



BC Centre for Disease Control  
An agency of the Provincial Health Services Authority

April 13, 2012

*Dear Members of the BC Environmental Health Policy Advisory Committee,*

**Re: Review of sections of the Radiofrequency Toolkit prepared by EHS/BCCDC**

As presented by Tom Kosatsky at your meeting of March 28, Environmental Health Services of BCCDC requests your help in making our toolkit for contextualizing and responding to physical and health concerns associated with radiofrequency electromagnetic fields, of greatest use to you.

The purpose of the toolkit is to offer a summary of current scientific information on RF issues, to which health officers and decision makers can refer when responding to public queries. It consists of 15 sections, please refer to the attached RF Outline. The chapters contain summaries and evaluations of the scientific and technical literature on specific aspects of interest related to radiofrequency electromagnetic waves.

The plan is to solicit reviews of two sections of the toolkit every two weeks. We would appreciate your comments on the focus and usefulness of each chapter as well as specific suggestions and queries on the material covered.

Please find attached the following sections:


- Section 2: Physics of Radiofrequency Electromagnetic Fields
- Section 11: Cognitive and Neurophysiologic Effects of RF


As an initial step in the review process, could you please send us any questions, concerns or comments pertaining to the contents of these initial two sections by April 22<sup>nd</sup>.

To allow for group discussion of issues related to these two sections, a conference call will be organized tentatively for April 25<sup>th</sup>. You are welcome to invite an additional participant to the discussion.

You will have the opportunity to send any detailed edits or further comments up to one week after the conference call. The written comments and discussion will be taken into consideration when revising the draft chapters.

Your contribution to the toolkit is gratefully appreciated.

  
\_\_\_\_\_  
Dr. Rachid Zitouni  
Provincial Radiation Specialist  
Environmental Health Services

  
for \_\_\_\_\_  
Dr. Helen Ward  
Environmental Health Scientist  
National Collaborating Centre for Environmental Health

Attach.

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# OUTLINE

*February 23, 2012*

## **RADIO-FREQUENCY ELECTROMAGNETIC FIELDS: What is it, how it is measured, biological and human health effects, how it is managed**

### **1. Introduction**

Why this report was written

- RF devices are used extensively for domestic, medical, and industrial purposes
- Information on RF and RF safety is abundant but broadly scattered, technically complex, and not easily understood by health professionals and the general public
- The variety of RF emitting devices differ in terms of frequency, power, and continuity of output; there are also differences in the distance between individuals and the various RF-emitting devices: the public tends to see RF as a single issue
- Reports of health effects associated with RF are inconsistent and there is extensive debate among reputable authorities as to their interpretation
- Conflicting reports about RF safety generate concerns among the general public
- There is a need to support public health policy makers and practitioners around RF safety issues on the basis of scientific evidence

For whom the report was written

- Health Officers
- Decision makers
- Users of RF devices in medicine and the industry
- Indirectly to the general public, through the groups above

Limits of the report

- Information is provided on the basis of existing knowledge in a field that is rapidly changing, in terms of the specifications of RF emitting devices, the degree and manner to which they are used, and health information related to them
- The many attributes of this issue require a multi-disciplinary approach, which we have attempted to cover, albeit unequally, and given time and resource limitations

### **2. Physics of radiofrequency electromagnetic fields**

- Nature and characteristics of radiofrequency waves
- The electro-magnetic spectrum
- Where RF waves fit on the EM spectrum; physical characteristics of RF waves
- Propagation of RF waves (reflectance; addition; interference; effect of medium — solid, water, air — through which waves are transmitted)
- RF quantities and units (emitted versus absorbed RF energy) (concept of effective power)
- Important characteristics of RF sources:
  - Frequency range

- Nominal power
- Duty cycle
- Pulsed and continuous beams
- Exposure to multiple RF fields:
  - EMF interferences
  - Additive and subtractive effects

### **3. Sources of RF fields (spectrum, power, directionality) and evolution of technology**

- Is there "natural" RF radiation?
- Is RF a part of biologic systems?
- Cell phones and base stations
- Baby monitors, cordless phones, and other appliances that communicate through RF
- WiFi Systems: computers and access points
- Smart Meter Systems: smart meters and collectors; general principles and characteristics specific to meter types
- AM and FM radio, TV, others
- Microwave ovens and other home appliances, which emit RF or other EMF
- EMF emission other than RF by RF emitting devices
- Comparison of different RF Sources: Frequency, Nominal Power, E Fields, H Fields, power density (focus on cell phones vs others)
- Sources of pulsed vs continuous wave RF
- Effects of change in technology, environment, and practices on power output

### **4. Detection and measurement of RF waves**

- RF detection techniques
- RF survey meters
- SAR measurements
- Individual RF monitors
- Limits of detection and their consequences for assessment of exposure

### **5. Exposure assessment**

- Assessment of exposure to RF-EMF for an individual using RF-emitting devices or within or passing through a field of RF-EMF
- Exposure measurements of different RF-emitting devices and technologies: cell phones, base stations, cordless phones, WiFi systems, etc. (see Section 3)
- Assessments of individual exposure: whole body, head, limbs, other organs
- Models of exposure in children versus adults and discussion of effects on dose.
- Discussion of exposures from devices relative to one another (eg., cell phones vs WiFi systems) and other factors that may affect exposure (eg, environment, metal accessories).

## **6. Effects of RF on biological tissue (contractor)**

- Objective is to identify biological processes which suggest the potential for adverse health outcomes or which may suggest mechanisms for health effects
- An overview and critique of published literature will include:
  - Endpoints such as genotoxicity, cancer-relevant non-genotoxic endpoints, gene and protein expression, nervous system and other physiological effects, induced animal carcinogenicity
  - Thermal and non-thermal effects
  - Exposure considerations — differences due to technologies used; realistic levels?
  - Dose: measured or estimated appropriately?
  - Hypothesized mechanisms?
  - Differences in biological effects and proposed mechanisms of action relating to exposures from different technologies, eg, 1G through 4G, frequency- vs code- vs time-delineated, pulsed vs continuous, and peak handovers vs soft handovers
  - Discussion of relevance of these general results of these studies to potential health effects
  - Limitation of study methods to evaluate biological effects from RF (eg, inability to simulate real-world exposures that include environmental conditions, moving/not moving, base station densities)
- Recommendations for further study of biological effects (reference to expert documents)

## **7. The Use of RF Waves in Medicine and their Effects on Patients**

- Radiofrequency applications in medicine
  - Medical Imaging: Magnetic Resonance Imaging
  - Interventional Cardiology: Radiofrequency Ablation
  - Physiotherapy
  - Tumor Therapy: RF tumor treatment
- Frequency and Power of RF Machines Used in Medicine
- Effects of Radiofrequency Waves on Patients
  - Thermal Effects
  - Non Thermal Effects
- Patient Protection in Medical RF
  - General Guidelines
  - Rules Applicable to Pregnant Patients for the Protection of the Fetus
  - Protection of Pediatric Patients

## **8. Occupational Exposure to Radiofrequency Waves**

- Industrial Applications of Radiofrequency Waves
- Occupational Risks associated with RF Sources
- Current Canadian and International RF Occupational Safety Regulations and Standards
- Protection of Workers against RF waves:
  - Occupational Exposure: Current Limits and ALARA
  - Practical Protection

## 9. RF and Cancer

- Objective is to evaluate the findings of recent literature reviews (published from 2006-2011) on the association of exposure to RF-EMF with brain tumors and other cancers
- Brain tumors considered include malignant gliomas, meningiomas, acoustic neuromas and tumors of the salivary glands
- Reviews are compared based on type (systematic or not), study periods covered, number of studies searched and selected, type of exposures considered, specific outcomes assessed and if a meta-analysis was done
- For each type of tumor or cancer evaluated, overall risk estimates if meta-analysis or pooled estimates were calculated; otherwise reference to summary descriptions

Grouped risk estimates for ipsilateral (versus contralateral use) and for >10 years latency

- Similarities and differences between the summary estimates for the reviews assessed
- Evaluation of potential biases associated with the identification and selection of reviews
  - confounding and selection and recall bias
  - difficulties in exposure ascertainment and the impact of technology changes
  - consideration of latency period relevant for cancer induction
  - (reference to expert commentaries on RF and Cancer)
  - **Limitations of existing studies in assessing risks by RF emitter type**
  - research gaps (reference to expert documents)
  - priorities for studies of longer-term exposures to RF-EMF
  - studies of vulnerable populations, including children

## 10. Effects of RF on male reproductive function

- Introduction
- Search strategy
- Effect of RF on male infertility
  - a. Human studies
    - 1. Epidemiological
    - 2. In vitro (semen)
      - i. Limitations of human studies
      - ii. Conclusions of studies on humans
  - b. Animal studies
    - 1. Rat, mouse, rabbit
      - i. Limitations of animal studies
      - ii. Animal conclusions
  - c. Non semen/sperm focused studies
- Possible mechanisms
  - a. thermal
  - b. non-thermal

1. oxidative stress
  2. DNA damage
  3. membrane potential and integrity
  4. upstream effects
- Limitations of the existing study base
  - Overall assessment

## **11. Cognitive and neurophysiologic effects of RF**

The purpose is to assess the current literature concerning the effects of RF-EMF exposure on cognitive function

- Content
  - strategy for searching the most recent review literature on neurophysiology and neurobehavioral testing
  - including studies on neurophysiology (EEG), auditory processing, cerebral flow and volume (PET scans) and neurobehavioral testing of attention and memory
  - comparing the study design and outcomes of two recent primary studies from each study area
  - considering only experimental designs of healthy normal volunteers and "real world" cell phone exposure to RF-EMF
  - evaluating effects of technology of exposures to RF-EMF, such as use of 2G (GSM, pulsed signals) versus 3G (UMTS) cell-phones
  - assessing consistency and contradictions in study findings
  - determining if cognitive performance corresponds to changes in neurophysiological parameters
  - considering biologically plausible mechanisms which may support the possibility of cognitive effects
  - inferring if subtle biological changes in cognitive function are indicative of adverse health outcomes.
- Exploring gaps in the literature (reference to expert assessments)

## **12. Electro-hypersensitivity (EHS) and RF**

- Introduction
- Search strategy
- Definitions of electrohypersensitivity
- Estimates of the prevalence of EHS
- Evidence linking EHS with RF
  - cross-sectional
  - cohort
  - experimental
- Nocebo effects
- Expert comments
- Limits of evidence

**13. Reference, guideline, and regulatory standards for Exposure to RF Fields**

- ICNIRP Recommendations
- Canadian Safety Code 6—history, risk assessment, safety margin, implementation
- (US Codes, OSHA, FCC) (Examples of similar and different limits)
- Maximum SAR (measured in required tests) vs. typical use SAR

**14. Strategies for exposure reduction by emitter type**

- Adults
- Children and youth
- Pregnant women and the fetus
- Strategies can include avoidance, limited use, distance, choice of technology, etc.

**15. Ongoing Research**

- World Health Organization EMF Project
- MOBI-KIDS – International study on communication technology, environment and brain tumors in young people
- Others

## Kendall, Perry HLTH:EX

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**From:** Kosatsky, Tom [Tom.Kosatsky@bccdc.ca]  
**Sent:** Wednesday, August 8, 2012 4:04 PM  
**To:** Kendall, Perry HLTH:EX  
**Cc:** Young, Eric R HLTH:EX  
**Subject:** RE: Delivery of scientific studies on the damaging effects of EMR.  
**Attachments:** Articles received (4t).docx

Note re articles on RF.

Dr. Tom Kosatsky  
Medical Director,  
Environmental Health Services  
Scientific Director,  
National Collaborating Centre for Environmental Health BC Centre for Disease Control  
Ph: 604-707-2447  
Fx: 604-707-2441  
Email: tom.kosatsky@bccdc.ca  
Website: www.bccdc.ca

-----Original Message-----

**From:** Kendall, Perry HLTH:EX [mailto:Perry.Kendall@gov.bc.ca]  
**Sent:** August 8, 2012 3:54 PM  
**To:** Kosatsky, Tom  
**Cc:** Eric.Young@gov.bc.ca  
**Subject:** Re: Delivery of scientific studies on the damaging effects of EMR.

Many thanks, Tom.  
Perry

Sent from my iPad

On 2012-08-08, at 3:32 PM, "Kosatsky, Tom" <Tom.Kosatsky@bccdc.ca> wrote:

> Hi Perry,  
> We can include a comment of that sort.  
> Will send shortly.  
>  
> The BCCDC toolkit is ever closer to being ready to send out.  
> Four sections are left to present for group review, others need additional revision after review. My guess is that the full product will be ready to send out by Halloween---doubt all will find it a treat. Important to recognize that the aim of the toolkit is to guide an informed response to a concerned public, and provide the basis for informed policy making, rather than serve itself as a policy document.  
> Happy to discuss when you are back.  
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>  
>  
> Dr. Tom Kosatsky  
> Medical Director,  
> Environmental Health Services  
> Scientific Director,



> National Collaborating Centre for Environmental Health BC Centre for  
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> Ph: 604-707-2447  
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> Website: www.bccdc.ca

> -----Original Message-----

> From: Kendall, Perry HLTH:EX [mailto:Perry.Kendall@gov.bc.ca]  
> Sent: August 8, 2012 3:09 PM  
> To: Kosatsky, Tom  
> Cc: Eric.Young@gov.bc.ca; Foster, Nick  
> Subject: Re: Delivery of scientific studies on the damaging effects of EMR.

> So Tom, this response is not in any way ready to be a response to the contents of the  
articles that were sent to me. For example it would be possible for the ?BCCDC reviewers to  
say that they have looked at these articles and the relevant ones will be included in their  
review which will be available ..... In the interim these articles do or do not give any  
reason to change our assessment of risk???

> When will the NCCEH overview of health effects be ready?

> PK

S22

> Sent from my iPad

> On 2012-08-08, at 2:32 PM, "Kosatsky, Tom"  
<Tom.Kosatsky@bccdc.ca<mailto:Tom.Kosatsky@bccdc.ca>> wrote:

> Hi Perry,

S22

> Attached is a review of our assessment of the hard-copy articles with which you were  
presented.

> Thanks,

> t

> Dr. Tom Kosatsky  
> Medical Director,  
> Environmental Health Services  
> Scientific Director,  
> National Collaborating Centre for Environmental Health BC Centre for  
> Disease Control  
> Ph: 604-707-2447  
> Fx: 604-707-2441  
> Email: tom.kosatsky@bccdc.ca<blocked::mailto:tom.kosatsky@bccdc.ca>  
> Website: www.bccdc.ca<blocked::http://www.bccdc.ca/>

> From: Kendall, Perry HLTH:EX [mailto:Perry.Kendall@gov.bc.ca]

> Sent: May 11, 2012 10:10 AM

> To: 'Steve Satow'

> Cc: Kosatsky, Tom;

> Sheila.Kowalewsky@gov.bc.ca<mailto:Sheila.Kowalewsky@gov.bc.ca>

> Subject: RE: Delivery of scientific studies on the damaging effects of EMR.

> Thank you for this information. I shall be referring the materials you sent me to Dr Tom  
Kosatsky at the National Collaborating Centre for Environment and Health, in order for them

to be reviewed and ensure they have been included in the comprehensive review of biologic and health effects of RF exposures.

> Sincerely  
 > Perry Kendall  
 >  
 >  
 > P. R. W. Kendall  
 > OBC, MBBS, MSc, FRCPC  
 > Provincial Health Officer  
 > Ministry of Health  
 > 4th Floor, 1515 Blanshard Street  
 > Victoria BC V8W 3C8  
 > Phone: 250 952-1330  
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 > http://www.health.gov.bc.ca/pho<http://www.healthservices.gov.bc.ca/ph  
 > o>  
 >  
 > From: Steve Satow [mailto: S22  
 > Sent: Tuesday, May 8, 2012 8:57 PM  
 > To: Kendall, Perry HLTH:EX  
 > Subject: Delivery of scientific studies on the damaging effects of EMR.  
 >  
 >  
 > Dear Dr. Kendall,  
 >  
 > This email is to inform you that supporters of  
 StopSmartMeters.ca<http://StopSmartMeters.ca> will be delivering to you more than 160  
 scientific studies and articles related to the harmful effects of Electromagnetic radiation  
 on biological systems.  
 >  
 > This event will take place between 12.00 PM and 1.00 PM on Wednesday May 9th at your  
 offices at 1515 Blanshard Street, Victoria.  
 >  
 > Prior to the delivery of these documents, there will be a series of statements made to the  
 media regarding your refusal to acknowledge any evidence of harmful effects and calling on  
 you to invoke the Precautionary Principle in the face of overwhelming scientific evidence and  
 mounting public concerns.  
 >  
 > We invite you to attend in order to make your own statement to the press if you so desire,  
 and also to personally take receipt of the documents.  
 >  
 > Yours Sincerely,  
 >  
 > Steve Satow  
 > President: the StopSmartMeters.ca<http://StopSmartMeters.ca> Society  
 >  
 >  
 >  
 > <Articles received (3t).docx>

Dear Dr. Kendall,

I write to follow up on BCCDC's incorporation of the articles you forwarded to BCCDC into our public health toolkit on the health effects of radiofrequency. The printed articles were received in May 2011. Most covers contained the first page and abstract of an article to do with effects of radiofrequency (RF) exposure; some complete articles were also included.

All articles were divided into the following categories according to the subject area:

- 1) Cardiovascular and Hearing effects – these 15 articles were on topics which were not covered by the RF toolkit.
- 2) Biological Effects –the majority of articles received were in this category, and most were animal studies. The articles were forwarded to the author of Section 6 on Biological Effects, currently under development, to determine their relevance. Only recent articles (since 2005) are being included in the RF toolkit section.
- 3) General reviews, e.g. public health implications - There is no specific RF toolkit section on public health, however these will be considered for the addition of general references regarding reviews of the health effects, including standards of exposure to RF waves.
- 4) Health symptoms – For the section on health symptoms, of the 3 primary articles received one was excluded from a recent meta-analysis for not adjusting for confounders and one was published over 20 years ago. The author of the third article had a more recent study cited in a review.
- 5) Neurophysiology and Cognitive performance - The RF toolkit section 11 incorporated recent published reviews on brain activity and neurobehavioral testing from 2009. A number of the articles received covered topics not included in this section. These include one study of children's behavioural problems, one on electrodermal activity and three on sleep effects. Two articles were written in Chinese. No reviews were received, but 7 of 9 primary articles received on brain activity had been included in the reviews as were 2 of 5 articles on different aspects of neurobehavioral testing.
- 6) Reproductive risks – Ch 19 is on epidemiological studies as well as in vitro human and animal studies published since 2005. Two studies on developmental and sexual behaviour of animal models are not relevant to this toolkit section. The 3 epidemiological studies, 2 human in vitro studies and 3 animal studies received were already described in Section 10. The review by Desai (2009) is being added.
- 7) Cancer risk - Section 9 of the RF toolkit on the risk of brain tumours and cancer included review articles of case-control and other epidemiological studies published since 2006 on the association of exposure from mobile phones with specific types of brain tumours, with tables on the findings of individual studies cited by the reviews. Two studies were on EMF exposures not specific to RF. All 17 primary epidemiological studies on this topic were either already described in the section, or were cited in an included review. A review article of cell phone use and acoustic neuroma by Han et al. (2009) was added to the toolkit, as was the discussion from the review by Myung et al (2009) on mobile phone use and risk of tumours.

As detailed above, all of the articles received have been scanned and any which our group had not reviewed previously as part of our toolkit have been incorporated where they meet generally accepted research standards. As with a number of international agencies, our group has reviewed hundreds of research articles on the health effects of RF; we do appreciate the addition of several articles which we had not ourselves identified. I would say that the addition of these articles has not changed the nature of our assessment of the health effects of RF, an assessment which is generally compatible with recent reviews by UK and Swiss health authorities.

Tom Kosatsky

Medical Director, Environmental Health, BCCDC

August 8, 2012