Radiation Protection Dosimetry (2017), pp. 1–4

Letter to the Editor

Dear Sir,

There are some serious errors and gaps in the study conducted by Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and published as 'Exposure to Radiofrequency Electromagnetic Fields From WiFi in Australian Schools' by Karipidis *et al.*[1]

First, the methodology employed for this study is questionable. In 20 of the 23 schools, measurements were taken in empty classrooms using only a single laptop and a WiFi router. This is far from the typical exposure situation in classrooms full of students simultaneously using wireless devices. Microwave radiofrequency electromagnetic radiation (RF-EMR) levels in active mode were significantly higher than in the idle mode (Figure 1 of Karipidis *et al.*), even with a single laptop communicating with the router in 20 of 23 samples. Therefore, exposure levels could be even higher in a typical classroom with 20–30 laptops or tablets in operation, a router transmitting, and multiple transmitting mobile phones belonging to students and teachers switched on. Measurements were only conducted with students or teachers present in three classrooms. No information was provided about how many devices were connected to the router(s) in each of these three cases.

The authors' claim of no significant difference in RF levels between empty classrooms and classrooms with multiple users based on 20 vs. 3 samples is questionable. ARPANSA ought to repeat this exercise with all 23 classrooms in empty state compared with the same in real life state with 20–30 devices actively connecting to WiFi. It is also not appropriate to use an idling WiFi router and a laptop (both actively emitting RF-EMR) for the baseline measurements. Rather, measurements should have been conducted with the WiFi system completely turned off to ascertain the background levels of exposure and subsequently with the WiFi system turned on. Three sets of data should have been provided: background (WiFi off), idle (WiFi ON but not actively communicating) and active (20–30 devices actively using WiFi). Only in this way could the real contribution of WiFi in the classrooms be assessed.

The measurements in the study are not necessarily representative of exposures to which children might typically be exposed from wireless devices in schools. Karipidis *et al.* reported total RF-EMR exposure maxima (from different sources) of 2.2×10^{-3} W/m^2 inside classrooms. These levels are lower than those reported in the UK and NZ studies discussed in Karipidis *et al.* The UK study found a maximum of 1.8×10^{-2} W/m^2 (2.6 V/m) at 1 m from a single laptop[2] while the NZ study reported 4.7×10^{-2} W/m^2 at 0.3 m from one[3]. The differences are likely due greater distances chosen from emitting devices and varying output power of different devices. Karipidis *et al.* also did not explain why they conducted 1 min measurements as opposed to the standard practice (as per ARPANSA RPS3 and ICNIRP guidelines) of averaging readings over 6 min. Longer exposure measurements would be more reliable. It is interesting to note the highly variable RF-EMR exposure from a laptop in normal use during a 60 min period as depicted in Section 4.3.2 of the New Zealand study[3].

Secondly, the interpretation of data is inaccurate. When the RF-EMR levels measured by Karipidis *et al.* are compared with levels associated with biological effects in scientific studies, it is not possible to exclude potential adverse health effects—both physical and psychological. Damage to human sperm has been demonstrated when kept close to a WiFi-enabled laptop computer for just 4 h at RF-EMR exposure levels 4.5×10^{-3}–1.1×10^{-2} W/m[4]—similar to levels reported at Australian schools by this ARPANSA study. These *ex vivo* sperm samples were maintained at 25°C with cooling to make sure any effects would not be based on heating effects. Headache and cognitive impairment have been reported at maximum RF exposure of 4.1×10^{-3} W/m[5], activation of stress responses has been found at 2.1×10^{-3} W/m[6], neuro-psychiatric problems including headache, dizziness, tremor, sleep disturbance and depressive symptoms have been reported at 5.4×10^{-2}[7], while irritability, poor concentration along with a host of other symptoms of 'microwave syndrome' at 1.1×10^{-3} W/m[8, 9]. Furthermore, an increased cancer mortality rate near mobile phone base stations (MPBS)[10] and higher risk of childhood leukemia near radio transmitters[11] have been reported at comparable exposure levels. These needed to be addressed in any meaningful study of RF-EMR exposure in schools. Even if a measured level is a very small fraction of the ICNIRP guidelines, that cannot assure safety if there are biological effects occurring at or below that level of exposure. Comparing the measured exposure levels to levels that have been found to be associated with biological/health effects in credible scientific studies and proper risk evaluation by multidisciplinary experts should have been done.

Karipidis *et al.* reported a maximum RF-EMR of 3.4×10^{-4} W/m^2 in the school yard. This may not necessarily be typical for a lot of schools. Karipidis *et al.* failed to explain how the schools were selected for the study without bias. Geographical location can highly influence the ambient RF-EMR levels. For

example, a school in close proximity to a high powered radio/TV transmitter which are relatively rare, or more common MPBS, would have higher or similar RF exposure from those external sources compared to internal WiFi, whereas a school away from such external transmitters would have internal WiFi and other wireless devices such as DECT cordless phones as the major source of exposure. Therefore, the statement 'the exposure from WiFi is typically comparable or lower to other common sources in the environment' is highly unlikely to be an accurate general statement. Taking an example of a Sydney school, before a MPBS was installed 100–200 m from this school (disregarding the Department of Education NSW policy guideline of a 500 m clearance), the ambient RF-EMR in 2013 was a low 3×10^{-7} W/m^2 despite good radio/TV/mobile reception that existed at this location (author's unpublished data, measured with a GIGAHERTZ HF38B tri-field RF EMF meter measuring 800 MHz–2.7 GHz frequency range, taken as 6-min average maximum measurements). At this time, the school's WiFi system and internal wireless devices appeared to be the main RF-EMR exposure contributor internally with a maximum RF level at 0.04 W/m^2 which was 133 333 times higher than ambient level in the school yard. However, following the installation of the MPBS, maximum exposure from the MPBS alone in the school yard is estimated to be 0.075 W/m^2 as per data provided by the telecom industry[12], i.e. 250 000 times higher than ambient level that existed in 2013. This external level is higher than the internal levels largely contributed by WiFi. In line with this industry estimated maximum exposure, recent spot measurements in the school yard have measured 2×10^{-2} W/m^2 (unpublished data), i.e. 66 666 times higher than what was measured in 2013 with the same instrument. This example indicates that both internal transmitters such as WiFi and external transmitters such as MPBS have largely increased RF-EMR exposure at schools in recent years. It would be inaccurate to imply that RF-EMR levels emanating from WiFi in schools are comparable to what is in the environment. Microwave RF-EMR is entirely man-made for telecommunications and surveillance and human exposure has highly and rapidly increased, particularly over the last couple of decades. The measured RF exposure levels must be considered with fact that natural background levels of RF-EMR in our living environment without the artificial RF generated for wireless communications are below 10^{-15} W/m^2[13].

Last but not least, it is necessary to express serious concerns about the conclusions of this paper that could be misleading. The authors' claim 'the results of this study showed that children's exposure to RF fields from WiFi in schools is several orders of magnitude below exposure reference levels recommended by international guidelines for protection against established health effects' is apparently aimed to assuage public concern without objectively evaluating the scientific evidence or addressing differences in guidelines. ARPANSA standards based on the guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) are less stringent/protective than standards of some countries by 10–1000 times. There is no scientific consensus on safe levels of RF internationally, and instead, there is intense debate on the topic as biological effects have been demonstrated to occur below even the most stringent current standards.

Based on the scientific findings of biological/health effects that have been found to be induced by or associated with currently permitted RF-EMR exposures, 225 EMF scientists from 41 countries have petitioned the UN and the WHO[14] urging measures to protect public health.

Moreover, reputable scientific organizations such as the US National Toxicology Program[15], US Environmental Protection Agency[16], American[17] and the European[18] Academies of Environmental Medicine have expressed concern as thermal guidelines cannot protect against non-thermal and long-term effects, the latter even published guidelines in 2016 for the prevention, diagnosis and treatment of EMF-related illnesses. With irrefutable scientific evidence of biological effects including deleterious cellular effects such as oxidative stress[19], DNA damage[20] and sperm damage[21], disruption of voltage-gated calcium channels[22] as well as physiological and biochemical changes in the brain demonstrated by EEG[23], changed metabolism[24] leaky blood brain barrier[25] and ADHD-like pathology[26] under non-thermal levels of exposure permitted by current 'safety' standards, potentially leading to serious chronic health consequences such as cancer[27], Karipidis *et al.* should not have simply checked compliance with ICNIRP guidelines.

An independent international expert panel of 29 from 10 countries reviewed the scientific literature on biological/health effects of RF-EMR and recommended a threshold of 1×10^{-3} W/m^2 (0.6 V/m) for outdoor exposure in 2007 in the Bioinitiative Report[28] which was adopted as an immediate precautionary indoor target along with 1×10^{-4} (0.2 V/m) as a medium-term target by the European Parliament in 2011[29], with particular attention to reducing children's exposure in schools by replacing WiFi and other wireless devices with wired options at schools. ARPANSA's readings at schools exceed these biologically-based proposed safety thresholds. Importantly, due to emerging evidence of biological interference at much lower levels of exposure, the Bioinitiative working group revised their guideline making it more stringent in 2012, recommending around 3×10^{-5} W/m^2 (0.1 V/m). It is disappointing that Karipidis *et al.* did not address these opposing expert views based on research findings and instead continued to promote ICNIRP guidelines that only takes into account acute heating effects.

The above quoted statement also implies that ICNIRP guidelines can assure protection from all adverse health effects without explaining what they meant by 'established' health effects. This failure to disclose to the Australia public that ICNIRP guidelines that allows up to 10 W/m^2 would only protect against health effects established to be arising out of thermal effects appears disingenuous. These facts are essential for a robust scientific discussion on this topic which is lacking at present in Australia and also at the World Health Organization.

The ICNIRP, an NGO of 14 self-appointed members frequently with conflicts of interest[30], have no public accountability for their guidelines. A former chairman of ICNIRP, Professor Paolo Vecchia made their position clear in 2008: 'The ICNIRP guidelines are neither a mandatory prescription for safety, the 'last word' on the issue nor are they defensive walls for Industry or others'[31]. ICNIRP has also admitted that their guidelines for non-ionizing radiation (including RF-EMR) may not provide adequate protection to more sensitive individuals: 'Different groups in a population may have differences in their ability to tolerate a particular NIR exposure. For example, children, the elderly and some chronically ill people might have a lower tolerance for one or more forms of NIR exposure than the rest of the population. Under such circumstances, it may be useful or necessary to develop separate guideline levels for different groups within the general population, but it may be more effective to adjust the guidelines for the general population to include such groups'[32]. Unfortunately, it appears that ARPANSA is following the ICNIRP guidelines as a mandatory prescription of safety without adjusting the guidelines to avoid biological effects, and in doing so, risking health of Australians.

In conclusion, contrary to the assurances implied by Karipidis *et al.*, existing scientific evidence clearly indicates that there are potential health risks for students and staff from microwave RF-EMR exposure levels found at schools from internal and external wireless infrastructure. ARPANSA should immediately recommend that schools use wired Internet instead of WiFi as several responsible government agencies in other parts of the world have already done to reduce exposure of children, a sensitive population that need particular protection.

REFERENCES

1. Karipidis, K., Henderson, S., Wijayasinghe, D., Tjong, L. and Tinker, R. *Exposure to radiofrequency electromagnetic fields from Wi-Fi in Australian schools*. Radiat. Prot. Dosimetry (2017) doi:10.1093/rpd/ncw370.
2. Peyman, A., Khalid, M., Calderon, C., Addison, D., Mee, T., Maslanyj, M. and Mann, S. *Assessment of exposure to electromagnetic fields from wireless computer networks (wi-fi) in schools; results of laboratory measurements*. Health Phys. **100**(6), 594–612 (2011).
3. Gledhill, M. *Exposures to radiofrequency fields from WiFi in New Zealand schools*. EMF Services Report (2014).
4. Avendano, C., Mata, A., Sanchez Sarmiento, C. A. and Doncel, G. F. *Use of laptop computers connected to Internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation*. Fertil. Steril. **97**, 39–45.e32 (2012) doi:10.1016/j.fertnstert.2011.10.012.
5. Hutter, H. P., Moshammer, H., Wallner, P. and Kundi, M. *Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations*. Occup. Environ. Med. **63**, 307–313 (2006) doi:10.1136/oem.2005.020784.
6. Augner, C., Hacker, G. W., Oberfeld, G., Florian, M., Hitzl, W., Hutter, J. and Pauser, G. *Effects of exposure to GSM mobile phone base station signals on salivary cortisol, alpha-amylase, and immunoglobulin A*. Biomed. Environ. Sci. **23**, 199–207 (2010) doi:10.1016/S0895-3988(10)60053-0.
7. Abdel-Rassoul, G., El-Fateh, O. A., Salem, M. A., Michael, A., Farahat, F., El-Batanouny, M. and Salem, E. *Neurobehavioral effects among inhabitants around mobile phone base stations*. Neurotoxicology **28**, 434–440 (2007) doi:10.1016/j.neuro.2006.07.012.
8. Gomez-Perretta, C., Navarro, E. A., Segura, J. and Portoles, M. *Subjective symptoms related to GSM radiation from mobile phone base stations: a cross-sectional study*. BMJ Open e003836 (2013) doi:10.1136/bmjopen-2013-003836.
9. Navarro, E. A., Segura, J., Portolés, M. and Gómez-Perretta, C. *The microwave syndrome: a preliminary study in Spain*. Electromagn. Biol. Med. **22**, 161–169 (2003).
10. Dode, A. C. *et al. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil*. Sci. Total Environ. **409**, 3649–3665 (2011) doi:10.1016/j.scitotenv.2011.05.051.
11. Ha, M., Im, H., Lee, M., Kim, H. J., Kim, B. C., Gimm, Y. M. and Pack, J. K. *Radio-frequency radiation exposure from AM radio transmitters and childhood leukemia and brain cancer*. Am. J. Epidemiol. **166**, 270–279 (2007).
12. Site No: 2154020 at Radio Frequency National Site Archive. http://www.rfnsa2.com.au (10 May 2017, date last accessed).
13. Raines, J. K. *Electromagnetic field interactions with the human body: observed effects and theories*. National Aeronautics and Space Administration (NASA), Goddard Space Flight Center, Greenbelt, Maryland 20771 (1981).
14. International EMF. *Scientist Appeal*. https://emfscientist.org/ (12 May 2017, date last accessed).
15. USA. *National Toxicology Program*. Dr. John Ducher, Assoc. Director's testimony at the Congressional Hearing on cell phone safety. https://www.youtube.com/watch?v=EDYTo7dHrl4 (10 May 2017, date last accessed).
16. US Environmental Protection Agency. http://www.humboldtgov.org/DocumentCenter/View/2858 (12 May 2017, date last accessed).
17. American Academy of Environmental Medicine. *Electromagnetic and Radiofrequency Fields Effect on*

Human Health. https://www.aaemonline.org/emf_rf_position.php (12 May 2017, date last accessed).
18. EUROPEAN Academy for Environmental Health. https://europaem.eu/en/library/blog-en/97-europaem-emf-guideline-2016?highlight=WyJlbGVjdHJvbWFnbmV0aWMiXQ== (12 May 2017, date last accessed).
19. Yakymenko, I., Tsybulin, O., Sidorik, E., Henshel, D., Kyrylenko, O. and Kyrylenko, S. *Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation*. Electromagn. Biol. Med. **35**, 186–202 (2015).
20. Ruediger, H. W. *Genotoxic effects of radiofrequency electromagnetic fields*. Pathophysiology **16**, 89–102 (2009).
21. Houston, B. J., Nixon, B., King, B. V., De Iuliis, G. N. and Aitken, R. J. *The effects of radiofrequency electromagnetic radiation on sperm function*. Reproduction **152**, R263–R276 (2016) doi:10.1530/REP-16-0126.
22. Pall, M. L. *Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects*. J. Cell. Mol. Med. **17**, 958–965 (2013) doi:10.1111/jcmm.12088.
23. Lustenberger, C., Murbach, M., Tushaus, L., Wehrle, F., Kuster, N., Achermann, P. and Huber, R. *Inter-individual and intra-individual variation of the effects of pulsed RF EMF exposure on the human sleep EEG*. Bioelectromagnetics **36**, 169–177 (2015) doi:10.1002/bem.21893.
24. Volkow, N. D., Tomasi, D., Wang, G. J., Vaska, P., Fowler, J. S., Telang, F., Alexoff, D., Logan, J. and Wong, C. *Effects of cell phone radiofrequency signal exposure on brain glucose metabolism*. J. Am. Med. Assoc. **305**, 808–813 (2011) doi:10.1001/jama.2011.186.
25. Nittby, H., Grafstrom, G., Eberhardt, J. L., Malmgren, L., Brun, A., Persson, B. R. and Salford, L. G. *Increased blood-brain barrier permeability in mammalian brain 7 days after exposure to the radiation from a GSM-900 mobile phone*. Pathophysiology **16**, 103–112 (2009).
26. Aldad, T. S., Gan, G., Gao, X. B. and Taylor, H. S. *Fetal radiofrequency radiation exposure from 800-1900 MHz-rated cellular telephones affects neurodevelopment and behavior in mice*. Sci. Rep. **2**, 312 (2012) doi:10.1038/srep00312.
27. Carlberg, M. and Hardell, L. *Evaluation of mobile phone and cordless phone use and glioma risk using the Bradford Hill Viewpoints from 1965 on Association or Causation*. Biomed. Res. Int. (2017) doi:10.1155/2017/9218486.
28. BioInitiative Working Group. *A Rationale for Biologically-Based Public Exposure Standards for Electromagnetic Radiation*. http://www.bioinitiative.org (last accessed 14 May 2017).
29. The European Parliamentary Assembly. *The Potential Dangers of Electromagnetic Fields and Their Effect on the Environment*. http://assembly.coe.int/nw/xml/XRef/Xref-XML2HTML-en.asp?fileid=17994 (11 May 2017, date last accessed).
30. Hardell, L. *World Health Organization, radiofrequency radiation and health—a hard nut to crack (Review)*. Int. J. Oncol. **51**, 405–413 (2017) doi:10.3892/ijo.2017.4046.
31. Evans, E. *Energy and Climate Change Committee Written Evidence Submitted by Dr Elizabeth Evans*. https://www.publications.parliament.uk/pa/cm201314/cmselect/cmenergy/161/161vw09.htm (12 May 2017, date last accessed).
32. International Commission on Non-Ionizing Radiation Protection. *ICNIRP statement: general approach to protection against non-ionizing radiation*. Health Phys. **82**, 540–548 (2002).

Priyanka Bandara[1,*] and Olle Johansson[2]
[1]Independent Researcher, PO Box 577, Castle Hill, NSW 1765, Australia
[2]Department of Neuroscience, Karolinska Institute, 171 77 Stockholm, Sweden

*Corresponding author: ayubowan1234@gmail.com
doi:10.1093/rpd/ncx108