

Responding to Wi-Fi Safety Concerns in Our Schools

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For more information or additional copies of this report contact:

Environmental Public Health
Washington State Department of Health
PO Box 47827
Olympia, WA 98504-7827

360-236-3300
FAX 360-236-2255

John Wiesman
Secretary of Health



Randy Dorn
Superintendent of Public Instruction



Special acknowledgments to:

Eric Ossiander

Division of Disease Control and Health Statistics
Washington State Department of Health

Dennis Small

Educational Technology
Office of Superintendent of Public Instruction
State of Washington

Juliet VanEenwyk

Division of Disease Control and Health Statistics
Washington State Department of Health

Scott Van Verst

Division of Environmental Public Health
Washington State Department of Health

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Executive Summary

An executive summary will be included with the final document.

Introduction

Washington has 295 school districts with more than 2,200 buildings and over one million students. Students, school staff and parents all expect schools to provide a healthy and comfortable environment conducive to learning and teaching.

A concerned resident has questioned the safety of Wi-Fi in schools. The Washington State Department of Health and the Office of Superintendent of Public Instruction have responded by evaluating comprehensive reviews of the literature on the health effects of radiofrequency (RF) radiation already conducted by national and international health agencies. This report presents the findings of these reviews.

Background

The fields generated by Wi-Fi devices are in the RF part of the electromagnetic spectrum. Cell phones, cell towers, radar, microwaves, and radio and TV broadcasts also generate RF fields. Most studies regarding the health effects of RF fields have evaluated cell phones because the level of exposure from cell phones is far greater than that from other devices, including Wi-Fi. Therefore, cell phones can be used as an indicator for health risks from other RF devices, at least if no evidence of risk is found; if there is no evidence of risk associated with cell phone use, then there is also no evidence of risk from other RF devices.

The International Commission on Non-Ionizing Radiation Protection (international commission, ICNIRP), an organization associated with the World Health Organization (WHO), sets guidelines for exposure to RF fields. At high levels, RF can cause dangerous thermal effects (inside microwave ovens, for example), and the international commission sets RF exposure levels so that thermal effects will not occur. Their review of the science found that thermal effects do not occur below a power density limit of 4 watts per kilogram (W/kg), and after incorporating a 50-fold safety factor, they have established a safety limit of 0.08 W/kg for public RF exposure for the whole body, and 2 W/kg for localized exposure. (Appendix A, document 4) Among RF devices to which the public is commonly exposed, cell phones provide by far the highest exposure, with some models providing an exposure of 1 W/kg or more to the head. Wi-Fi, cell towers and Bluetooth devices all provide roughly similar levels of exposure, about 100 to 1,000 times lower than exposure from cell phones. (Appendix A, documents 3 and 4)

Documents Review Process

An enormous amount of research has been conducted into the possible health effects of RF fields. The WHO maintains a catalog of this research which includes more than 3,000 scientific articles (<http://www.who.int/peh-emf/research/database/en/>). The Department of Health and Office of the Superintendent of Public Instruction work group determined that conducting a comprehensive review of this research was not feasible within current staffing resources. However, the working group found that many comprehensive reviews have already been conducted and that preparing a summary of those reviews was a reasonable approach for describing potential hazards from exposure to Wi-Fi. In order to be certain of not selecting only particular viewpoints, the working group established objective criteria and conducted a search to find all reviews meeting those criteria. The criteria the reviews needed to satisfy included that they were:

- Conducted by a national or international health agency.
- Published in English or had an official summary published in English.
- Published in 2000 or later.
- A comprehensive review of the scientific literature on some aspect of human exposure to RF.

Some agencies published updated versions of previous reviews during this time period; when this was the case, the working group included only the most recent version of the review. Some agencies published separate reviews of different aspects of RF exposure; in these cases, the working group included each of the reviews. The working group found 16 documents satisfying the criteria and reviewed them for this report. The documents came from nine national health agencies and six international health agencies (one agency had two reports included in the review). Appendix A lists the 16 documents.

For each document, the working group determined:

- Which exposure and health outcome categories were evaluated. The working group looked for exposure categories of RF, RF in children, Wi-Fi, Wi-Fi in schools, Wi-Fi in other settings, mobile phones, cell towers and other. Health outcome categories included cancer (meningioma, glioma, acoustic neuroma, other or unspecified brain tumors, or other cancers), non-cancer health effects (cognitive, behavioral, immune system, hearing, brain development, nerve conduction, endocrine system or other), and electrosensitivity.
- The findings for each health outcome category.
- If each document provided an overall conclusion regarding health risks from RF exposure in general and Wi-Fi exposure specifically.

Finally, for each document, the working group summarized the overall scientific findings, including uncertainties. These are summarized in Table 1, and the [accompanying spreadsheet](#) provides the entire set of data for each document.

TABLE 1: Overall scientific findings regarding RF exposure and conclusion of 16 documents reviewed

| Country/Entity | Year Published | Overall scientific findings/conclusions: |
|------------------------------|-----------------------|--|
| The Netherlands ¹ | 2013 | (p. 121) "Based on the available epidemiological evidence described in this report and taking into account the quality of the different studies and their strengths and weaknesses, the final conclusion from this systematic analysis is then, that there is no clear and consistent evidence for an increased risk of tumours in the brain and other regions in the head in association with up to approximately 13 years use of a mobile telephone. For longer term use, for which no data are available, such risk cannot be excluded at present." |
| Sweden ² | 2013 | There is no good evidence of adverse health effects of RF exposure, but there is still uncertainty regarding the effects of long-term (more than 15 years) exposure to cell phones. |
| WHO ³ | 2013 | (p. 419) "There is limited evidence in humans for the carcinogenicity of radiofrequency radiation. Positive associations have been observed between exposure to radiofrequency radiation from wireless phones and glioma, and acoustic neuroma." (p. 419) "Radiofrequency electromagnetic fields are possibly carcinogenic to humans (Group 2B)." There was no evidence that environmental exposure [i.e. RF from cell towers and radio/TV transmitters] causes cancer. |
| England ⁴ | 2012 | (p. 4) "...in summary, although a substantial amount of research has been conducted in this area, there is no convincing evidence that RF field exposure below guideline levels causes health effects in adults or children." |
| European Union ⁵ | 2012 | (p. 41-44) There is limited evidence that long-term cell phone exposure causes brain tumors in adults, evidence that RF does not cause symptoms in electrosensitive people, and inadequate evidence for all other associations that were considered. |
| Norway ⁶ | 2012 | (p. 38) "The large total number of studies provides no evidence that exposure to weak RF fields causes adverse health effects. Some measurable biological / physiological effects cannot be ruled out." (p. 38) "This uncertainty [regarding mobile phone use] is considered to be low. There is negligible uncertainty in the risk assessment associated with other sources, such as base stations, wireless networks, ..." |
| The Netherlands ⁷ | 2011 | (p. 33-34) Based on currently available knowledge, there is not an increased risk of harmful health effects in children from RF exposure from cell phones, cell towers, or Wi-Fi, but more research is needed. |
| Spain ⁸ | 2011 | (p. 43) "Present evidence from clinical and epidemiological studies indicates that there is no causal relationship between exposure to the radio frequencies used in mobile telephony and adverse effects on health." Long-term studies are still needed, but "...there are not sufficient scientific reasons at present to justify a reduction in current levels of exposure to electromagnetic waves from mobile telephony..." |

| | | |
|------------------------------|------|---|
| European Union ⁹ | 2010 | (p. 29) "...the environmental levels of RF due to anthropogenic sources are not sufficient to produce observable health effects." But there is still scientific uncertainty, especially regarding long-term exposure. |
| European Union ¹⁰ | 2009 | (p. 60-61) Exposure to RF fields is unlikely to cause cancer in humans, according to epidemiological, animal, and in vitro studies, but there is still some uncertainty regarding the effects of long-term exposure. There is some evidence RF exposure can influence EEG patterns but the health relevance of this is uncertain. Studies on functions of the nervous system, including cognitive and sensory functions, and studies on human reproduction and development show no or no consistent effects. Information on the possible effects of RF fields in children is limited. |
| ICNIRP ¹¹ | 2009 | (p. 260-261) The plausibility of the mechanisms that have been proposed for non-thermal effects is very low. Recent studies suggest that genotoxicity effects are unlikely. There may be effects on other endpoints, such as cell signaling and EEG, but there is no evidence of adverse health effects associated with them. There is no consistent evidence of increased cancer risk, but there is still uncertainty regarding long-term effects. The data do not suggest that children are more susceptible than adults to the effects of RF radiation, but there have been few studies. |
| Ireland ¹² | 2007 | (p. 3) "So far no adverse short or long-term health effects have been found from exposure to the RF signals produced by mobile phones and base station transmitters. RF signals have not been found to cause cancer. However research is underway to investigate whether there are likely to be any subtle, noncancer effects on children and adolescents." |
| France ¹³ | 2005 | (p. 97) "The expert group feels that it cannot currently draw definitive conclusions concerning the existence of adverse health effects caused by the electromagnetic fields resulting from mobile telephony." (p. 79) Wi-Fi uses the same frequency as cell phones, but the exposure is at a lower level. There is a lot known about the biological effects of this exposure, and the results have overwhelmingly not shown adverse effects at the exposure levels provided by Wi-Fi. |
| USA ¹⁴ | 2003 | (p. 2) "This Commentary concludes that the scientific literature related to modulation-dependence of biological effects of RF energy is not sufficient to draw any conclusions about possible modulation-dependent health hazards of RF fields, nor is there any apparent biophysical basis from which to anticipate such hazards apart from exposure to very intense RF pulses produced by some specialized military equipment." |
| Australia ¹⁵ | 2002 | (p. 76) No adverse health effects have been consistently observed when exposures are within the current standards. There is no need to revise the standards to lower exposure levels. |
| New Zealand ¹⁶ | 2000 | (p. 2) "The Ministry of Health considers there are no established adverse effects from exposures to radiofrequency fields which comply with the ICNIRP guidelines and the New Zealand Standard." |

Summary/Results

Among the 16 documents the working group included in the review, 15 reported on the health effects of RF in general, and one reported solely on the health effects of cell phones. (See Table 2.) Twelve of the documents commented on health effects of RF in children. Only four of the documents commented specifically on the health effects of Wi-Fi. Fifteen documents reviewed evidence regarding the relationship between RF exposure and cancer. Two of these documents were concerned only with cancer; the others also included a review of at least some other health conditions, but the specific conditions varied among the documents. Eight of the documents were published in 2011 or more recently, and as a whole, the documents include a review of the most recent research in the field.

The documents generally described their conclusions in terms of there being ‘no evidence’ or ‘no clear and consistent evidence’ that RF causes a particular health effect (except for the few times they concluded there was limited evidence of an effect). It is usually very difficult for health studies to show that a harmful effect does not exist, so a conclusion of ‘no evidence’ of a harmful effect may cover a wide range of possibilities—it may mean that numerous high-quality studies found no harmful effect, or it may mean that few studies evaluated the effect. For this reason, the working group also tabulated the uncertainty in the estimates of effect, when that was reported.

Among the 16 documents reviewed, 13 concluded there is no clear and consistent evidence that RF has any adverse health effects. Three documents concluded there is limited and uncertain evidence that cell phone use can cause brain tumors. All three of these documents also concluded there is no evidence that RF exposure at lower levels—such as those obtained from Wi-Fi, cell towers or Bluetooth devices—has any adverse health effect.

Many of the documents noted that cell phones have been used for a shorter period of time than the latency period for slow-growing brain tumors, such as meningioma and acoustic neuroma, and therefore epidemiological studies have not properly evaluated the health effects of long-term use. However, most of these documents also noted that since cell phone prevalence was very high (approaching 100 percent) in many countries by 2000, some effects on national trends should have been seen by now unless the increased risk due to cell phone use is small.

Nine of the documents specifically stated that the long-term effects of cell phone use are still uncertain, or that long-term studies are needed. Two of the documents concluded that there was little uncertainty in their assessment that RF has no adverse health effects. Among the nine documents that concluded there is uncertainty regarding cell phone use, none of the documents concluded that there is uncertainty regarding low-level RF exposure.

Seven of the documents addressed the possible cognitive effects of RF exposure. All seven of these documents concluded that there is no clear and consistent evidence that RF exposure has adverse cognitive effects. Four of the documents addressed behavioral effects. All four concluded that there is no clear and consistent evidence that RF exposure has adverse behavioral effects.

Several other health effects were addressed by one or more of the documents, including effects on the immune system, hearing, brain development and function, nerve conduction, the endocrine system, the cardiovascular system, and the reproductive system. No clear and consistent evidence for adverse health effects was found for any of these. Although RF was found to possibly affect nerve conduction, this was not associated with adverse health effects.

Eight of the documents commented on the phenomenon of electrosensitivity—the phenomenon in which people exhibit symptoms that they attribute to RF or other electromagnetic field (EMF) exposure. The documents were unanimous in concluding that, although the symptoms exhibited by electrosensitive people are real, there is good evidence from numerous, well-controlled studies that these symptoms are not actually caused by RF or EMF exposure. Further, there is no evidence that anyone can detect the presence of EMF at the levels to which people are commonly exposed.

One report (Appendix A, document 1) measured the magnitude of exposure to RF in school settings, and concluded that levels were far below the international commission threshold.

Conclusion

The work group reviewed every comprehensive scientific review performed by national or international health agencies, and published in English since 2000. The consensus conclusion of these 16 documents was that there is no clear and consistent evidence that low levels of RF fields, such as produced by Wi-Fi equipment, have any adverse health effects in humans. Although there is some uncertainty regarding the possible effects of cell phones, which expose users to RF fields with much higher power density, there is little uncertainty regarding health effects of the low levels of RF produced by Wi-Fi equipment. All of this means that, based on current evidence, the low level RF exposure produced by Wi-Fi is unlikely to pose a health risk.

TABLE 2: Characteristics and conclusions of the 16 reviewed documents

| | Report number (see Appendix A) | | | | | | | | | | | | | | | |
|---|--------------------------------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Reported on RF in general | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Reported on cell phones only | X | | | | | | | | | | | | | | | |
| Reported on RF in children | | X | | X | X | X | X | X | X | X | X | X | X | | X | |
| Reported on health effects of Wi-Fi | | | | X | | X | X | | | | | | X | | | |
| Concluded there is no evidence RF has adverse health effects | X | X | | X | | X | X | X | X | X | X | X | | X | X | X |
| Concluded there is limited evidence cell phones cause brain tumors | | | X | | X | | | | | | | | X | | | |
| Concluded long-term effects of cell phone use are still uncertain | X | X | X | | X | | | X | X | X | X | | X | | | |
| Concluded there is little uncertainty in conclusion of no adverse effects | | | | X | | X | | | | | | | | | | |
| Reported on cognitive effects | | X | | X | | | X | | X | X | X | | X | | | |
| Reported on behavioral effects | | | | X | | X | X | | | X | | | | | | |
| Reported on electrosensitivity | | X | | X | X | X | | X | | X | X | X | | | | |

Appendix A: Documents Reviewed

Text in parentheses at the end of each citation refers to the corresponding tab in the [accompanying spreadsheet](#).

1. Health Council of the Netherlands. Mobile phones and cancer. Part 1: Epidemiology of tumours in the head. Health Council of the Netherlands, 2013.
<http://www.gezondheidsraad.nl/en/publications/environmental-health/mobile-phones-and-cancer-part-1-epidemiology-tumours-head>, accessed on September 12, 2013.
(Neth13)
2. SSM:s Scientific Council on Electromagnetic Fields. Eighth report from SSM:s scientific council on electromagnetic fields. 2013:19, Swedish Radiation Safety Authority, SSM, 2013. <http://www.stralsakerhetsmyndigheten.se/om-myndigheten/Organisation/Radnamnder/Vetenskapligt-rad-for-elektromagnetiska-falt/>, accessed on September 11, 2013. (Swed13)
3. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Non-ionizing radiation, Part II: Radiofrequency electromagnetic fields, vol. 102. Geneva: International Agency for Research on Cancer (IARC), 2013.
<http://monographs.iarc.fr/ENG/Monographs/vol102/mono102.pdf>, accessed on September 5, 2013. (WHO13)
4. Independent Advisory Group in Non-ionising Radiation. Health effects from radiofrequency electromagnetic fields. ISBN 978-0-85951-714-0, Health Protection Agency, 2012.
<http://www.hpa.org.uk/Publications/Radiation/DocumentsOfTheHPA/RCE20HealthEffectsfromRFElectromagneticFields/>, accessed on September 17, 2013. (Eng12)
5. European Health Risk Assessment Network on Electromagnetic Fields Exposure. Risk analysis of human exposure to electromagnetic fields (revised). EFHRAN, 2012.
http://efhran.polimi.it/docs/D2_Finalversion_oct2012.pdf, accessed on September 20, 2013. (EU12)
6. The Expert Committee. Low-level radiofrequency electromagnetic fields an assessment of health risks and evaluation of regulatory practice. ISBN: 978-82-8082-509-4, Norwegian Institute of Public Health, 2012.
<http://www.fhi.no/dokumenter/c5ab86c32b.pdf>, accessed on September 17, 2013.
(Nor12)
7. Health Council of the Netherlands. Influence of radiofrequency telecommunication signals on children's brains. Health Council of the Netherlands, 2011.
<http://www.gezondheidsraad.nl/en/publications/environmental-health/influence-radiofrequency-telecommunication-signals-children-s-brain>, accessed on September 12, 2013. (Neth11)
8. Scientific Advisory Committee on Radio Frequencies and Health (CCARS). Report on radio frequencies and health (2009-2010). Scientific Advisory Committee on Radio Frequencies and Health (CCARS), 2011.
http://ccars.es/sites/default/files/Report_on_RF_health_2009-2010_EN.pdf, accessed on September 13, 2013. (Sp11)

9. Promoting healthy environments with a focus on the impact of actions on electromagnetic fields (lot 3). Contract Reference: 2009 62 03, Executive Agency for Health and Consumers, 2010.
http://ec.europa.eu/health/electromagnetic_fields/docs/bio_frep_en.pdf, accessed on September 13, 2013. (EU10)
10. SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks). Health effects of exposure to EMF. European Commission Health & Consumer Protection Directorate-General, 2009.
http://ec.europa.eu/health/ph_risk/committees/04_scenihr/docs/scenihr_o_022.pdf, accessed September 5, 2013. (EU-09)
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<http://www.icnirp.de/documents/RFReview.pdf>, accessed on September 5, 2013. (ICNIRP-09)
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<http://www.ncrppublications.org/Commentaries/18>, accessed on September 17, 2013. (USA-03)
15. Maximum exposure levels to radiofrequency fields 3 kHz to 300 GHz. Radiation Protection Series Number 3, Australian Radiation Protection and Nuclear Safety Agency, 2002. <http://www.arpansa.gov.au/Publications/codes/rps3.cfm>, accessed on September 13, 2013. (Aust-02)
16. Ministry for the Environment, in partnership with the Ministry of Health. National guidelines for managing the effects of radiofrequency transmitters. The Ministry for the Environment, 2000. <http://www.mfe.govt.nz/publications/rma/radio-freq-guidelines-dec00.html>, accessed on September 24, 2013. (NZ-00)

APPENDIX B: Glossary

| Terminology | Definition |
|-------------------------|--|
| acoustic neuroma | Also called a vestibular schwannoma, it is a benign primary intracranial tumor of the myelin-forming cells of the vestibulocochlear nerve (8th cranial nerve). A type of schwannoma, this tumor arises from the Schwann cells responsible for the myelin sheath that helps keep peripheral nerves insulated. |
| behavioral effects | In RF studies, this may refer to many aspects of animal and human behavior; in this review, it refers to general behavior in people, especially children, such as the ability to concentrate on tasks or follow directions. |
| cognitive effects | These include effects on conscious mental activities such as thinking, understanding, learning, and remembering. |
| electrosensitivity | A common name for the phenomenon in which some people are sensitive to the presence of electromagnetic fields, either to RF fields, or to other parts of the EMF spectrum. Electrosensitivity is associated with a very wide range of symptoms, including some which are clinically observable, such as skin rashes and heart rate variability. Some medical organizations have termed this phenomenon "idiopathic environmental intolerance attributed to electromagnetic fields" (IEI-EMF) to reflect the fact that the actual cause of the symptoms is unknown. |
| glioma | A glioma is a type of tumor that starts in the brain or spine. |
| meningioma | Meningiomas are a diverse set of tumors arising from the meninges, the membranous layers surrounding the central nervous system. |
| nerve conduction | The electrical conduction of nerve cells in either the peripheral or central nervous systems. Usually measured with an electroencephalogram (EEG) or a test of event-related potential (ERP). |
| power density | The rate at which energy from an electromagnetic field is absorbed by human tissue. |
| precautionary principle | There are many definitions of this concept; all of them express the idea that when there is evidence that a particular exposure is harmful, people or governments need not wait for proof of harm before taking steps to limit exposure. |
| RF | RF is an acronym for radiofrequency, part of the electromagnetic spectrum. |
| Wi-Fi | Wi-Fi stands for "wireless fidelity"; Wi-Fi is a popular technology that allows an electronic device to exchange data or connect to the internet wirelessly using radio waves. |