Epidemiological Studies of Potential Health Risks of Mobile Phones

Daniel Krewski, PhD MHA
Professor and Director
McLaughlin Centre for
Population Health Risk Assessment

October 20, 2009

Université d'Ottawa | University of Ottawa

uOttawa

L'Université canadienne
Canada's university

www.uOttawa.ca

Epidemiological Studies

- 48 epidemiological studies identified through searches of electronic databases, peer-reviewed scientific journals, web resources, and other sources up to May 31, 2008
- Ecologic, hospital-based case-control, population-based case-control, cohort, pooled-analysis, meta-analysis
- Evaluated for consistency, temporality, dose-response, exposure assessment, sample size, participant selection and recruitment
- Little clear evidence for an association between handheld cellular telephone use and tumours of the head and neck

Summary of Studies of Glioma

Reference, Country	Endpoint	Longest duration of use	
		n cases (%)	OR (95% CI)
Cohort Studies			
Johansen et al. (2001), Denmark	Glioma	66	0.94 (0.72-1.20)*
Schuz et al. (2006b), Denmark	Glioma	257	1.01 (0.89-1.14)*
Hospital-based Studies			
Muscat et al. (2000), USA	Malignant brain tumours	17 (4%)	0.7 (0.4-1.4)
Inskip et al. (2001), USA	Glioma	11 (2%)	0.6 (0.3-1.4)
Population-based Studies			
Auvinen et al. (2002), Finland	Glioma	11 (5%)	1.7 (0.9-3.5)
INTERPHONE			
Christensen et al. (2005), Denmark	Low-grade glioma High-grade glioma	6 (7%) 8 (5%)	1.64 (0.44-6.12) 0.48 (0.19-1.26)
Lonn et al. (2005), Sweden	Glioma	22 (6%)	0.9 (0.5-1.6)
Hepworth et al. (2006), UK	Glioma	48 (5%)	1.14 (0.74-1.73)
Schuz et al. (2006a), Germany	Glioma	12 (3%)	2.20 (0.94-5.11)
Klaeboe et al. (2007), Norway	Glioma	55 (19%)	0.7 (0.4-1.2)
Pooled INTERPHONE Studies			
Lahkola et al. (2007), Denmark, Finland, Norway, Sweden, SE England	Glioma	88 (6%)	0.94 (0.69-1.28)
Meta-Analysis			
Lahkola et al. (2006)	Glioma	-	0.96 (0.78-1.18)

* Overall results presented.

Summary of Studies of Meningioma

Reference, Country	Endpoint	Longest duration of use	
		n cases (%)	OR (95% CI)
Cohort Studies			
Johansen et al. (2001), Denmark	Meningioma	16	0.86 (0.49-1.40)*
Schuz et al. (2006b), Denmark	Meningioma	68	0.86 (0.67-1.09)*
Hospital-based Studies			
Inskip et al. (2001), USA	Meningioma	6 (3%)	0.9 (0.3-2.7)
Population-based Studies			
Auvinen et al. (2002), Finland	Meningioma	2 (2%)	0.8 (0.2-3.5)
INTERPHONE			
Christensen et al. (2005), Denmark	Meningioma	6 (3%)	1.02 (0.32-3.24)
Lonn et al. (2005), Sweden	Meningioma	8 (3%)	0.7 (0.3-1.6)
Schuz et al. (2006a), Germany	Meningioma	5 (1%)	1.09 (0.35-3.37)
Klaeboe et al. (2007), Norway	Meningioma	28 (14%)	1.2 (0.6-2.2)
Meta-Analysis			
Lahkola et al. (2006)	Meningioma	-	0.87 (0.72-1.05)

* Overall results presented.

Summary of Studies of Acoustic Neuroma

Reference, Country	Endpoint	Longest duration of use	
		n cases (%)	OR (95% CI)
Cohort Studies			
Johansen et al. (2001), Denmark	Nerve sheath tumours	7	0.64 (0.26-1.32)*
Schuz et al. (2006b), Denmark	Nerve sheath tumours	32	0.73 (0.50-1.03)*
Hospital-based Studies			
Inskip et al. (2001), USA	Acoustic Neuroma	5 (5%)	1.9 (0.6-5.9)
Muscat et al. (2002), USA	Acoustic Neuroma	11 (12%)	1.7 (0.5-5.1)
INTERPHONE			
Christensen et al. (2004), Denmark	Acoustic Neuroma	2 (2%)	0.22 (0.04-1.11)
Lonn et al. (2004b), Sweden	Acoustic Neuroma	11 (7%)	1.6 (0.7-3.6)
Takebayashi et al. (2006), Japan	Acoustic Neuroma	4 (4%)	0.79 (0.24-2.65)
Klaeboe et al. (2007), Norway	Acoustic Neuroma	7 (16%)	0.5 (0.2-1.5)
Pooled INTERPHONE Studies			
Schoemaker et al. (2005), Denmark, Finland, Norway, Sweden, UK	Acoustic Neuroma	31 (5%)	1.1 (0.7-1.8)
Meta-Analysis			
Lahkola et al. (2006)	Acoustic Neuroma	-	1.07 (0.89-1.30)

* Overall results presented.

Authoritative Reviews

Report	Conclusion
Health Council of the Netherlands (2005)	"No potential adverse effects could be identified from the introduction of new telecommunication systems."
Health Physics Society (2006)	"There is no reason to believe that cellular base station towers could constitute a potential health hazard to nearby residents or students."
The USA Food and Drug Administration (2005)	"There is no hard evidence of adverse health effects on the general public. With regards to the safety and use of cell phones by children, the scientific evidence does not show a danger to users of wireless communication devices including children."
WHO Working Group (Valberg et al., 2007)	"Despite unavoidable uncertainty, current scientific data are consistent with the conclusion that public exposures to permissible RF levels from mobile telephony and base stations are not likely to adversely affect human health."

World Health Organization INTERPHONE Study

uOttawa

L'Université canadienne
Canada's university

Université d'Ottawa | University of Ottawa

www.uOttawa.ca

WHO INTERPHONE Study

Eur J Epidemiol
DOI 10.1007/s10654-007-9152-z

ORIGINAL PAPER

The INTERPHONE study: design, epidemiological methods, and description of the study population

Elisabeth Cardis · Lesley Richardson · Isabelle Deltour · Bruce Armstrong · Maria Feychting · Christoffer Johansen · Monique Kilkenny · Patricia McKinney · Baruch Modan · Siegal Sadetzki · Joachim Schüz · Anthony Swerdlow · Martine Vrijheid · Anssi Auvinen · Gabriele Berg · Maria Blettner · Joseph Bowman · Julianne Brown · Angela Chetrit · Helle Collatz Christensen · Angus Cook · Sarah Hepworth · Graham Giles · Martine Hours · Ivano Iavarone · Avital Jarus-Hakak · Lars Klaeboe · Daniel Krewski · Susanna Lagorio · Stefan Lönn · Simon Mann · Mary McBride · Kenneth Muir · Louise Nadon · Marie-Elise Parent · Neil Pearce · Tiina Salminen · Minouk Schoemaker · Brigitte Schlehofer · Jack Siemiatycki · Masao Taki · Toru Takebayashi · Tore Tynes · Martie van Tongeren · Paolo Vecchia · Joe Wiart · Alistair Woodward · Naohito Yamaguchi

Study Design

- Prospective international case-control study, involving 13 countries
- Cases:
  - 2,765 glioma
  - 2,425 meningioma
  - 1,121 acoustic neuroma
  - 109 malignant parotid gland
- Controls:
  - 7,658
  - Matched on year of birth (5-year groups), sex, study region

Methodology

- CAPI questionnaire
- Validation studies
  - Prospective validation using software modified phones (SMPs)
  - Retrospective validation using service provider billing records
- Tumour localization
- RF exposure gradients

ORIGINAL ARTICLE

Validation of short term recall of mobile phone use for the Interphone study

M Vrijheid, E Cardis, B K Armstrong, A Auvinen, G Berg, K G Blaasaas, J Brown, M Carroll, A Chetrit, H C Christensen, I Deltour, M Feychting, G G Giles, S J Hepworth, M Hours, I Iavarone, C Johansen, L Klæboe, P Kurttio, S Lagorio, S Lönn, P A McKinney, L Montestrucq, R C Parslow, L Richardson, S Sadetzki, T Salminen, J Schüz, T Tynes, A Woodward, for the Interphone Study Group

Occup Environ Med 2006;**63**:237–243. doi: 10.1136/oem.2004.019281

Aim: To validate short term recall of mobile phone use within Interphone, an international collaborative case control study of tumours of the brain, acoustic nerve, and salivary glands related to mobile telephone use.
Methods: Mobile phone use of 672 volunteers in 11 countries was recorded by operators or through the use of software modified phones, and compared to use recalled six months later using the Interphone study questionnaire. Agreement between recalled and actual phone use was analysed using both categorical and continuous measures of number and duration of phone calls.
Results: Correlations between recalled and actual phone use were moderate to high (ranging from 0.5 to 0.8 across countries) and of the same order for number and duration of calls. The kappa statistic demonstrated fair to moderate agreement for both number and duration of calls (weighted kappa ranging from 0.20 to 0.60 across countries). On average, subjects underestimated the number of calls per month (geometric mean ratio of recalled to actual = 0.92, 95% CI 0.85 to 0.99), whereas duration of calls was overestimated (geometric mean ratio = 1.42, 95% CI 1.29 to 1.56). The ratio of recalled to actual use increased with level of use, showing underestimation in light users and overestimation in heavy users. There was substantial heterogeneity in this ratio between countries. Inter-individual variation was also large, and increased with level of use.
Conclusions: Volunteer subjects recalled their recent phone use with moderate systematic error and substantial random error. This large random error can be expected to reduce the power of the Interphone study to detect an increase in risk of brain, acoustic nerve, and parotid gland tumours with increasing mobile phone use, if one exists.

See end of article for authors' affiliations

Correspondence to: Dr M Vrijheid, International Agency for Research on Cancer (IARC), 150, Cours Albert Thomas, 69372 Lyon Cedex 08, France; vrijheid@iarc.fr

Accepted 27 October 2005

Recalled/Actual Cellular Phone Use

Study	Number of Calls	Call Duration
Prospective Validation (SMPs)	0.92 (controls)	1.42 (controls)
Retrospective Validation* (billing records)	0.81 (cases) 0.81 (controls)	1.40 (cases) 1.39 (controls)

*Vrjheid et al. (2008). *Journal of Exposure Science and Environmental Epidemiology*, to appear.

Participation Rates

• Glioma	65% (37%-92%)
• Meningioma	78% (57%-92%)
• Acoustic neuroma	82% (70%-100%)
• Malignant parotid gland	75% (wide range)
• Controls	53% (35%-74%)

Journal of Exposure Science and Environmental Epidemiology (2006), 1–14

www.nature.com/jes

The effects of recall errors and of selection bias in epidemiologic studies of mobile phone use and cancer risk

MARTINE VRIJHEID[a], ISABELLE DELTOUR[a], DANIEL KREWSKI[a,b], MARIE SANCHEZ[a] AND ELISABETH CARDIS[a]

[a]*International Agency for Research on Cancer, Lyon, France*
[b]*McLaughlin Centre for Population Health Risk Assessment, University of Ottawa, Ottawa, Ontario, Canada*

This paper examines the effects of systematic and random errors in recall and of selection bias in case–control studies of mobile phone use and cancer. These sensitivity analyses are based on Monte–Carlo computer simulations and were carried out within the INTERPHONE Study, an international collaborative case–control study in 13 countries. Recall error scenarios simulated plausible values of random and systematic, non-differential and differential recall errors in amount of mobile phone use reported by study subjects. Plausible values for the recall error were obtained from validation studies. Selection bias scenarios assumed varying selection probabilities for cases and controls, mobile phone users, and non-users. Where possible these selection probabilities were based on existing information from non-respondents in INTERPHONE. Simulations used exposure distributions based on existing INTERPHONE data and assumed varying levels of the true risk of brain cancer related to mobile phone use. Results suggest that random recall errors of plausible levels can lead to a large underestimation in the risk of brain cancer associated with mobile phone use. Random errors were found to have larger impact than plausible systematic errors. Differential errors in recall had very little additional impact in the presence of large random errors. Selection bias resulting from underselection of unexposed controls led to J-shaped exposure–response patterns, with risk apparently decreasing at low to moderate exposure levels. The present results, in conjunction with those of the validation studies conducted within the INTERPHONE study, will play an important role in the interpretation of existing and future case–control studies of mobile phone use and cancer risk, including the INTERPHONE study. *Journal of Exposure Science and Environmental Epidemiology* advance online publication, 14 June 2006; doi:10.1038/sj.jes.7500509

Keywords: *mobile phones, recall bias, measurement error, selection bias, sensitivity analyses, Monte–Carlo simulations, case–control studies.*

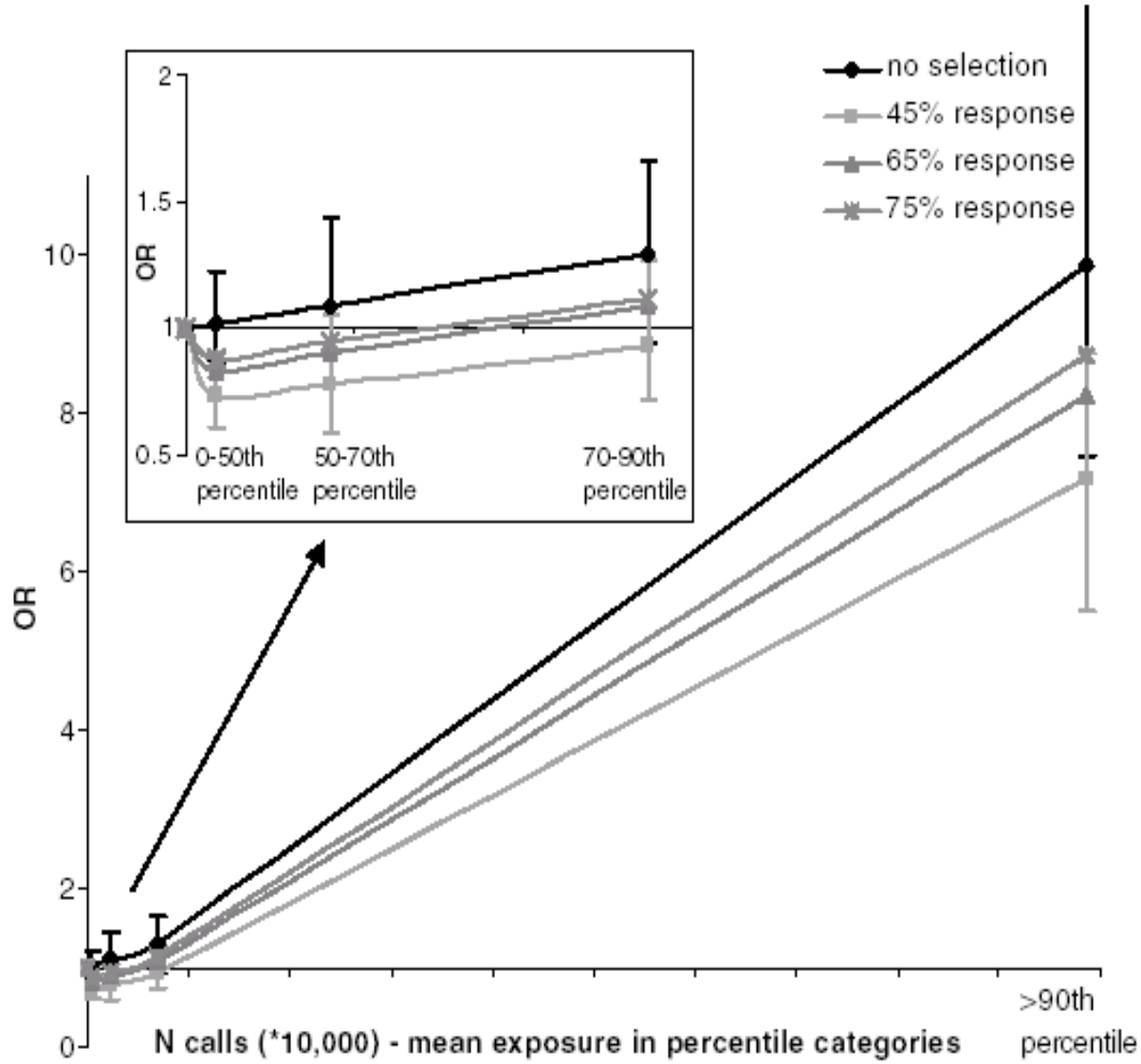


Figure 1. J-shaped exposure–response relationship in the case of underselection of unexposed controls, based on 64% users among participants, 50% among non-participants. (see Table 7 for values of the ORs).

IOP PUBLISHING PHYSICS IN MEDICINE AND BIOLOGY

Phys. Med. Biol. 53 (2008) 1–13 UNCORRECTED PROOF

Distribution of RF energy emitted by mobile phones in anatomical structures of the brain

E Cardis[1], I Deltour[1], S Mann[2], M Moissonnier[1], M Taki[3,4], N Varsier[4], K Wake[4] and J Wiart[5]

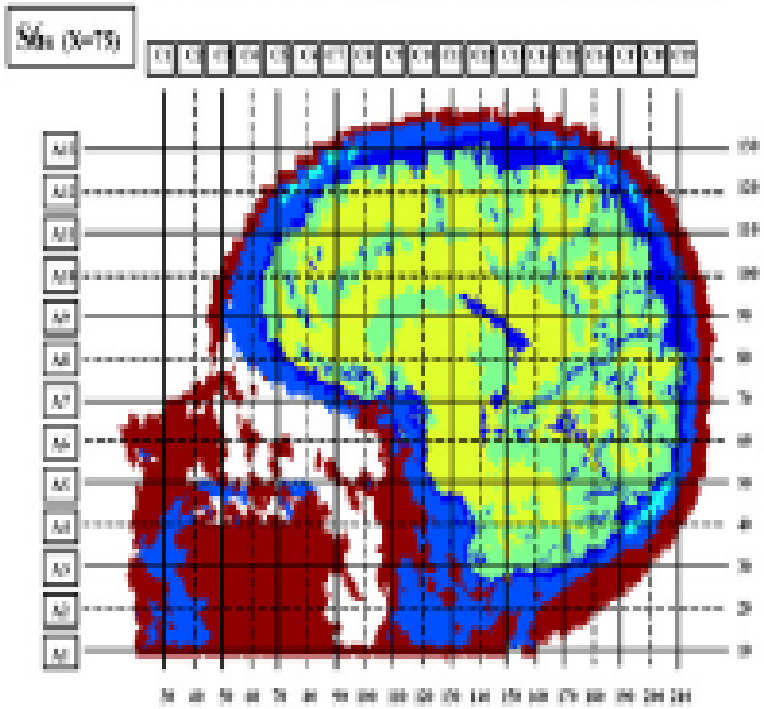
[1] Radiation Group, International Agency for Research on Cancer, 150 cours Albert Thomas, Lyon 69372, France
[2] EMF Dosimetry Group, Health Protection Agency, Centre for Radiation, Chemical and Environmental Hazards, Didcot, OX11 0RQ, UK
[3] Department of Electrical and Electronic Engineering, Tokyo Metropolitan University, 1-1, Minami-Osawa, Hachioji, Tokyo 192-0397, Japan
[4] EMC Group, Applied Electromagnetic Research Center, National Institute of Information and Communications Technology, 4-2-1 Nukui-Kitamachi, Koganei 184-8795, Tokyo, Japan
[5] France Telecom RD 38-40, rue du General Leclerc, 92794 Issy-les-Moulineaux Cedex 9, France

Received 18 January 2008, in final form 10 March 2008
Published DD MMM 2008

Distribution of RF Energy in the Brain

- “Most (97–99% depending on frequency) appears to be absorbed in the brain hemisphere on the side where the phone is used, mainly (50–60%) in the temporal lobe.”
- “The average relative SAR is highest in the temporal lobe (6–15%, depending on frequency, of the spatial peak SAR in the most exposed region of the brain) and the cerebellum (2–10%) and decreases very rapidly with increasing depth, particularly at higher frequencies.”
- “The SAR distribution appears to be fairly similar across phone models, between older and newer phones and between phones with different antenna types and positions.”

Future Work: Tumour Localization



- Use cartography of the human head to indentify the anatomical origin of brain tumours based on MRI and CT scans
- Link RF exposure gradients with tumour localization data

Identification of Research Needs Relating to Potential Biological and Adverse Health Effects of Wireless Telecommunication Devices

Université d'Ottawa | University of Ottawa

uOttawa

L'Université canadienne
Canada's university

www.uOttawa.ca

MOBI-KIDS

- Multi-national prospective population-based case-control study: "*Risk of brain cancer from exposure to RF in childhood and adolescence*" (similar to INTERPHONE)
- 8 European countries funded by the European Commission
- Other countries (3) (Australia, Canada, and New Zealand) are also part of the consortium, subject to national funding

uOttawa

L'Université canadienne
Canada's university

Conclusions

Université d'Ottawa | University of Ottawa

www.uOttawa.ca

Conclusions

- Cellular telephones remain of concern due to the high prevalence of use and potential impact:
  - prevalence is over 100% in Nordic countries
  - even a small risk could have consequences for public health
- Authoritative reviews have failed to conclude that there is a link between cellular telephone use and health risk
- Await INTERPHONE results
- Initiate research to fill important data gaps (MOBI-KIDS)

NRC Research Recommendations

1. Characterization of exposure to juveniles, children, pregnant women, and fetuses from personal wireless devices and RF fields from base station antennas.
2. Characterization of radiated electromagnetic fields for typical multiple element base station antennas and exposures to affected individuals.
3. Characterization of the dosimetry of evolving antenna configurations for cell phones and text messaging devices.
4. Prospective epidemiologic cohort studies of children and pregnant women.
5. Epidemiologic case-control studies and childhood cancers, including brain cancer.

NRC Research Recommendations

6. Prospective epidemiologic cohort studies of adults in a general population and retrospective cohorts with medium to high occupational exposures.
7. Human laboratory studies that focus on possible adverse effects on electroencephalography activity and that include a sufficient number of subjects.
8. Investigation of the effect of RF electromagnetic fields on neural networks.
9. Evaluation of doses occurring on the microscopic level.
10. Additional experimental research focused on the identification of potential biophysical and biochemical/molecular mechanisms of RF action.

uOttawa

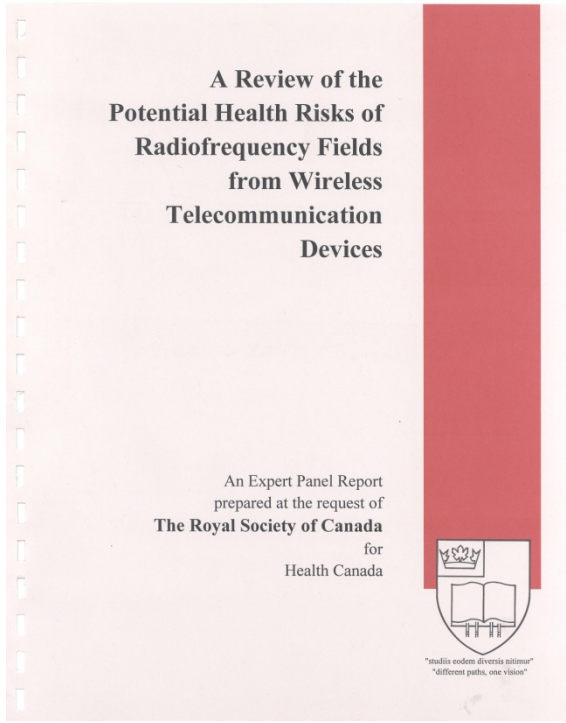
L'Université canadienne
Canada's university

RF Exposure Guidelines

Université d'Ottawa | University of Ottawa

www.uOttawa.ca

Health Canada's Safety Code 6



Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 KHz to 300 GHz

Updates to Royal Society of Canada Report

Journal of Toxicology and Environmental Health, Part B, 10:287–318, 2007

ISSN: 1093-7404 print / 1521-6950 online
DOI: 10.1080/15287390600974973

Taylor & Francis
Taylor & Francis Group

RECENT ADVANCES IN RESEARCH ON RADIOFREQUENCY FIELDS AND HEALTH: 2001–2003

Daniel Krewski[1], Barry W. Glickman[2], Riadh W. Y. Habash[1], Brian Habbick[1], W. Gregory Lotz[3], Rosemonde Mandeville[4], Frank S. Prato[5], Tarek Salem[1], Donald F. Weaver[6]

[1]R. Samuel McLaughlin Center for Population Health Risk Assessment, University of Ottawa, Ottawa, Ontario, Canada, [2]Center for Environmental Health, University of Victoria, Victoria, British Columbia, Canada, [3]Division of Biomedical and Behavioral Science, National Institute for Occupational Health and Safety, Cincinnati, Ohio, USA, [4]Biophage, Inc., Montréal, Québec, Canada, [5]Department of Diagnostic Radiology and Nuclear Medicine and Lawson Health Research Institute, University of Western Ontario, London, Ontario, Canada, and [6]Departments of Chemistry and Medicine, Queen's University, Kingston, Ontario, Canada

Safety Code 6 Exposure Guidelines (W/kg)

Tissue	Workers	General Public
Whole body	0.4	0.08
Head, neck & trunk	8.0	1.60
Limbs	20.0	4.00

Public Perception of Risk

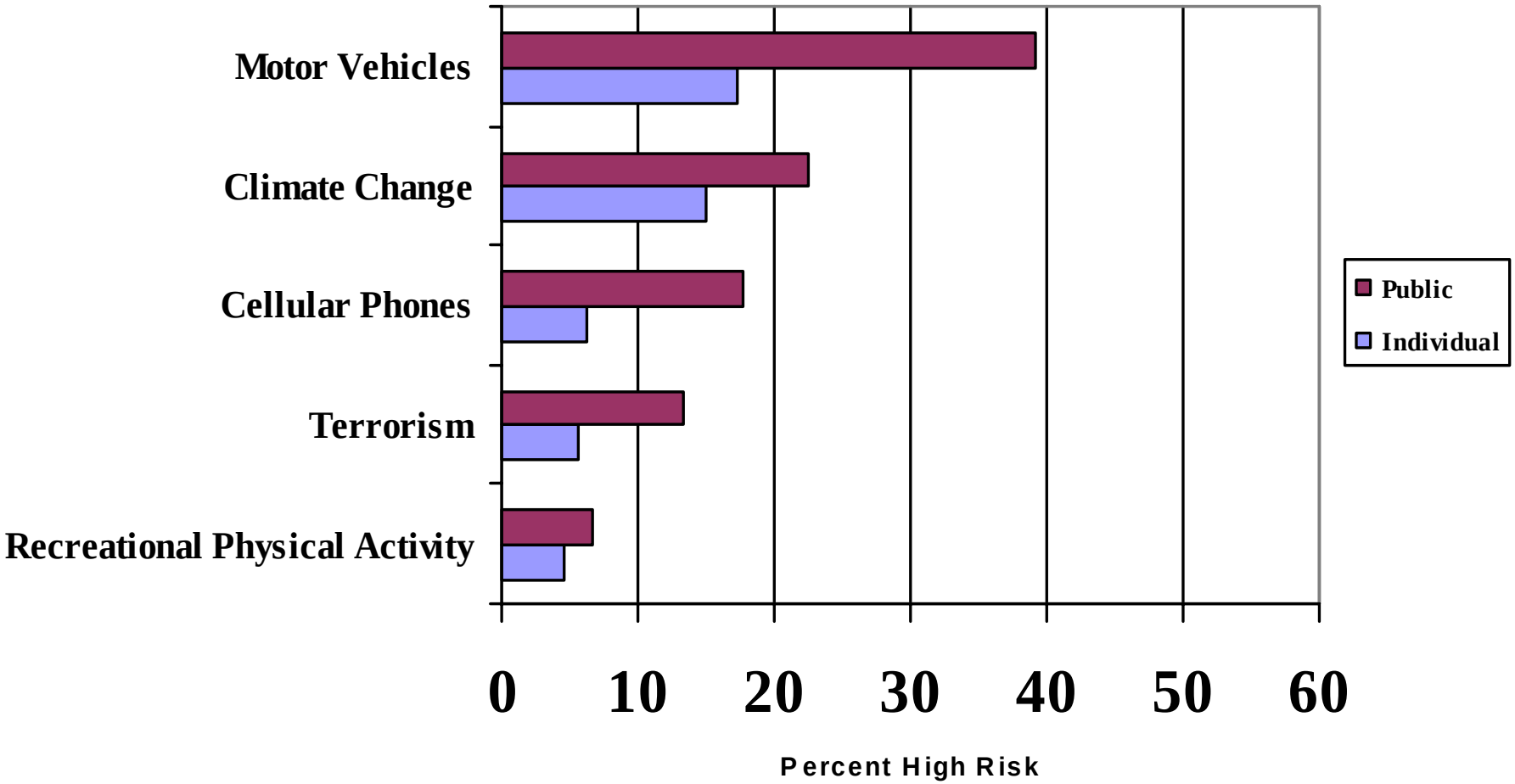
uOttawa

L'Université canadienne
Canada's university

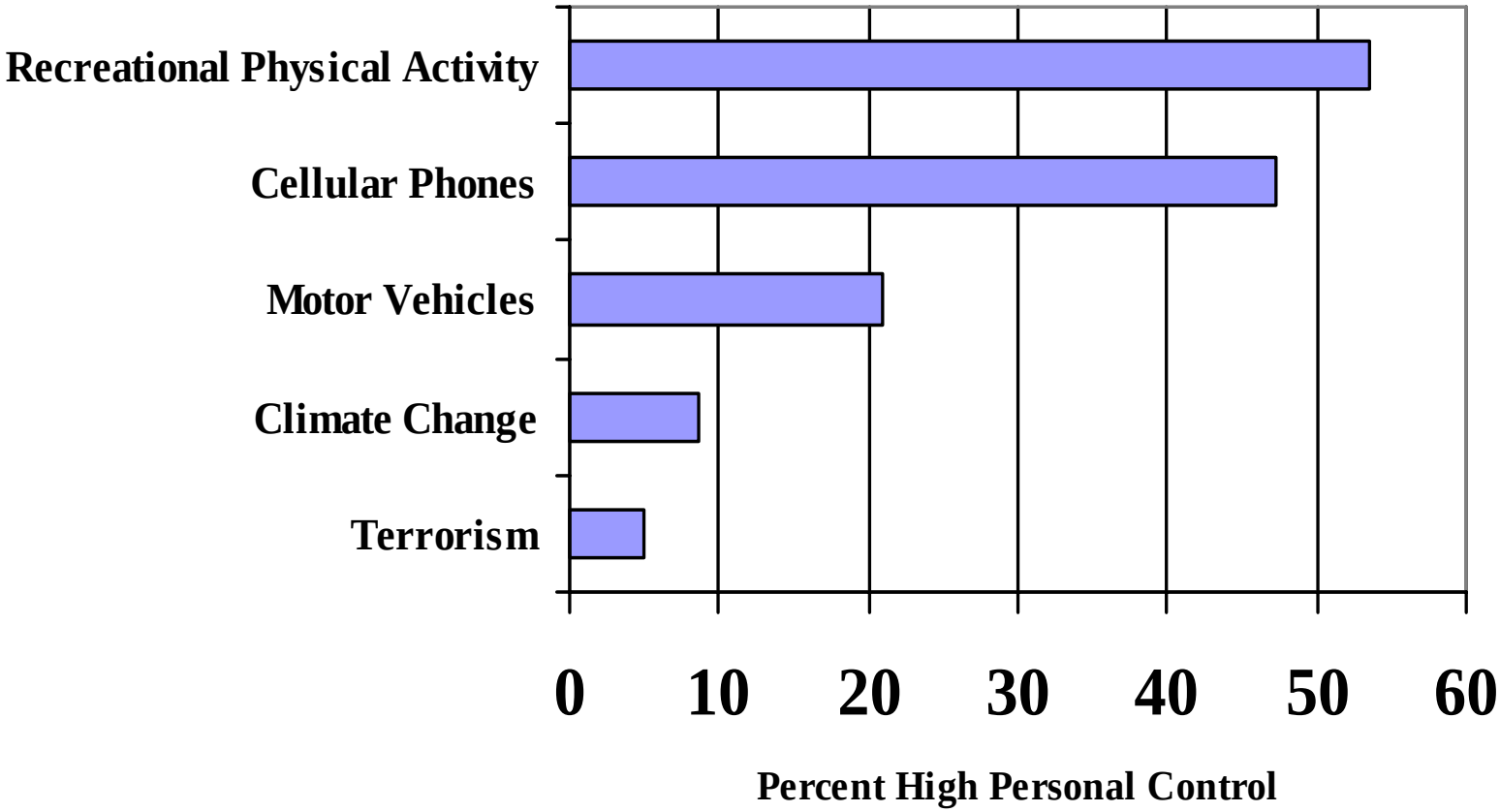
Université d'Ottawa | University of Ottawa

www.uOttawa.ca

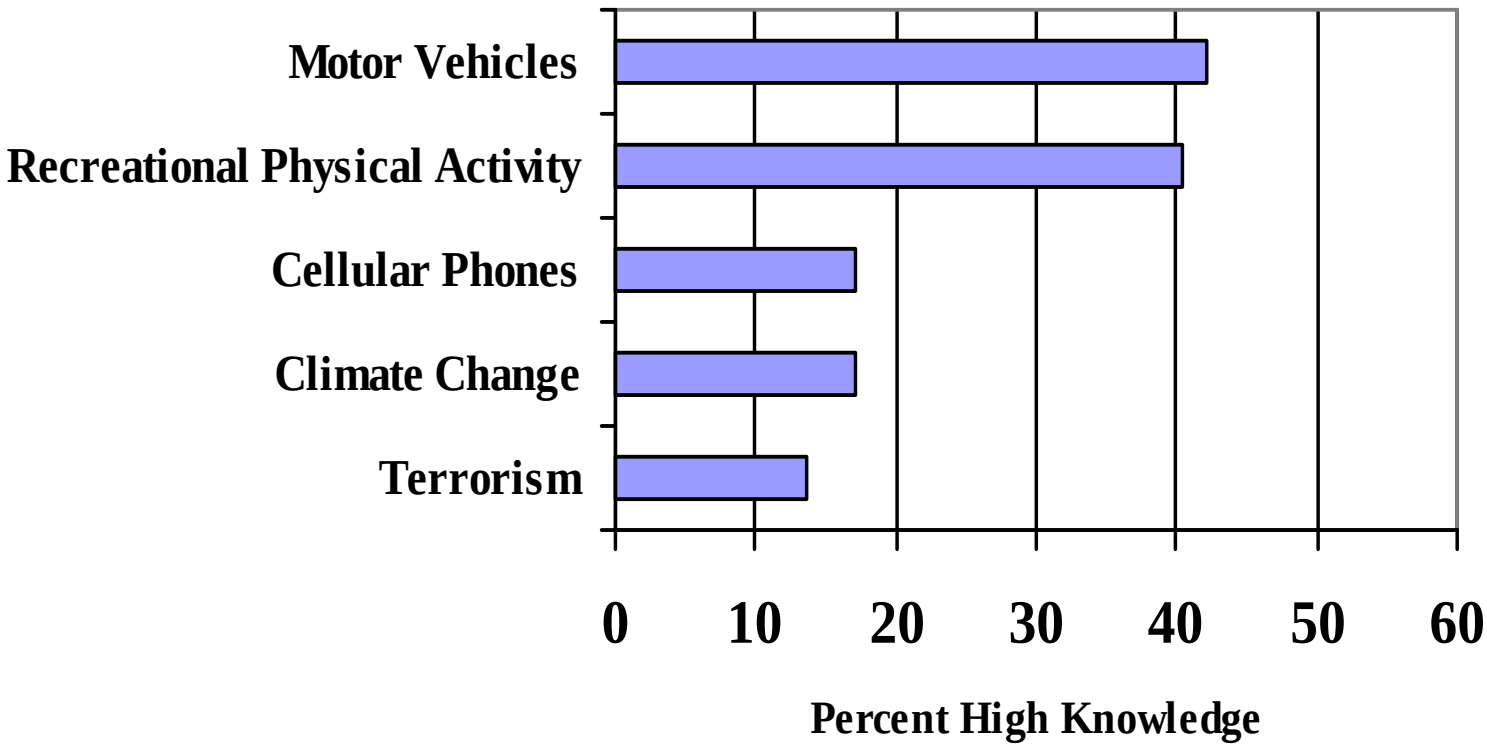
1a. Risk for health hazards



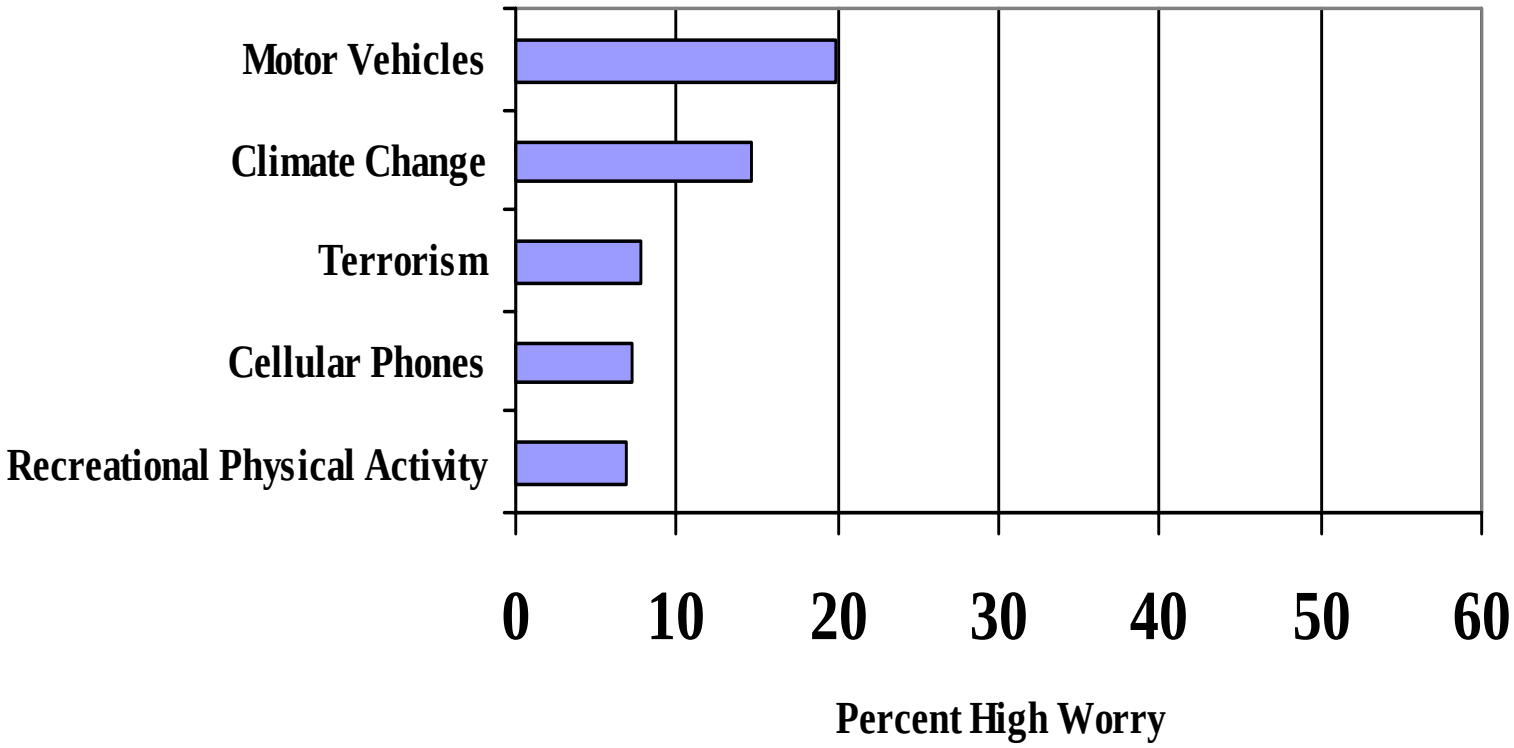
2a. Personal control over health hazards



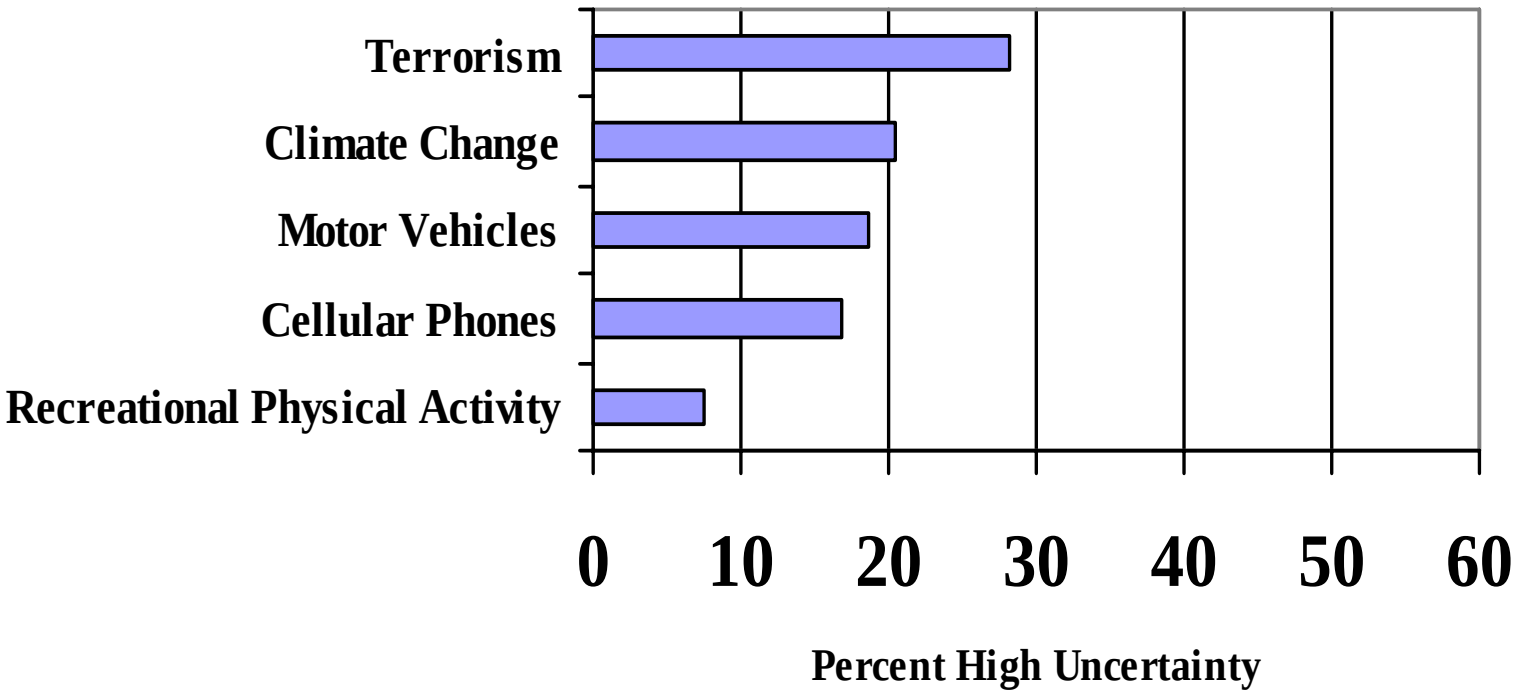
3a. Perceived knowledge about health hazards



4a. Perceived worry about health hazards



5a. Perceived uncertainty about health hazards



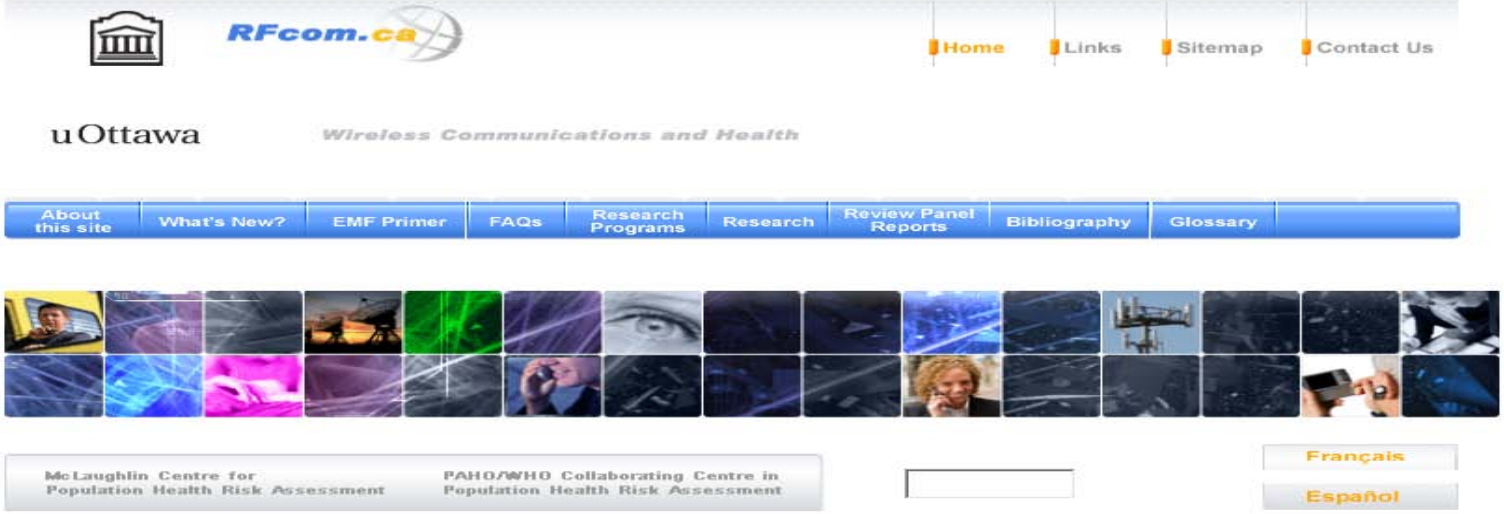
uOttawa

L'Université canadienne
Canada's university

Risk Communication

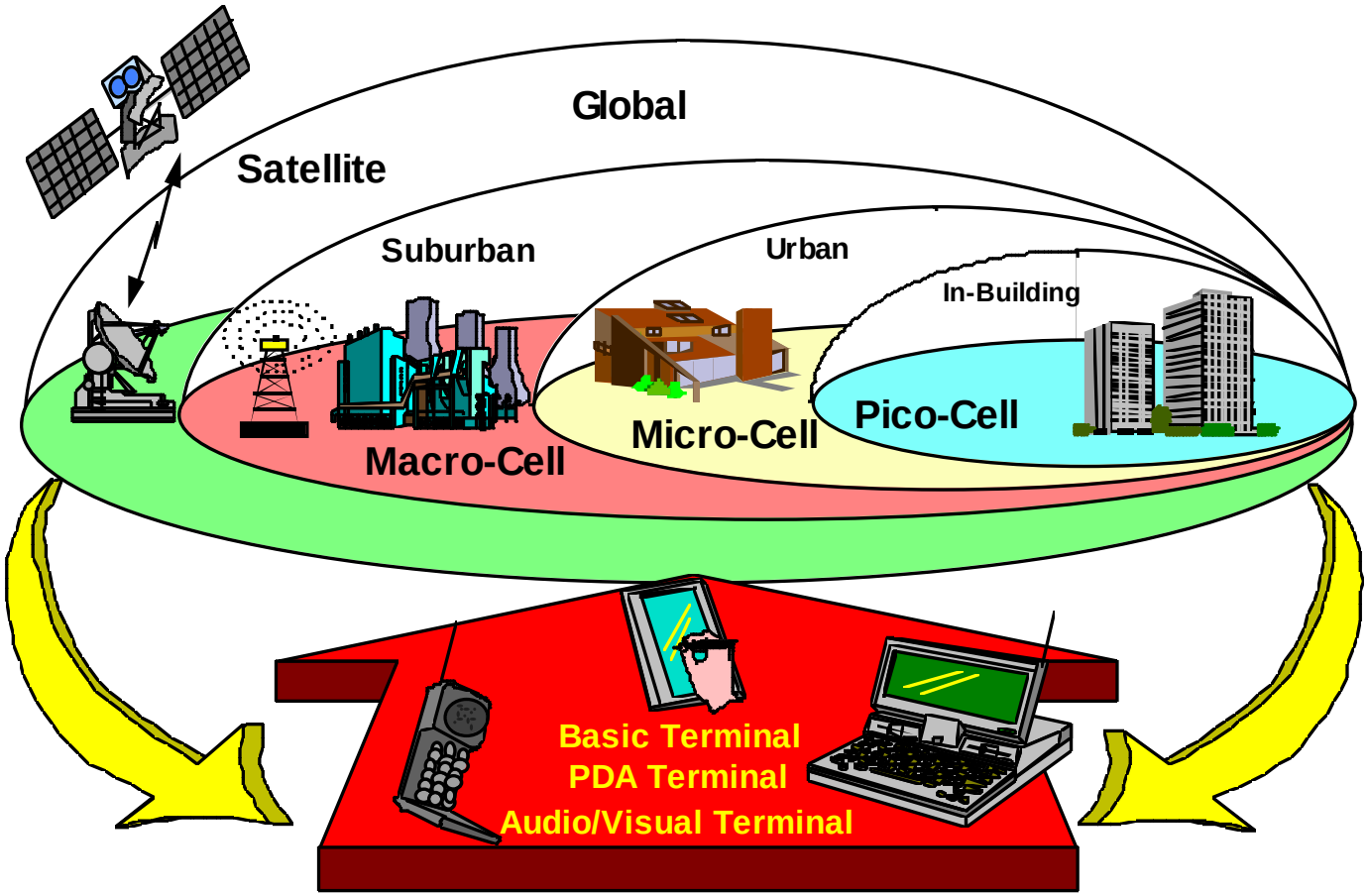
Université d'Ottawa | University of Ottawa

www.uOttawa.ca


RFcom.ca
Home
Links
Sitemap
Contact Us
uOttawa
Wireless Communications and Health
About this site
What's New?
EMF Primer
FAQs
Research Programs
Research
Review Panel Reports
Bibliography
Glossary
McLaughlin Centre for Population Health Risk Assessment
PAHO/WHO Collaborating Centre in Population Health Risk Assessment
Français
Español
Welcome to RFcom.ca
RFcom is based at the University of Ottawa McLaughlin Centre for Population Health Risk Assessment. RFcom is a science-based, independent and credible source of information on health issues related to wireless communications.
We would like to hear from you. If you have any questions or comments regarding rfcom or the information found on our site, please contact us.
What's New?
RFcom.ca
McLaughlin Centre for Population Health Risk Assessment
1 Stewart St., Ottawa, ON K1N 6N5 Canada
rfcom@uottawa.ca
© McLaughlin Centre for Population Health Risk Assessment

www.RFcom.ca

21st Century Vision



Flexible, Multi-Functional Network