RADIO FREQUENCY EXPOSURE RISK ASSESSMENT AND COMMUNICATION: CRITIQUE OF ARPANSA TR-164 REPORT. DO WE HAVE A PROBLEM?

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ABSTRACT

ARPANSA's Technical Report Series No. 164 (TRS-164) was written by a panel of three external academics and three ARPANSA support staff. The panel's main task was to assess the available peer-reviewed scientific literature on radiofrequency electromagnetic radiation (RF-EMR) in order to determine whether the current RPS3 thermally-based standard (modelled on the ICNIRP 1998 Guidelines) was still relevant and appropriate for providing the general public with a high level of protection. The TRS-164 report considered 12 years of accumulated scientific research along with the May 2011 announcement by the International Agency for Research on Cancer (IARC), that RF-EMF is a Group 2B "possible" carcinogen. The conclusion of the TR-164 report is highly supportive of the original ICNIRP exposure guidelines and corresponding reference limits.

In order to evaluate the TRS-164 report, the current authors obtained from ARPANSA all the studies in the ARPANSA database that would have been available to the scientific panel when producing the TRS-164 report, which covered the specific period from January 2000 to August 2012. Although 1,354 studies were available in ARPANSA's database, it is apparent that only a fraction were actually used in the ***in vivo***/***in vitro*** assessment. The aforementioned 1,354 studies can be individually selected from more than 2,400 studies comprising the Oceania Radiofrequency Scientific Advisory Association Inc. (ORSAA) Electromagnetic Radiation (EMR) bio-effects database.

This paper demonstrates that thermal limits as advised by ARPANSA and ICNIRP may not afford suitable protection against a range of biological effects associated with RF exposure at athermal levels. When ICNIRP first established their original guidelines almost 20 years ago, it may have been true that there was insufficient evidence for biological damage likely to result in disease in vulnerable people. That situation has now clearly changed. Even ICNIRP has admitted in the past that their guidelines may not provide adequate protection to the more sensitive individuals within the population [8]. While cancer, neurological degeneration or other disease outcomes may not currently (or in the immediate future) be conclusively linked to oxidative stress which has resulted specifically from permitted microwave exposures, there is now enough medical research evidence to suggests that the oxidative stress pathway can lead to disease. When considered with the large body of research showing that exposure to microwaves (at or below basic restrictions) can produce oxidative stress, there is sufficient evidence to require that the RPS3 revision currently underway to seek to minimise biological effects from environmental exposures and to provide warnings to achieve this when using personal devices.

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KEY WORDS

Electromagnetic Radiation, EMR, EME, EMF, RF, Microwaves, Wi-Fi, Mobile phones, Health, Cancer.

INTRODUCTION

This paper is an independent assessment of the RF literature found within the ARPANSA database.

ARPANSA's TRS-164 was the outcome of a review performed by a three-member external expert panel supported by ARPANSA staff to assess whether Australia's almost two-decade old RF standard, which focuses on providing protection against known harmful thermal effects, is still relevant in light of research findings since the RF standard was originally published.

ARPANSA states in TRS-164 [1]: "The RF literature database assembled by ARPANSA includes 1354 studies with health/biological outcomes from January 2000 till August 2012 (298 epidemiological, 238 human/provocation, 453 *in vivo* and 365 *in vitro*). The database also includes 72 major reviews or specialist reviews on *in vivo*/ *in vitro* research published during that period."

ORSAA obtained a copy of the ARPANSA RF literature referred to in TRS-164 and classified these papers into effect categories as defined within the ORSAA database [2]. The ORSAA database design is shown in Table 1 below.

In the allotted study period, a number of additional peer review papers (>100) were also available but were not part of the ARPANSA titles provided to ORSAA.

The following selection criteria for adding peer-reviewed scientific papers to the ORSAA database was applied:

- All ARPANSA papers for the period 01/01/2000 to 31/08/2012
- All ARPANSA monthly surveys of the literature with reviews after January 2008
- All scientific studies in the following categories that had appeared in a peer-reviewed journal:
    - *in vivo* experiments
    - *in vitro* experiments
    - dosimetry experiments
    - epidemiological studies
    - human provocation experiments

- Non-English papers with an abstract in English, published in peer-reviewed national journals in the country of origin

Result	Selection Criteria	Comment
Effect	A significant change of status occurred	Bio-effects observed are categorised.
No Effect	No significant change in status occurred	
Uncertain Effect	Defined outcomes are not clearly reported or are unsure and conclusions are qualified	ORSAA had these papers assessed by a number of independent reviewers to ensure correct classification
Non-Experimental Supporting Study (NESS)	These articles, although of general interest, have no experimentally derived data (e.g. reviews, standards documents or measurement studies or supporting information of national disease statistics)	Review papers were published in a peer-reviewed journal and other reviewed reports (mainly government) were the result of internal reviews.

Table 1
Simple Classification of Peer-Reviewed Paper Outcomes

- Excluded were microwave ablation procedures used in medical applications
- All review articles, government EMR summary reports, guideline material, measurement surveys; government-issued disease statistical reports and brochures, which cited summarised opinions, were classified as Non-Experimental Supporting Studies (NESS).

There are now in excess of 2400 studies in the ORSAA database, including both *in vitro* and *in vivo* studies. A significantly greater number of these studies show biological effects compared to those that do not show statistically significant biological effects. This finding raises serious questions about the accuracy and validity of ARPANSA's TRS-164 analysis, which suggests that the ratio between studies showing effects and studies showing no effects is almost even (see Tables 2 and 3 below).

IN VITRO STUDIES

Table 2 below shows that there is a discrepancy between the TR-164 *in vitro* assessment and the ORSAA review of the ARPANSA database. In Table 2 below, the column entitled 'Y(TR-164)' details the number of studies that found statistically significant biological effects as reported by ARPANSA, while the column entitled 'Y(ORSAA/ARPANSA DB)' shows the

Topic	Y (TR-164)	Y (ORSAA/ARPANSA DB)	N (TR-164)	N (ORSAA/ARPANSA DB)
Genotoxic	16	34 (+9 Synergistic Effect with mutagen and +1 Effect DNA Repair)	32	39 (+2 Effect Positive)
Proliferation/Apoptosis	25	Apoptosis 26 Proliferation 33 (+1 Uncertain) Combined 59 (+1 Uncertain)	30	Apoptosis 22 (+1 Effect Positive) Proliferation 35 Combined 57 (+1 Effect Positive)
Gene Expression	4	61 (+6 Uncertain Effect)	10	14
Stress Response/Heat Shock Proteins (HSP)	4	28 (3 at Thermal Levels) (+1 Uncertain Effect)	17	19
Intracellular Signalling	1	10 (+1 Uncertain Effect – synergistic with potassium-induced depolarization)	3	2
Membrane Effects	17	27	4	4 (+1 Effect Positive)
Direct Effects on Proteins	15	77 (+5 Uncertain Effects)	1	3
Oxidative Stress	N/S	17	N/S	11
Totals	82	313	97	149

Table 2
Summary of *in vitro* studies

Table definitions:
"Y" in column heading represents a statistically significant biological effect finding
"N" in column heading represents no significant effect finding
"N/S" represents "not specified"

Yellow text under the heading of "Topic" represents divergent findings between the ARPANSA database and TRS-164 findings either in terms of ratio of "effect" vs "no effect" or a topic is of importance but was not covered in any detail in the TR-164 review.

TR-164 *Effect 46% vs No Effect 54% of in vitro papers*
ORSAA *Effect 68% vs No Effect 32% of in vitro papers*

Topic	Y (TR-164)	Y (ORSAA/ARPANSA DB)	N (TR-164)	N (ORSAA/ARPANSA DB)
Cell Physiology, Injury, Apoptosis	21	72 (+1 Uncertain Effect)	17	16 (+2 Effect Positive)
Neurotransmitters	1	10	1	1
Brain Electrical Activity	3	13	2	2
Blood Brain Barrier and Micro Circulation	4	10	8	15
Endocrine System	3	27	5	7
Autonomic Function	0	2 (+1 Uncertain Effect)	2	0
Spatial Memory	7	15	4	10
General learning	4	13 (+1 Effect Thermal Effects)	5	9
Auditory Function	4	4 (+1 Uncertain Effect)	7	8
Genotoxicity and Mutagenesis	8	34	10	20 (+1 Positive Effect - γ-Radiation)
Immune system and Haematological Effects	5	37 (+2 Uncertain Effect) (+13 Positive Effect)	3	16
Testicular Function	8	25 (+1 Uncertain Effect)	5	4 (+1 Positive Effect)
Pregnancy and Foetal Development	9	17 (+2 Uncertain Effect)	10	23

Table 3
***In vivo* Studies**

Table definitions:
"Y" in column heading represents a statistically significant biological effect finding
"N" in column heading represents no significant effect finding
"N/S" represents "not specified"

Yellow text under the heading of "Topic" represents divergent findings between the ARPANSA database and TRS-164 findings either in terms of ratio of "effect" vs "no effect" or a topic is of importance but was not covered in any detail in the TR-164 review.

Orange text under the heading of "Topic" represents both divergent findings between the ARPANSA database and TRS-164 as well as suggesting these topics may have a role to play in the development of human diseases.

TR-164 Effect 49% vs No Effect 51% of in-vivo papers
ORSAA Effect 74% vs No Effect 26% of in-vivo papers

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corresponding number of effect studies found in ARPANSA's own database (directly imported into the ORSAA database). Similarly, the next two columns give the number of ARPANSA and ORSAA database reports of no-effects papers in each category. It is clear from the assessment of the ARPANSA database that TR-164 has significantly under reported the number of papers that showed bio-effects while reporting almost all the papers that had found no effect outcomes.

IN VIVO STUDIES

The *in vivo* studies in both the ORSAA and ARPANSA databases are predominantly animal studies, along with a very limited number of human studies, such as EEG or ECG monitoring of human female volunteers (foetal and neonatal exposure) with some blood or saliva testing from provocation studies.

Table 3 clearly demonstrates that the ARPANSA

database actually contains predominantly more "Effect" studies than "No Effect" studies, contrary to the statements made by ARPANSA in the TRS-164 report.

Both Table 2 and Table 3 show marked discrepancies between the TRS-164 report by ARPANSA and the reports generated from the ORSAA database, in terms of the number of studies that have shown effects vs no-effects. The primary reason for these surprising, yet clear differences is most likely due to the review methodology limitations that were applied by ARPANSA [1], as stated below.

Summaries on the epidemiological and human/provocation research were prepared by ARPANSA staff in order to assist experts in the panel representing these particular areas of research. Due to the wide range of specialised research topics found within the published in vivo and in vitro research, ARPANSA staff did not prepare similar summaries. Instead, ARPANSA collected in vivo/in vitro summaries prepared for health authorities or for peer-reviewed journals by expert individuals or groups of scientists and made these available to the academic experts in the panel.

It appears that the expert reviewer was not requested to use the ARPANSA literature database but instead has simply reproduced the findings obtained from the UK Health Department Report of the independent Advisory Group on Non-Ionising Radiation (AGNIR) [3]. That is, the author of the TRS-164 *in vitro/in vivo* review section has essentially relied upon the AGNIR report to develop the content and conclusions. The TRS-164 report has therefore inherited all the flaws and deficiencies identified in Dr Sarah Starkey's peer-reviewed critique of the AGNIR report[4]. Some of the flaws identified by Dr Starkey include:

- ***Scientific inaccuracy*** – conclusions did not accurately reflect the evidence (which is supported by the data in the tables above).
- ***Studies omitted, included in other sections but without any conclusions, or conclusions left out*** – For example, as the tables above reveal, oxidative stress was not given adequate coverage, while fertility effects, cognitive function and behavioural effects were all misrepresented.
- ***Evidence dismissed and ignored in conclusions***. These deficiencies are also observed in TRS-164.

SUMMARY *IN VITRO* AND *IN VIVO* FINDINGS

ORSAA's review of the ARPANSA database indicates that the majority of studies show biological effects, with potential undesirable health consequences, compared to the number of studies resulting in "No effect". These findings have implications for ARPANSA's position on the current safety standard for RF-EMF exposure. There are a large number of biological effect EMF studies that show cellular stress responses at exposure levels well below the current thermal based RF standard. A summary of biological effect findings (created using an ORSAA export reporting function) is shown in Figure 1 below.

Oxidative stress is strongly linked to RF exposure and can potentially lead to a toxic state as a result of accumulated damage to cellular macromolecules such as DNA, RNA, protein and lipids. Oxidative stress is well established to play a role in the development of various chronic diseases such as cancer and neurodegenerative diseases.

PROVOCATION STUDIES

Using the ORSAA database and selecting only those studies in the frequency band UHF (300MHz-3GHz), see the automated report, produces results as shown in Table 4 below. Again, it appears that none of the ARPANSA assembled RF literature was used; rather the TRS-164 provocation study review has relied heavily on the reviews from UK AGNIR report, the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) [5] and ICNIRP reviews. In TRS-164, the important finding showing cortical excitability was deemed to be unimportant because it was not known as to whether it might be related to any potential health problems. This conclusion is surprising given that EEG effects provide direct evidence of RF impacting the brain [7]. The consequences of such interactions are not fully known, especially in situations where exposure is maintained continuously over a long period of time. Therefore, a conclusion such as 'there are early indications of effects of EMR on cortical activity' would be preferable since this is the standard phrasing used in scientific papers in similar situations.

Finally, with regard to the EHS "effect" studies in the ORSAA database (see Table 4), not all studies have used subjective symptoms as an end point;

Figure 1
Summary of biological effect end points

Topic	Y (TR-164)	Y (ORSA)	N (TR-164)	N (ORSAA)
All Studies		132 (+25 Uncertain Effect)		87
ARPANSA Studies available for TRS-164	Not Stated	126 (+26 Uncertain Effect)	Not Stated	85
EEG Studies		78 (+5 Uncertain Effect)		7
EHS Studies		24 (+5 Uncertain Effect)		18

Table 4
Summary of Provocation Studies

therefore, care needs to be taken when interpreting this result.

EPIDEMIOLOGICAL STUDIES

This paper does not cover the epidemiological studies in TRS-164 because this issue was discussed previously at the 2016 ARPS conference [2].

RESEARCH FUNDING – A SOURCE OF BIAS?

The ORSAA database provides funding source(s) information when this has been explicitly stated in the disclosure section of a given research paper. Unless the paper specifically refers to the funding source, it cannot be assumed that the institution or department where the research is conducted has provided the funds.

Approximately one third of all experimental studies in the ORSAA database do not declare funding sources. Funding sources are classified in the ORSAA database into the following major categories:

1. Government;
2. Private;
3. Public Not-for Profit;
4. Industry;
5. Institutional;
6. United Nations (WHO);
7. Not known.

The ORSAA database captures the specific funder(s) in a free text field. It should be noted that funding could be disbursed from multiple sources. Figure 2 shows a summary of funding for all experimental type studies (i.e. non NESS) in the ORSAA database.

Figure 3 (over) shows the funding sources for DNA studies and clearly demonstrates that more than half of the "No Effect" studies are mainly funded by Industry and Government (>60%).

Figure 4 illustrates that institutional only funded studies have mainly resulted in significantly more "Effect" than "No Effect" outcomes.

The ORSAA database also collates research by country, based on the origin of the primary author or the principle-funding source. Figure 5

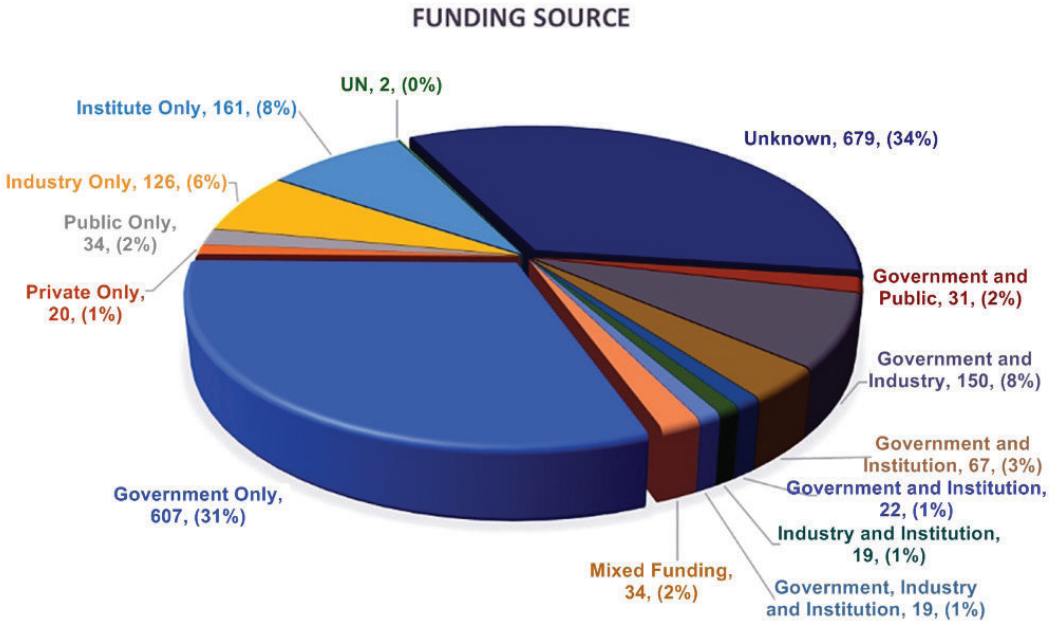

Figure 2
Funding sources for all experimental studies in the ORSAA database

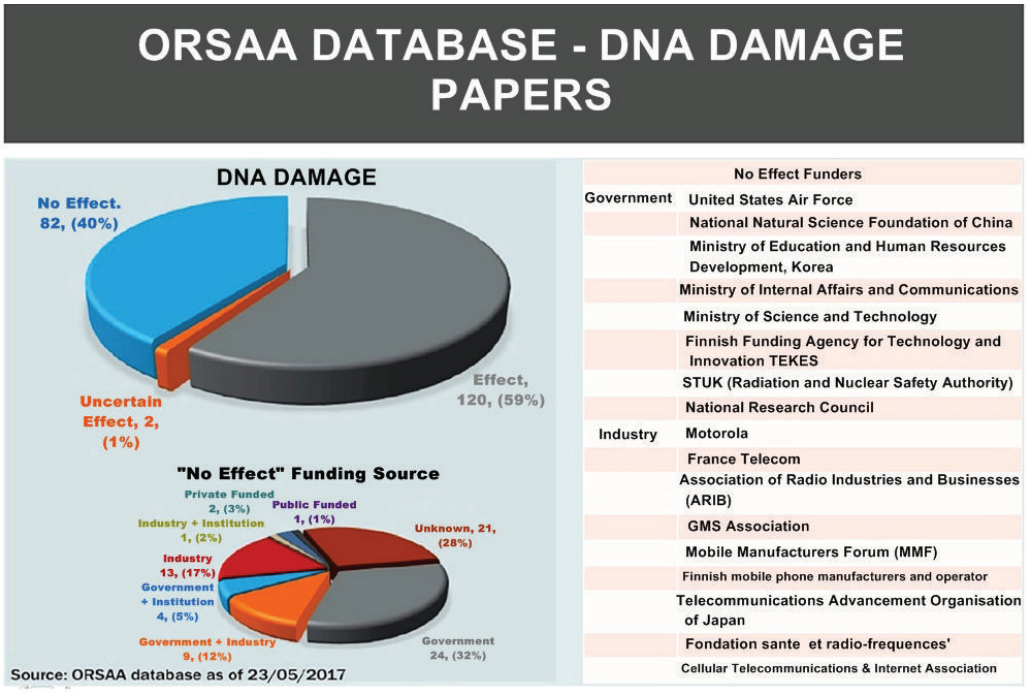

Figure 3
Typical funding source of DNA studies

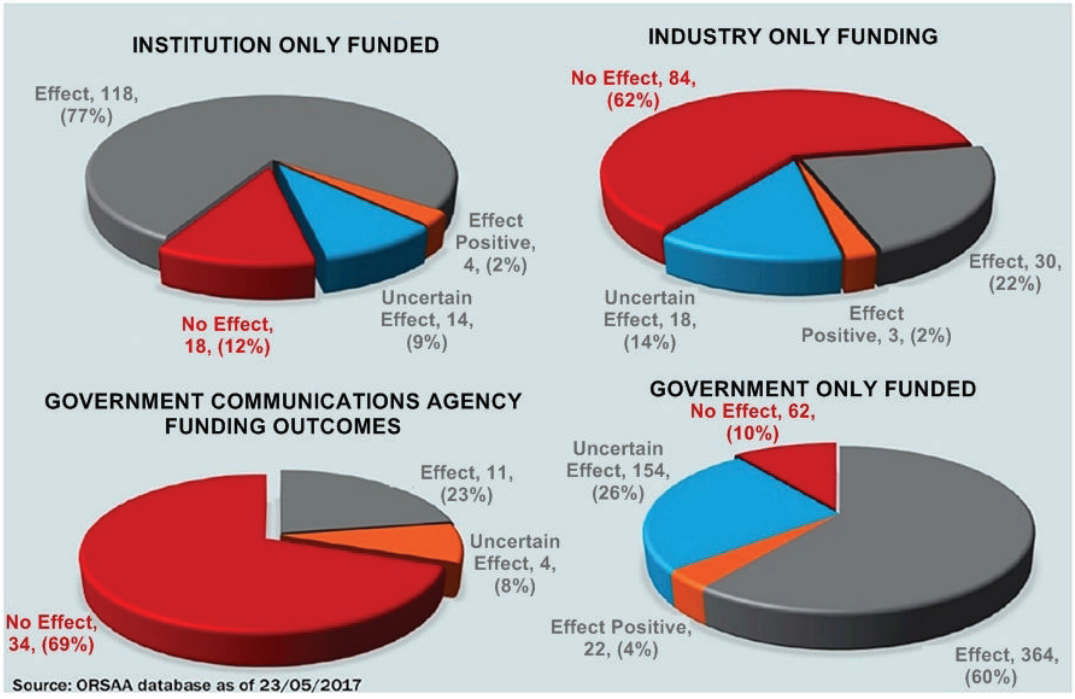

Figure 4
Review of funding sources in ORSAA database
Country of origin – issues of potential bias and potential industry and government influence?

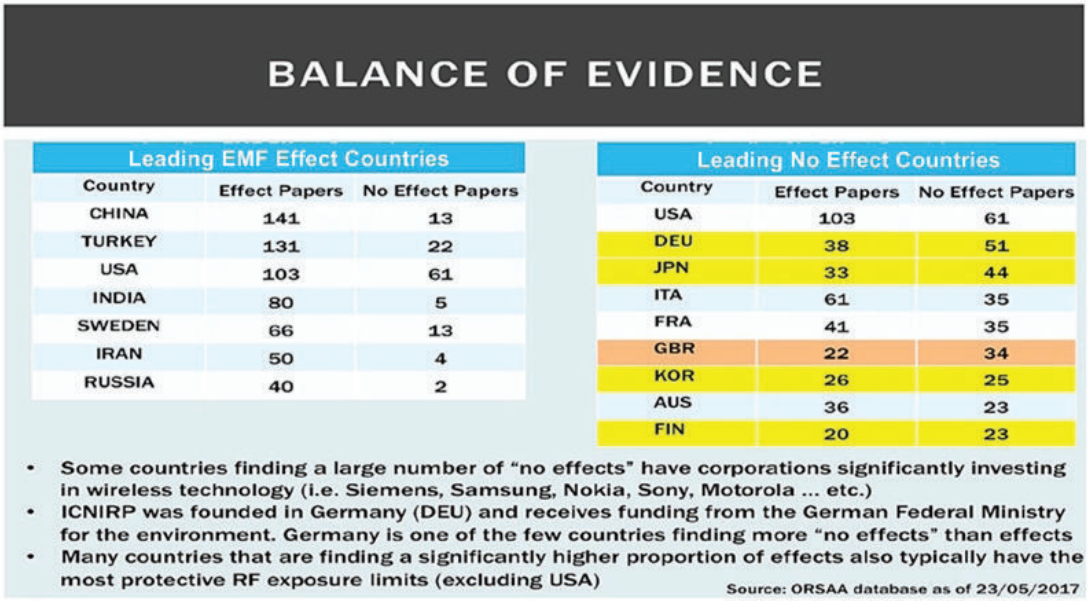

Figure 5
Review of research by country of origin

summarises some of the key findings, showing that countries with a significant economic stake in the communications industry also produce the most "No Effect" studies compared to countries that have a modest interest in communications technology.

ICNIRP AND ICRP

The International Commission on Non-Ionising Radiation (ICNIRP) and the International Commission on Ionising radiation (ICRP) are completely separate organisations with completely different philosophies when setting radiation safety guidelines. An attempt to reconcile these philosophies at a workshop in June 2014 failed [6].

ICNIRP guidelines are entirely based on acute thermal effects and ICNIRP policy requires that adverse health effects first be established before they will consider taking any action. On the other hand, ICRP has taken a more pragmatic risk based approach in the setting of limits. ICRP has developed concepts such as "As Low As Practicable" (ALAP) and "As Low As Reasonably Achievable" (ALARA) while utilising a cost-benefit approach to radiation protection. ICRP has also taken a more prudent and conservative approach than ICNIRP when it comes to dealing with uncertainties associated with low-dose exposures. At low dose, the bio-effects being observed for ionising radiation and for non-ionising radiation are very similar in their characteristics (oxidative stress, DNA damage etc.), despite the uncertainty associated with low-level exposures. However, while animal and plant species have evolved with low level ionising radiation exposure, the environmental characteristics of non-ionising radiation have dramatically changed over a very short evolutionary time period. Exposure to the spectrum region called RF-EMF has increased at least a billion fold since World War 2 and this form of non-ionising radiation, which is used extensively for communication, surveillance, radar, and the Internet of things (IoT) etc. is completely man-made.

CONCLUSIONS

ORSAA has performed a comprehensive review of the scientific evidence that was available to ARPANSA and its expert panel in their 2012 review report TRS-164. The analysis by ORSAA has found that ARPANSA's TRS-164 is a poor representation of the state of the science from within the specified review timeframe. TRS-164 has inherited all the flaws identified by Dr Starkey in the rebuttal of the UK's AGNIR report. Furthermore, it fails to objectively review all observable biological effect findings with respect to their potential implications for health. It appears that TRS-164 has simply recycled the same scientifically unsubstantiated claims made by AGNIR, SCENIHR and ICNIRP.

The Australian public could be misled into

believing the TRS-164 report is a review of APRANSA's extensive database of 1354 peer-reviewed studies. Furthermore, although TRS-164 is also being cited in the literature and on industry websites as another independent review of the science https://www.gsma.com/publicpolicy/consumer-affairs/emf-and-health/expert-reports, this is clearly not the case. Instead, it seems to be a recycling of previous flawed and biased scientific reviews.

Other shortcomings have been noted and include:

- The TRS-164 terms of reference (page 64) for the Expert Panel was to prepare an independent assessment. In contradiction, it is known that a number of TRS-164 sections relied almost exclusively on HPA's AGNIR report.
- AGNIR referenced papers were not meant to be looked at in isolation. They were a 'supplement' to the existing pool of papers. It would appear that the single author of the TRS-164 *in vivo*/*in vitro* section simply performed a paper count of 'no effect' versus 'effect' studies referenced by the AGNIR report, which means that other important papers available within the time period were not considered. Therefore, the comparison of "effect" vs "no effect" counts in TRS-164 becomes meaningless.
- TRS-164 was intended to be an "examination of the science in this area from January 2000 till August 2012". The AGNIR report did not cover this entire period.

ARPANSA appears to be unable or unwilling to conduct a rigorous and independent analysis of the available scientific literature on RF-EMF. There also appears to be a failure by ARPANSA to consider the possible consequences to public health from long-term chronic exposure with respect to the variety of biological effects that have been found in the scientific literature. Rather than waiting for a full understanding of the mechanisms by which these potential harmful effects are occurring, a precautionary approach is necessary when it comes to the regulation and deployment of wireless technologies in our society. The public also needs to be informed of the potential risks clearly and without prejudice. Educational programs and fact sheets need to be developed to cover these risks along with exposure minimisation techniques. Such actions are necessary to ensure that the general public is able to make informed decisions when choosing to use wireless devices, and to improve public understanding of how to use communications technology in a safer manner.

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