Assessing risk across the health landscape

Professor Daniel Krewski describes his application of risk science to the assessment of threats to human health in order to determine optimal prevention and management strategies

How did your interest in risk science develop?

While working for the Canadian Federal Department of Health early in my career, I became involved in a number of food safety and environmental health issues. It became apparent to me that an organised, multidisciplinary approach to risk assessment would help in its understanding. At the time, formalised approaches to risk assessment were in their infancy. When I entered the academic world full-time in 1997, I left behind a decision-making framework that is still used by Health Canada. As an academic, I became interested in advancing methods and policies to support risk management decision making. This was greatly facilitated by the establishment of the McLaughlin Centre for Population Health Risk Assessment and Management at the University of Ottawa in 2000. My current position in the School of Epidemiology, Public Health and Disease Prevention provides an ideal platform to pursue my work in health risk science.

Can you describe your investigations into wireless telecommunications and, more specifically, the potential health effects of radiofrequency fields?

Between 1997 and 2010, I participated in a 13-country study of potential brain cancer risks associated with the use of mobile phones, called INTERPHONE, coordinated by the International Agency for Research on Cancer (IARC). An effort of that magnitude was needed to achieve a sufficiently large sample size to detect even a small increase in risk. The results suggested a possible increase among the top 10 per cent of mobile phone users; data uncertainties precluded a more definitive conclusion.

I am currently involved in a follow-up 15-country study of mobile phone use among children and adolescents called MOBI-KIDS, led by the University of Barcelona. The five-year fieldwork phase of this study will be completed by the end of this year.

What approaches have you employed in researching ambient air pollution?

Our research team has been involved in studies based on a follow-up of a cohort of over a million people established by the American Cancer Society in 1980 that show increased mortality from long-term exposure to particulate matter and ozone in ambient air. This work contributed to a determination by IARC in 2012 that air pollution is a cause of human lung cancer.

Using satellite imaging to predict tropospheric global concentrations of particulate matter, we recently completed an analysis of global burden. This indicated that particulate air pollution is associated with 10 per cent of mortality worldwide, in line with results subsequently reported by the World Health Organization (WHO).

Could you outline your findings on residential radon?

Radon in underground mines has long been known to increase lung cancer risk in miners. While individual epidemiological studies were unable to characterise the potential risks of residential radon, analyses of seven North American studies led by the McLaughlin Centre and 13 European studies led by Oxford University were able to clearly identify increased lung cancer risk. Based on this, WHO estimates that radon contributes to 10 per cent of all lung cancer deaths. This risk can be effectively mitigated by enhanced residential ventilation.

How will your work contribute to risk management of prion diseases?

The outbreak in the UK of bovine spongiform encephalopathy (BSE), or mad cow disease, and its subsequent transmission to humans as Creutzfeldt-Jacob disease, raised global awareness of prion diseases.

The BSE outbreak in Canada in 2003 spawned a $35 million research effort to understand animal prion diseases in the form of a national Network of Centres of Excellence. One of the uniquely North American concerns considered was the epidemic of chronic wasting disease (CWD). Although the CWD epidemic has been confined to deer and elk, there remains the possibility of transmission to other species such as caribou, or even to humans. Our work on prion disease risk management emphasises a proactive ‘anticipate and prevent’ approach to avoid further spreading.

What was your involvement in the US Environmental Protection Agency’s NexGen project?

My role was to develop a framework for the next generation of risk science that incorporates new scientific developments in rapidly advancing fields such as toxicogenomics, high-throughput in vitro screening and computational systems biology. This culminated in the publication of a new paradigm for risk assessment and management in 2014. A major goal of the new paradigm was to make risk assessment for environmental agents faster, less expensive and more scientifically robust.
IN MANY WAYS, people are safer and healthier now than ever before, thanks in large part to essential evidence-based research and the development of policies that influence health practices, food standards and environmental safety regulations. However, there is no room for complacency. The epidemic of bovine spongiform encephalopathy (BSE) about 25 years ago is a case in point: it affected many countries worldwide and its burden in terms of both human health and the economy was enormous. The fact that BSE was only characterised as a zoonotic disease well after the epidemic started, and governments and international organisations were initially slow to respond – or even acknowledge the possibility of BSE – could be interpreted as a sign of poor risk assessment and preparation. The BSE epidemic did, however, provoke greater attention to risks from novel hazards, which has led to the development of more powerful techniques and tools for the anticipation and estimation of consequences. In turn, this is resulting in better preparedness for decision making about preventive measures.

Chronic wasting disease (CWD), like BSE, is a neurodegenerative disease caused by prions – misfolded ubiquitous proteins – that has so far only affected animals. Initially detected in a few North American states in the 1980s among wild deer and other cervids, it has since spread across the US and into Canada, and gone on to infect captive and farm animals. CWD and other prion diseases are one focus of research in risk science at the McLaughlin Centre for Population Health Risk Assessment at the University of Ottawa, under the scientific directorship of Professor Daniel Krewski, who seeks to use risk science to anticipate and prevent or mitigate harms that may be avoidable.

ZOONOTIC DISEASE
CWD has been shown capable of transmission to primates, so there is a risk that it could infect humans. Krewski’s group has conducted studies of how the BSE epidemic was handled and the systems put in place to guard against recurrence. They have also modelled the biology of CWD perpetuation, such as the effects of seasonal changes on deer infection rates, and evaluated future risk scenarios by projecting the likely trajectory of the disease. Where definitive data is lacking, Krewski’s team has elicited the opinions of international experts on uncertain issues such as the possibility of infectious prions in urinary-derived products for women undergoing fertility treatment leading to human prion disease. Krewski’s investigations have led him to assert that traditional assessment and management techniques such as surveillance, monitoring and controls may not be enough to address the risks of prion diseases. Instead, he advocates a formal, iterative cycle of intelligence gathering and risk policy making to anticipate and prevent the further spread of such diseases.

DANGER IN THE AIR
Another serious danger to public health is particle pollution, a high concentration of fine particles less than about two microns in diameter in the air, which has direct effects on health, as their tiny size allows them to pass into lungs and even into the bloodstream. Generally present in smog or smoke, they can exacerbate asthma, cause heart attacks and interfere with normal lung function.

Krewski probed the effects of ozone and fine particulate matter in the air on health in major Canadian cities, where, in 2008, air pollution was estimated to have caused 20,000 premature deaths and 92,000 emergency hospital visits, with an economic burden of over $10 billion. “The good news is that air pollution levels have consistently declined in North America over the last decades, as a result of new technologies to reduce emissions from vehicle and industrial sources,” Krewski observes. Air quality guidelines in North America and Europe are becoming increasingly more rigorous as the health effects of low levels of exposure to air pollutants are better understood.

RADIATION AND RADIOWAVES
In the early 20th Century, high concentrations of radon gas in unventilated mines were linked to a prevalence of lung cancer cases among non-smoking miners. This discovery led to the classification of radon as a cause of human cancer by the International Agency for Research on Cancer and to more stringent requirements for ventilation in mines. Less known is the fact that radon is also present in homes across the world and is now the second leading cause of lung cancer after smoking.

According to Krewski, about two-thirds of radon-induced cases of lung cancer occur in homes with levels of radon below health and environmental protection agencies’ guideline thresholds – currently 200 Becquerels per cubic metre of air in the UK and Canada, and approximately 150 Bq/m³ in the US. Krewski’s more recent work on radon in residential properties has also shown it contributes to chronic obstructive pulmonary disease: “The Canadian building code now includes
provisions for the installation of ventilation systems for radon mitigation in new constructions,” he reports.

Krewski is now involved in a large multinational project seeking to ascertain whether long-term mobile phone usage by children and adolescents carries the risk of brain cancer caused by exposure to radiofrequency fields used in wireless telecommunication. The study builds on the methodology of an earlier, somewhat inconclusive investigation into the risk for adults. The premise is that, if there is indeed a link, it will be more clearly seen in young people because of their possibly increased susceptibility.

NEXT-GENERATION RISK SCIENCE

Linking all these endeavours together is Krewski’s NexGen framework, as explained in ‘A Framework for the Next Generation of Risk Science’, which tackles the limitations of existing risk assessment and management methods and practices, and incorporates advanced methods and techniques for identifying and responding to risk. “It integrates three perspectives on risk science: the US National Research Council’s vision for toxicity testing in the 21st Century, our own work on incorporating a population health approach to assessment by allowing for multiple determinants of health and their interactions, and new assessment methodologies,” states Krewski.

NexGen divides risk in three phases. The first focuses on objectives and covers problem formulation and scoping, in light of context, decision-making options and information value. The second, risk assessment, aims to identify and characterise risks of toxicity and uncertainty, applying the latest technologies to characterise hazards, assess dose responses and determine human exposure guidelines. This is conducted via high-throughput screening, computational biology and toxicology, in vitro to in vivo extrapolation, molecular and genetic epidemiology, and high-performance mass spectrometry, as well as new risk assessment methodologies. The third phase, risk management, is centred on the development of strategies according to regulatory, economic, advisory, community or technological need, to inform decision making. In this phase, fundamental risk management principles, economic analysis, socio-political factors and risk perception are all considered before selecting risk management interventions.

Krewski observes that, already, many aspects of the NexGen framework are being adopted in practice. He is now working on risk management decision-making principles, and evolving his research programme to explore new internationally important concerns: “High on our priority list are technological risk issues, such as carbon capture and storage and hydraulic fracturing,” he concludes.

ADVANCING RISK SCIENCE

OBJECTIVE

To advance the field of risk science, and its application to the reduction of risks to public health, particularly in relation to the environment and technology.

COLLABORATORS AND PARTNERS

Investigators in the McLaughlin Centre for Population Health Risk Assessment strive to maintain active collaborations with individuals and organisations with common interests in risk science from both North America and Europe.

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CONTACT

Dr Daniel Krewski
Professor of Epidemiology and Community Medicine; Director of the McLaughlin Centre for Population Risk Assessment
School of Epidemiology, Public Health, and Disease Prevention
University of Ottawa
118-850 Peter Morand Crescent
Ottawa, Ontario
K1G 3Z7, Canada
T +1 613 562 5381
E dkrewski@uottawa.ca, cphra@uottawa.ca
www.mclaughlincentre.ca
www.riskcom.ca

DANIEL KREWSKI is the Director of the McLaughlin Centre for Population Health Risk Assessment where he holds the position of NSERC Industrial Research Chair in Risk Science. Krewski has been a professor in the Department of Epidemiology and Community Medicine in the Faculty of Medicine at the University of Ottawa since 1997. His professional interests are in epidemiology, biostatistics, risk assessment and risk management, and he has broad experience as a member of national and international expert panels in the fields of public health, life sciences, chemical safety, cancer and environmental hazards.