies was the quality of the RF EMF exposure assessment(2, 3). This study aimed to improve on previous methodological shortcomings to determine if any association between occupational RF EMF exposure and numerous cancers existed.

Methods

We investigated possible associations between occupational exposure to RF EMF and glioma and follicular lymphoma in two separate Australian case-control studies. The Australian Genomics and Clinical Outcomes of Glioma (AGOG)(4) case-control study of glioma included cases aged between 18 and 85 years diagnosed between 2013-2017. There were 467 cases and 367 controls included in analysis for glioma. The Lymphoma, Lifestyle, Environment and Family (LEAF)(5) case-control study of follicular lymphoma included cases aged between 20 and 74 years diagnosed between 2011-2016. There were 727 cases and 484 controls included in analysis for follicular lymphoma.

We overcame previous methodological shortcomings by applying two newly developed job exposure matrices (JEMs), INTEROCC (6) and the Canadian JEM (CANJEM)(7) to assess occupational RF EMF exposure. We estimated the odds ratios (ORs) with 95% confidence intervals (CIs) and adjusted for sociodemographic and socioeconomic factors and the relationship between cases and controls to test the associations between lifetime cumulative exposure and with 2- 5- and 10-year lag periods. We assessed levels of exposure by dividing the cumulative lifetime exposure distribution into quartiles and using the lowest quartile as the reference group.

Results

There were no statistically significant positive associations observed between occupational RF EMF and risk of glioma when applying either JEM. For glioma, when comparing the highest to the lowest quartiles of lifetime exposure, the INTEROCC JEM showed an OR of 0.74 (95%CI: 0.47–1.15), while CANJEM showed an OR of 0.85 (95%CI: 0.54–1.32). For follicular lymphoma, using the same exposure assessment, s 47E(a), s 47E(b), s 47E(d) [redacted]

Discussion

Our analysis found no statistically significant positive associations between occupational RF EMF exposure and glioma. These results are in line with previous studies examining occupational RF EMF exposure and brain cancer, including those included in the recent World Health Organization commissioned systematic reviews(1, 2). In a previous Australian study of 414 glioma cases, Karipidis et al(8) also found no positive associations. However, that study only estimated RF EMF exposure for four occupations. Additionally, a more recent multinational study of 1,943 glioma cases by Turuban et al(9) also applying the INTEROCC RF JEM generally found no clear associations for glioma risk.

Across most of our analyses for follicular lymphoma, s 47E(a), s 47E(b), s 47E(d) [redacted] Previous case-control studies have had inconsistent results, with Zheng et al(10) and Fabbro-Peray et al(11) reporting both positive and negative associations. However, these studies only estimated exposure based on job-title. Another Australian study by Karipidis et al (2007) assessed occupational exposure to RF EMF using a Finnish JEM (12), reported no statistically significant associations between RF EMF and lymphomas. However, this study only classified 4 occupations as being exposed to RF radiation and the 95%CI varied widely. Our study was a major improvement in exposure assessment compared to these previous case-control studies and provides additional evidence that s 47E(a), s 47E(b), s 47E(d) [redacted]

Conclusion

s 47E(a), s 47E(b), s 47E(d) [redacted] Future research should focus on refining occupational RF EMF exposure assessment, including more accurately describing the most exposed occupations and exposure levels and sources over time.

References

1. Karipidis K, Baaken D, Loney T, Blettner M, Mate R, Brzozek C, et al. The effect of exposure to radiofrequency fields on cancer risk in the general and working population: A systematic review of human observational studies - Part II: Less researched outcomes. Environ Int. 2025;196:109274.
2. Karipidis K, Baaken D, Loney T, Blettner M, Brzozek C, Elwood M, et al. The effect of exposure to radiofrequency fields on cancer risk in the general and working population: A systematic review of human observational studies–Part I: Most researched outcomes. Environ Int. 2024:108983.
3. International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz). Health physics. 2020;118(5):483-524.
4. AGOG project team. (AGOG) Australian Genomics and Clinical Outcomes of Glioma: University of New South Wales; 2013
5. Odutola MK, van Leeuwen MT, Bruinsma FJ, Benke G, Turner MC, Trotman J, et al. Occupational exposure to extremely low-frequency magnetic fields and follicular lymphoma risk: a family case-control study. Occup Environ Med. 2023;80(10):599-602.
6. Migault L, Bowman JD, Kromhout H, Figuerola J, Baldi I, Bouvier G, et al. Development of a job-exposure matrix for assessment of occupational exposure to high-frequency electromagnetic fields (3 kHz–300 GHz). Ann Work Expo Health. 2019;63(9):1013-28.
7. Siemiatycki J, Lavoué J. Availability of a new job-exposure matrix (CANJEM) for epidemiologic and occupational medicine purposes. J Occup Environ Med. 2018;60(7):e324-e8.
8. Karipidis KK, Benke G, Sim MR, Kauppinen T, Giles G. Occupational exposure to ionizing and non-ionizing radiation and risk of glioma. Occupational Medicine. 2007;57(7):518-24.
9. Turuban M, Kromhout H, Vila J, Vallbona-Vistós M, De Vocht F, Baldi I, et al. Occupational exposure to radiofrequency electromagnetic fields and brain tumor risk: Application of the INTEROCC job-exposure matrix. Int J Cancer. 2024.
10. Zheng T, Blair A, Zhang Y, Weisenburger DD, Zahm SH. Occupation and risk of non-Hodgkin’s lymphoma and chronic lymphocytic leukemia. Journal of Occupational and Environmental Medicine. 2002;44(5):469-74.
11. Fabbro-Peray P, Daures J-P, Rossi J-F. Environmental risk factors for non-Hodgkin's lymphoma: a population-based case–control study in Languedoc-Roussillon, France. Cancer Causes & Control. 2001;12(3):201-12.

12. Karipidis KK, Benke G, Sim MR, Kauppinen T, Kricker A, Hughes AM, et al. Occupational exposure to ionizing and non-ionizing radiation and risk of non-Hodgkin lymphoma. Int Arch Occup Environ Health. 2007;80:663-70.

Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

Public communications: ARPANSA's Talk to a Scientist (TTAS) program

Rohan Mate
ARPANSA

Talk to a Scientist - TTAS

- ARPANSA provides a unique opportunity for the community to talk directly with our scientists on issues about radiation exposure and protection in Australia
- Phones are open for 1.5 hours on Tuesdays and Thursdays
  - 11 am – 12:30pm AEST
- E-mail enquiries and social media are responded to

Talk to a Scientist - TTAS

- Made up of around 12 ARPANSA scientists
  - Managing about 600-900 enquiries per year

Talk to a Scientist - TTAS

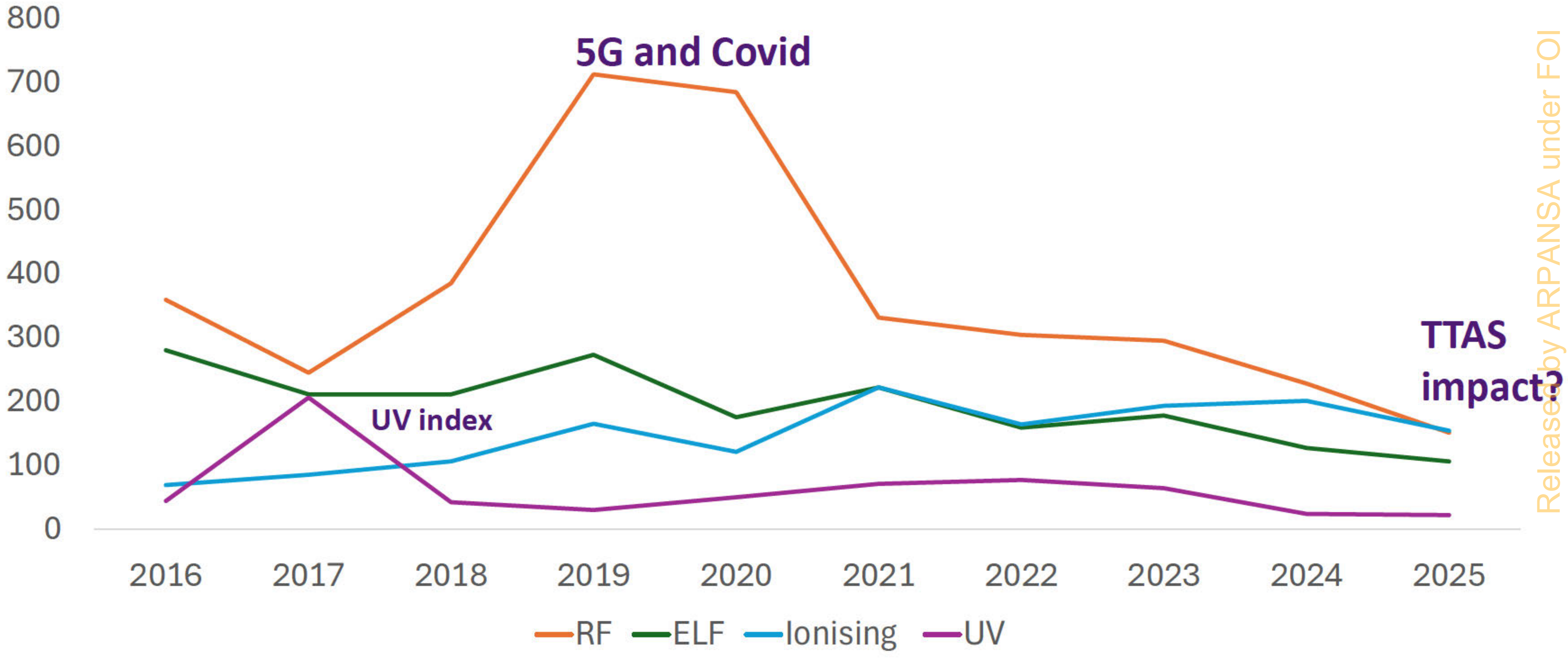
Problems

Technical

Clarification

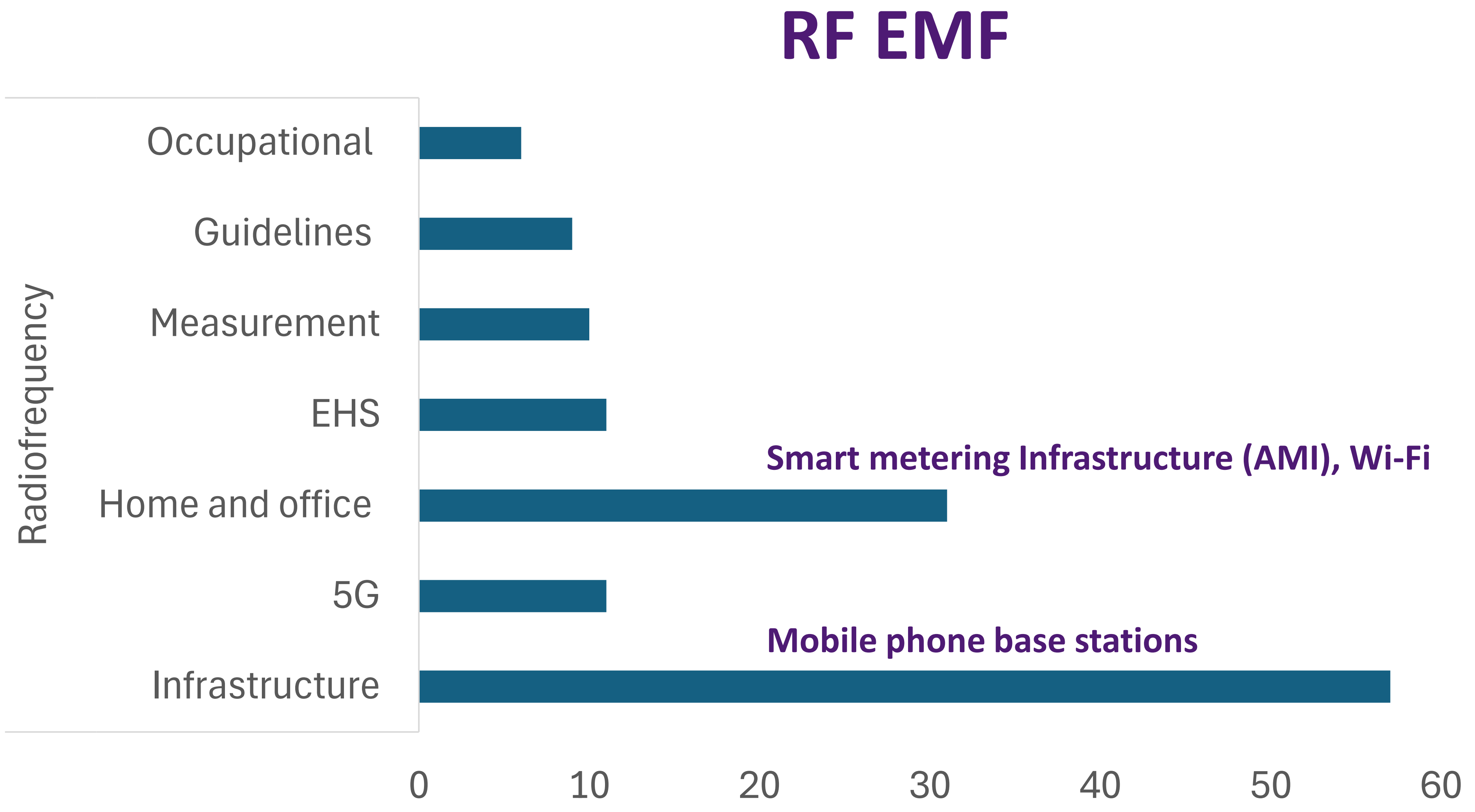
Am I safe?

TTAS – Statistics

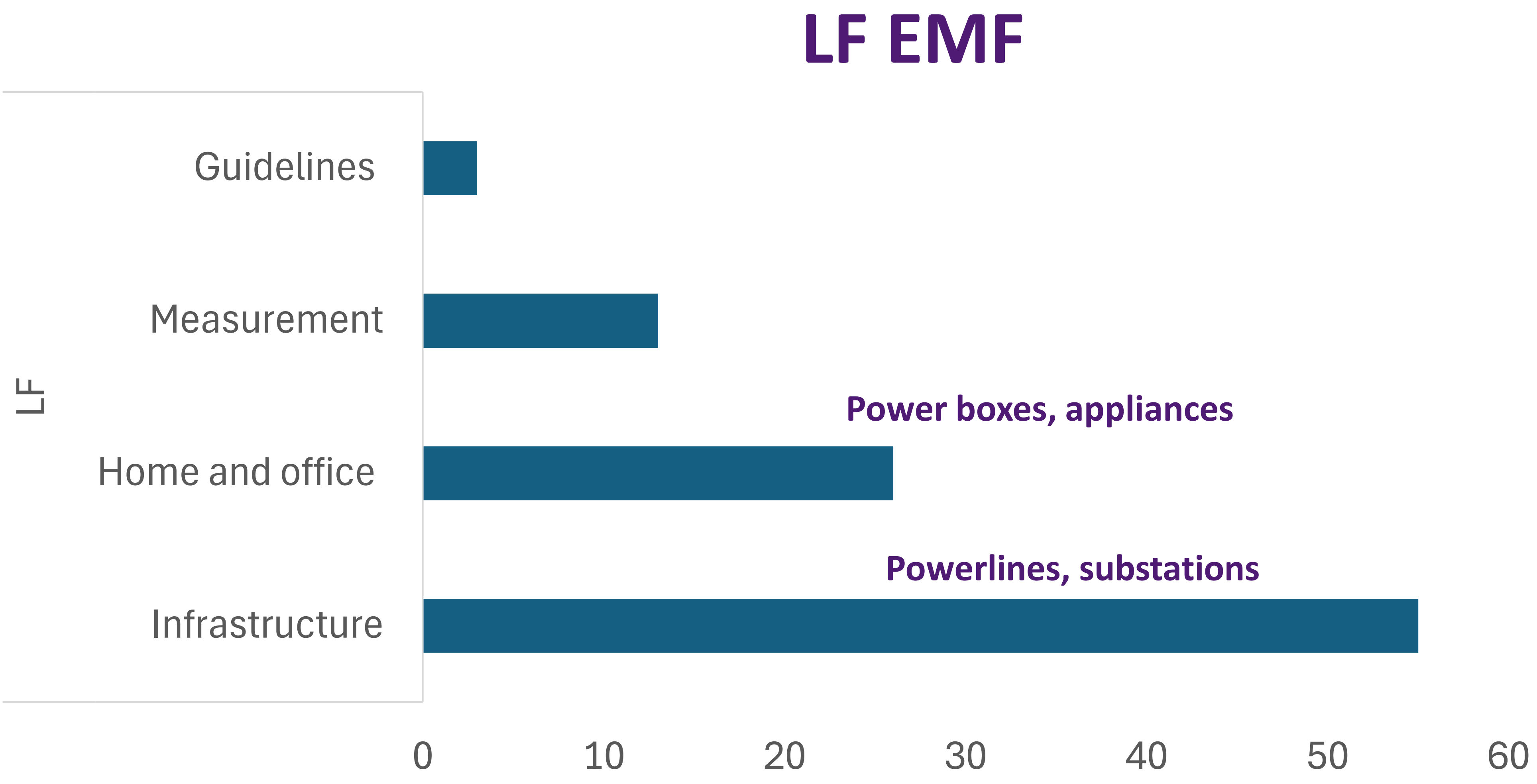


Cancer Council WA | SunSmart

Questions from 2025



Questions from 2025



"How can I protect myself from the radiation coming from the wiring in my home"

"My partner and I are looking at buying a house near powerlines, but we have children, and we have heard it causes childhood leukemia, should we buy this house?"

Low frequency fields

Exposure guidelines (ICNIRP)

Public: 2000 mG, 200 µT

Directly under powerlines:
~ 50 mG

Background levels at 50 meters aways:
1 – 10 mG

No substantiated evidence

Exposure reduces dramatically with distance

EME blockers

NO

Meter hire

Magnetic field meter

Radon meter

Ionising meter

UV meter

“I just saw a Facebook post about the dangers of smart meters and Wi-Fi and I feel like it’s killing me.”

Standard

- Radiation Protection Series ***RPS S-1***

Exposure Limit

- 2 to 10 W/m^2

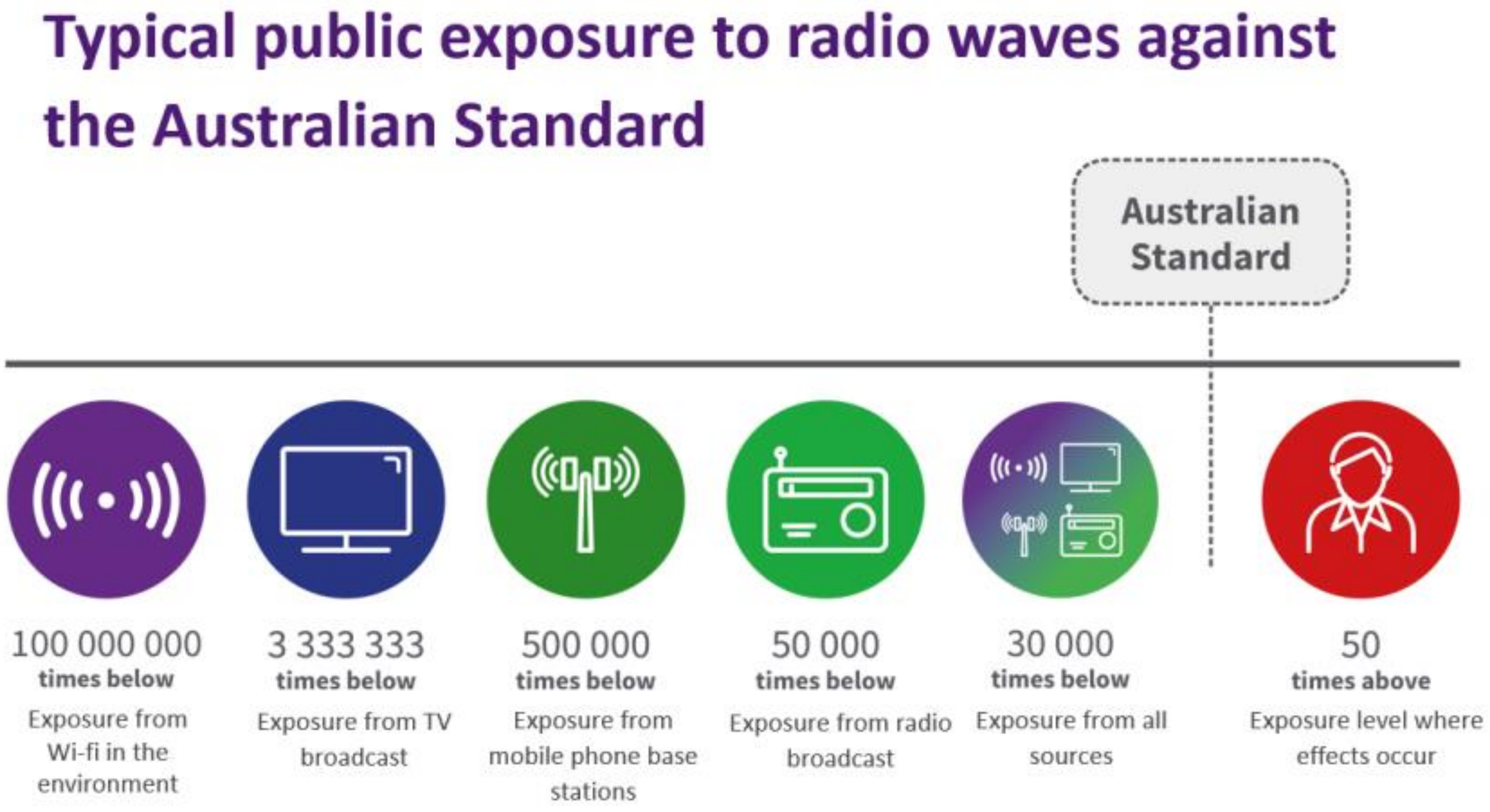
Low power

- Exposed to less than 1% of the standard
- Equivalent to a car key fob

Short time transmitting

- Once every 3 hrs

“I just saw a Facebook post about the dangers of smart meters and Wi-Fi and I feel like it’s killing me.”



Complex and emotionally charged questions

Mobile Base Stations

“Since the towers have been installed, I have been experiencing serious health issues, including weakness, fatigue, confusion, constant tingling in my face and arms, and a burning sensation on my skin. These symptoms have become severe enough that I have had to travel to Melbourne to get away.

I have lived in this apartment for many years without any of these issues, and I have always been fine until the installation of the towers. The timing of these symptoms is deeply concerning to me.

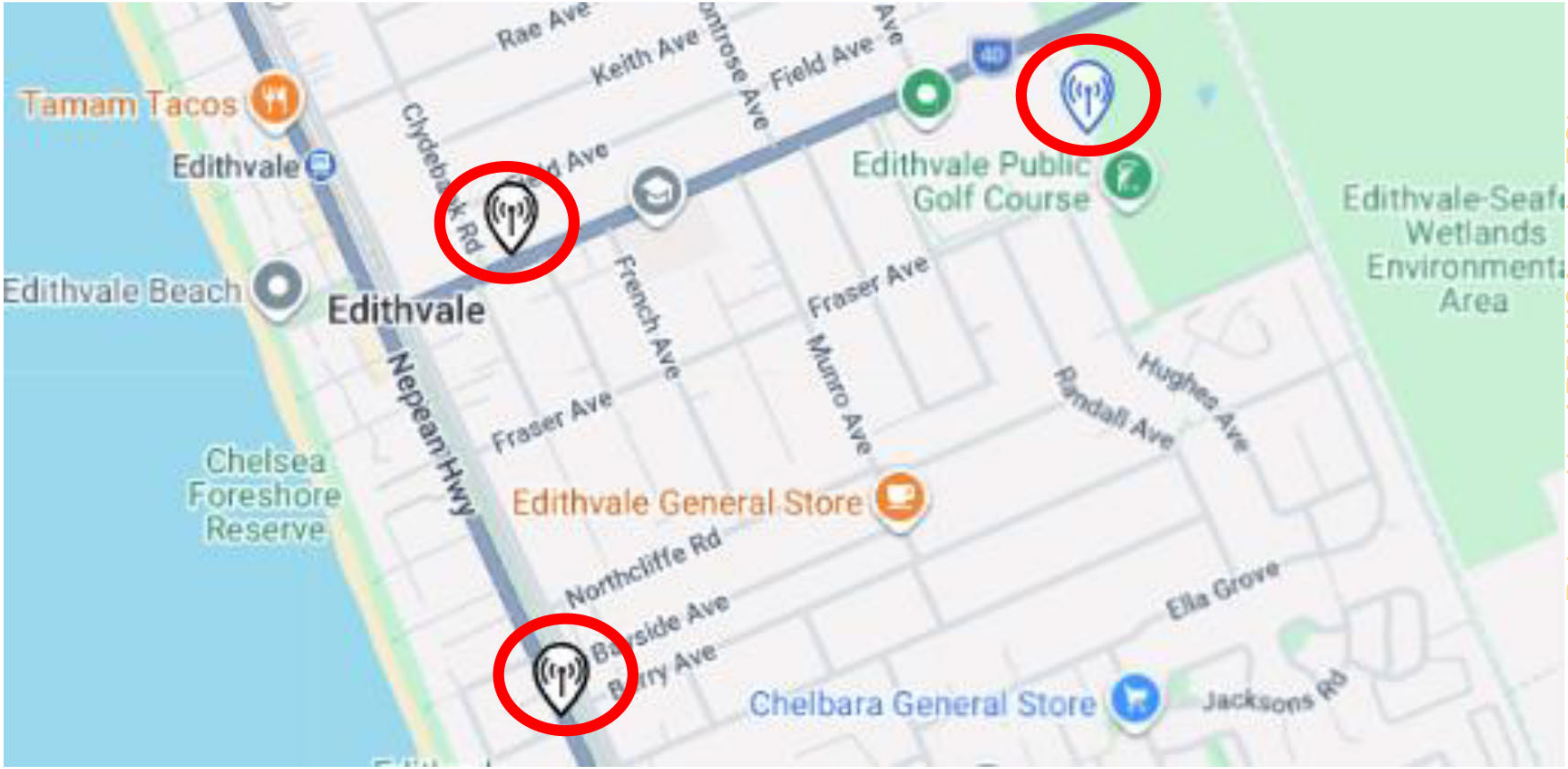
My daughter has measured the radiation levels in my apartment using an ENV RD-10 Electromagnetic Field Meter, and the readings indicate high levels (in the red zone)

Please help me!”

Complex and emotionally charged questions

1. Empathy – Acknowledgment of symptoms or issue
2. Authority – Reference ARPANSA, WHO, ICNIRP
3. Evidence – Present scientific information
4. Reassurance – No evidence of harm below limits
5. Alternatives – Validate symptoms but not the cause
6. Action – Consult GP

Mobile Phone Base Stations



Mobile Phone Base Stations

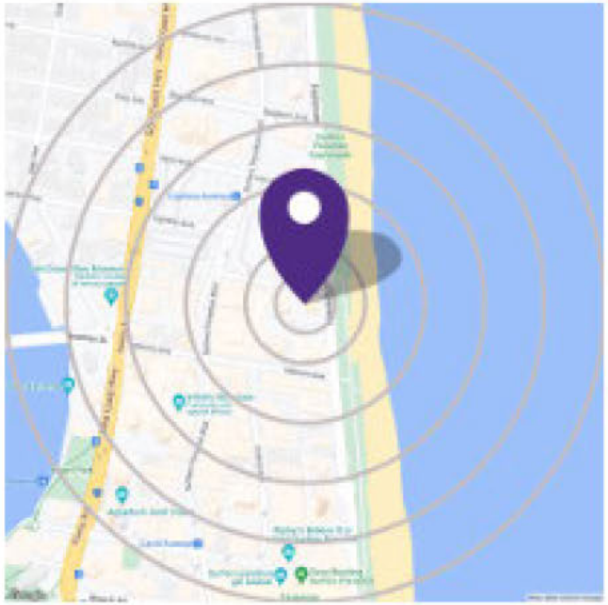
A snapshot of calculated EME levels at this site

There are currently no existing radio systems for this site.

The maximum EME level calculated for the **proposed** changes at this site is

1.32%

out of 100% of the public exposure limit, 248 m from the location.



EME levels with the proposed changes	
Distance from the site	**Percentage of the public exposure limit**
0-50 m	0.08%
50-100 m	0.15%
100-200 m	0.77%
200-300 m	1.32%
300-400 m	0.89%
400-500 m	0.24%

Challenges by worried enquirers

- Dr. Google or Dr. AI
- 10 W/m2 is wrong!
  - Should be 0.7 W/m2
- Other countries
  - Banning additional towers
  - Banning 5G
  - Pulling down existing towers
- Don’t acknowledge WHO and other international authorities we quote

“But it’s what the AI said, why are you saying the it’s wrong?”

Challenges: Artificial intelligence

Language models

- Improved spelling and grammar
- Greatly increased the size of some emails
- Waffle and slop

Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

Thank you

Rohan Mate

ARPANSANews

ARPANSAGovernment

ARPANSA

ARPANSA

Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

Executive Group meeting

EME Program

Title: EME Program review and proposed changes

Date: 14 October 2025

Item no: x.x

Purpose:

For **noting** of the review of the EME program contained in this paper and previous EG Papers and for **approval** of the recommendations to change the EME Program.

Issue

The EME Program Action Plan concluded at the end of 2024. At the 4 February and 11 June EG meetings, the EG considered proposed changes to the EME Program.

s 47C [redacted] and structure change was notionally approved pending the review of further information requested by the EG on the proposed structure of the EME Program, other proposed structures of the section, and further information on the roles in the section. The priorities of the EME program and the risks to the delivery of the EME program in the form of a SWOT analysis were presented in the previous two papers (attached).

Background

See February and June EG Papers attached for previous background information.

Attachment 1 considers the different strengths, weaknesses, opportunities and threats for several different section structure options. While all options are viable, the best option that provides support and success for both research and services is Option 2.

In selecting Option 2, ARPANSA will be able to focus on high priority research, while developing expertise and supporting the growth and progress of translational EME and health research, particularly research that focuses on anechoic chamber research and dosimetry. s 22(1)(a)(ii) [redacted]

Attachments 2 and 3 provide further information on the proposed structure of the RRAS section (aligned with Option 2), summaries of the roles within RRAS, and an overview of the budget.

Recommendation 1: Agree to proceed with Option 2, s 47C [redacted] and RRAS and RPS remain separate sections, with a commitment for both sections to work more closely together to balance the need for both research and service provision.

Resource Allocation

s 47E(c) [redacted]

Research Review

See June EG Paper attached.

Engagement

See June EG Paper attached.

Communication

See June EG Paper attached.

New EME Program Action Plan

See June EG Paper attached.

Sensitivity

s 47C [redacted]

Legislation

None

Financial implications

None – no further funding requested, just a change in how the current funds are allocated.

Risk analysis

Noted within this paper.

Timing/handling:

As soon as possible to allow use of current financial years research framework funding.

Communication

Consultation

s 22(1)(a)(ii) [redacted]

Communication activities

None

Recommendations

That the EG **APPROVE**:

Recommendation no.	Recommendation	Chair comments
R1:	Agree to proceed with Option 2, s 47C [redacted] and RRAS and RPS remain separate sections, with a commitment for both sections to work more closely together to balance the need for both research and service provision.	

Contact

Author details	Clearance branch or office head details:
Name: Rick Tinker and Sarah Loughran	Name: Rick Tinker
Position: Branch Head and Chief Radiation Health Scientist, Director Radiation Research and Advice	Position: Branch Head and Chief Radiation Health Scientist
Branch/office: Radiation Health Services	Branch/office: Radiation Health Services

Attachment 1: Proposed Structures SWOT Analysis

SWOT Options

The scope of the SWOT analysis was to consider Strengths, Weaknesses, Opportunities and Threats for the different structure options for RRAS.

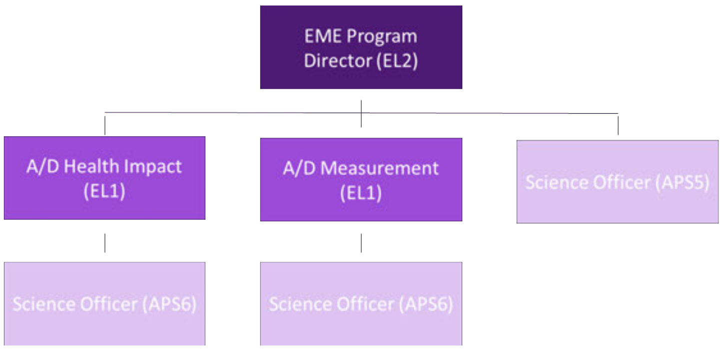
- **(1) RRAS** – Maintain similar structure, s 47C [redacted]
- **(2) RRAS plus research commitment** – Maintain similar structure, s 47C [redacted], as well as a commitment from both RRAS and RPS sections to actively explore and pursue research opportunities, particularly those that involve the use of the anechoic chamber.
- **(3) RRAS plus RFC** – For RFC to move from the RPS section and sit within RRAS.
- **(4) RRAS plus RFC and UV Services** – For RFC and UV Services to move from the RPS section and sit within RRAS.

Option	Strengths	Weakness	Opportunities	Threats
(1) **RRAS**	s 22(1)(a)(ii) [redacted]	s 22(1)(a)(ii) [redacted]	EME to work more closely with RPS.	Potentially less opportunity for research.
(2) **RRAS plus research commitment**	Provides more opportunity for research. s 22(1)(a)(ii) [redacted]	Requires commitment to balance services and research.	EME to work more closely with RPS. Expand on RF EME dosimetry research and expertise, and use of the anechoic chamber.	Surges in service or research needs.
(3) **RRAS plus RFC**	All EME (both services and research) sit together.	s 22(1)(a)(ii) [redacted]	Expand on RF EME dosimetry research and expertise.	s 22(1)(a)(ii) [redacted] Dual focus on research and service performance – potential competing priorities. Lack of funding to support research and development. s 22(1)(a)(ii) [redacted]

Option	Strengths	Weakness	Opportunities	Threats
		s 22(1)(a)(ii) [redacted]		s 22(1)(a)(ii) [redacted]
(4) **RRAS plus RFC and UV Services**	s 22(1)(a)(ii) [redacted] Having all NIR together in one section.	EME team would expand significantly (7 FTE). s 22(1)(a)(ii) [redacted] [redacted]	Expand on RF EME dosimetry research and expertise. s 22(1)(a)(ii) [redacted] Opportunities for staff development in research.	s 22(1)(a)(ii) [redacted] [redacted] Dual focus on research and service performance - potential competing priorities. Lack of funding to support research and development. s 22(1)(a)(ii) [redacted]

Attachment 2: RRAS current and proposed structure and position summaries

EME Program Current Structure



EME Program Proposed New Structure

s 47C [redacted]

EME Program Position Summaries

s 47C [redacted]

EL2: Director RRAS

- Provide strategic and operational leadership for the effective and efficient management of the section, with due regard to established consultative mechanisms.
- Manage the delivery of outcomes related to non-ionising and as required ionising radiation and health, including relevant deliverables of the EME program, including commissioning targeted research and collaborating with established research centres to address research needs and areas of public concern.
- Represent ARPANSA at key conferences and meetings, nationally and internationally and negotiate and liaise with external stakeholders in relation to non-ionising radiation and health.

- Provide high-level strategic advice with regard to non-ionising radiation and health and engage with related Government policy departments for the effective delivery of the EME Program.
- Manage any potential risks including meeting expectations on the delivery of EME Program outcomes, maintaining ARPANSA's independence and addressing potential conflicts of interest.

EL1: Assistant Director, Health Impact Assessment:

- Leads the Health Impact Assessment team including providing direction and mentoring of staff and supporting the goals of the RRAS section, the EME Program and ARPANSA overall.
- Leads research programs on radiation and health including the conduct and review of scientific studies, collaboration with universities and research centres and the supervision of PhD projects.
- Participates in national and international authorities on radiation protection such as ICNIRP (Vice-Chair), ICOH, VICRAC and others.
- Leads radiation protection programs such as the development and maintenance of radiation standards and information programs such as TTAS and the Radiation Literature Survey.

EL1: Assistant Director EMR & UVR Exposure Assessment

- Lead and undertake the EME exposure measurement program to assess EME exposure levels in various settings. This includes devising, testing and implementing measurement protocols for assessing environmental RF EME levels in the home, in the workplace, and in the wider community and mentoring of staff and supporting the goals of the RRAS section, the EME Program and ARPANSA overall.
- Collaborate with industry and other agencies to refine RF measurement techniques for existing and future services.
- Participates in national and international authorities on radiation protection such as Standards Australia and the WHO collaborating centre on optical radiation.
- Providing information on EME exposure and measurement to key stakeholders and the public, including via peer-reviewed publications and ARPANSA website.

s 47C [redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

APS6: Science Officer (Health Impact)

- Conduct and critically evaluate scientific research on the health effects of radiation exposure.
- Manage and participate in radiation protection programs such as Talk To A Scientist, radiation protection standards, and the radiation literature surveys.
- Participate in global expert bodies including ICNIRP and WHO to help shape international radiation protection guidelines.
- Work with external researchers, industry partners, and community groups to support evidence-based decision-making and public engagement.

APS6: Science Officer (Measurement)

- Responsible for undertaking ARPANSA's electromagnetic energy (EME) exposure monitoring, conducting research and providing advice on radiation and health.
- Contributing to health risk assessment and representing ARPANSA in Standards Australia technical committee: TE-007 Human Exposure to Electromagnetic Fields.
- Participate in radiation protection programs such as Talk To A Scientist and the radiation literature surveys.
- Work with external researchers, industry partners, and community groups to support evidence-based decision-making and public engagement.

APS5: Science Officer s 47C [redacted]

- Conduct and critically evaluate scientific research on the health effects of radiation exposure.
- Participate in radiation protection programs such as Talk To A Scientist and the radiation literature surveys.
- Provide technical advice and miscellaneous scientific services to key stakeholders and other public health agencies in Australia.
- Participate in global expert bodies including ICNIRP and WHO to help shape international radiation protection guidelines.
- Work with external researchers, industry partners, and community groups to support evidence-based decision-making and public engagement.
- Supports other work in the section by collecting RF exposure measurements and developing programmatic solutions to research problems.

Attachment 3: Current Budget Summary

s 47C [redacted]

Item	Amount	Description
Measurement Program	$30K	This includes costs associated with performing measurements (e.g. domestic travel), software, freight, laboratory supplies, and equipment maintenance.
Communication and Engagement	$150k	This includes costs associated with staff training and development, conference attendance, domestic and international travel, publication costs, and promotional activities.
Research Program	$430K	Currently split between funds for external research ($350k*) and ARPANSA internal research (PhD stipends and other related research costs - $80K).

s 47C [redacted]