Strengthening the Use of Science for Emergency Management in Canada

A Brief Report from the Chief Science Advisor of Canada

October 2024

Office of the Chief Science Advisor of Canada
Bureau du conseiller scientifique en chef du Canada

Canada

This document is available at www.canada.ca/OCSA

Cette publication est aussi disponible en français.

Cat. no.: lu37-49/2024E-PDF
ISBN: 978-0-660-73977-9

In case of discrepancy between the printed version and the electronic version, the electronic version will prevail.

Table of Contents

About this Report

This report summarizes opportunities and challenges with science advice coordination in Canada during national emergencies across a wide range of threats. It aims to improve the use of science for emergency management based on international best practices, learnings from recent simulation exercises on the use of science in emergencies, expert advice and the lived experience of the covid-19 pandemic.

Executive Summary

Emergencies are becoming more frequent and more complex around the world due in part to climate change, biodiversity loss and population movement. They include zoonotic diseases, toxin release, extreme weather, floods, droughts and wildfires, to name a few. Emergencies can also arise following the disruption of supply chains caused by natural or man-made disasters. All these threats are compounded by several other stressors such as inequities and economic pressures, distrust and misinformation, as well as stretched health systems and social safety nets, among others.

The experience of the global covid-19 pandemic can and must inform Canada's emergency preparedness and response moving forward, including the use of science to address a broad range of future threats. Science, including natural, social, engineering and applied sciences and technologies, along with science advice provided through experts, knowledge brokers and evidence syntheses, support decision-makers in interpreting evidence and implementing the needed actions. Science can inform decisions across all stages of the emergency management cycle, from mitigation and preparedness to risk assessment, response and recovery. The sustainability and effectiveness of science advice under emergency circumstances require a well planned, disciplined, and coordinated approach to maximize individual and group contributions across disciplines and link science to decision-making.

Canada boasts first-class scientists and research infrastructure that can be mobilized to inform and support emergency management as evidenced during the covid-19 pandemic. However, clear and agile frameworks and ways of operating must be developed to strengthen the use of science for and during emergencies. Key among them is the need for science advice and research prioritization processes; robust and timely data collection and sharing; and evidence-informed engagement and communication plans tailored to communities and the most at-risk.

Additionally, critical health needs in emergencies must be planned. They include basic and clinical research capacity, knowledge of drivers and risk mitigation, planned surge capacity, science-informed stockpiling, and secure supply chains and manufacturing capabilities for medical countermeasures and protective equipment.

The following 10 recommendations aim to support the federal government's objective to strengthen the use of science across the key stages of emergency management:

1. Implement an agile, comprehensive, and multidisciplinary federal science advice framework for emergencies that is aligned with the Federal Emergency Response Plan and the National Risk Profile.
2. Take practical steps to improve the science-policy nexus for emergency preparedness.
3. Ensure protocols are in place for high-quality data collection and sharing suitable for risk analysis and scenario modelling as required by major threats.
4. Review the existing evidence gaps to support prevention, mitigation and preparedness for major threats and develop prioritization and coordination processes to address gaps.
5. Embed the process for integrated science advice in the federal government response from the beginning of an emergency through to recovery considerations, as a means to mitigate further cost burdens on the federal government and on Canadians.
6. Establish a federal research and development prioritization and coordination framework to be activated during national emergencies and through the recovery phase.
7. Enhance trust and reduce dis- and misinformation by improving science literacy and societal understanding of policymaking through dialogue, openness and transparency.
8. Develop a comprehensive national health risk register and promote evidence-based actions that strengthen the health resilience of populations and health systems.
9. Adopt interrelated One Health approaches to effectively detect, mitigate and address disease threats to humans, animals and environments.
10. Use science to ensure the readiness and deployment of appropriate countermeasures and protective equipment for the health concern at hand.

Introduction

A famous quote, sometimes attributed to Winston Churchill, advises, "Don't let a good crisis go to waste." Canada, like the rest of the world, recently faced a pandemic, an important increase in the frequency and magnitude of wildfires, a surge of floods as well as other extreme weather events. We must learn from these crises, as well as from the simulation exercises and international best practices, to further protect the well-being of Canadians.

Science and science advice have a place across all stages of the emergency management cycle, from mitigation, prevention and preparedness to risk assessment, response and recovery. Emergencies and national crises present two challenges: (i) time and (ii) complexity of the issues that need to be addressed. From the scientific perspective, a nuanced understanding of complex issues requires the integration of multidisciplinary science and expert insights. Because of that, a clear process of gathering and providing integrated science advice in an emergency would enhance the benefit of science use. Within the Government of Canada, the existing science process relies on individual departments and agencies being science leads for their respective mandated area. A process to meaningfully integrate all scientific input to inform policy options and actions during complex emergencies has not been developed yet.

This report summarizes opportunities and challenges with science advice coordination in Canada during national emergencies, building on existing science processes and systems. It aims to improve the use of science for emergency management in Canada based on international best practices, recent learnings from emergencies, simulation exercises and the lived experience of the covid-19 pandemic. This report outlines critical elements to consider in using science in national emergencies and detailed recommendations to strengthen evidence-informed emergency prevention, risk mitigation, preparedness, response and recovery for Canada.

A Three-Point Framework for the Use of Science in Emergencies

Goal

To use the best available scientific evidence for disaster prevention and harm reduction.

Principles

Actions for strengthening the use of science and science advice in emergencies should be guided by the following principles:

1. **Legitimacy** and **trust:** with decision-makers, impacted communities, and scientific experts.
2. **Governance:** science is an integral part of emergency management governance, including at the very onset of an emergency.
3. **Agility:** science prioritization and science advice are conducted in a timely and tailored manner.
4. **Relevance:** science advice and research gaps identification and prioritization are guided by policy and operational needs.
5. **Equity** and **diversity:** science includes diverse perspectives and disciplines and benefits all.
6. **Inclusive knowledge systems:** Indigenous and community knowledge are used to enhance evidence-informed decisions.
7. **Collaborative, community**- and **person-centred** research agendas are developed to mitigate, prepare, respond and recover from emergencies.

8. **Integrity:** science and evidence advice are based on the best science available whether it comes from governments (provincial/territorial or federal), academia, industry, or community organizations.

9. **Living learning system:** emergencies are used to gather relevant data and lessons learned to improve understanding and outcomes for the emergencies that will follow.

10. **Data stewardship:** ensures that relevant data is accessible, interoperable and of high quality.

Framework recommendations

Science can and should inform all stages of emergency management. As such, the recommendations below are organized into three categories: recommendations that are relevant for (i) prevention, mitigation and preparedness, (ii) response and recovery, and (iii) recommendations that are specific to health, since health impact accompanies different types of emergencies.

The following 10 recommendations are provided to strengthen the use of science across the stages of emergencies management. Advancing these recommendations and related actions will require cross-sectoral and cross-jurisdictional collaboration.

Arctic thaw simulation exercise series

In 2023, the Canadian government and the US Department of Homeland Security (DHS) Science & Technology branch went through a tabletop exercise series focused on the use and coordination of science and science advice in a complex emergency, i.e., where the breadth of scientific disciplines spans the mandates of multiple government departments. In this fictional scenario an ancient pathogen has been released from a melting permafrost infecting wildlife and causing threat to humans and wildlife near the Alaska-Yukon border.

The scenario-specific observations from the exercise include fostering relationships with Indigenous leadership and local knowledge keepers in the Arctic region, strengthening science capabilities in the North, and enhancing environmental monitoring for potential threats in the Arctic.

The process-specific lessons learned include the importance of integration of the Office of the Chief Science Advisor into Public Safety's Government Operations Centre communications and governance, raising awareness of the Chief Science Advisor's capabilities among federal partners, and having a greater clarity of how multi-organizational coordination and dissemination of science advice may occur during an emergency. The exercise further underscored the need for a clear and agile science advice framework and the importance of embedding science advice in emergency management from the get go.

I. Use of Science to Reduce Risks and Reinforce Preparedness

A. Governance for integrating science advice and science policy nexus

Establishing a flexible and comprehensive governance structure and processes for integrating science into decision-making during emergencies is essential to foster clarity, transparency and accountability. This is best done during peacetime. Effective science advice also necessitates a strong receptor capacity and appropriate dialogue between science advisors and decision-makers. Putting the governance structure through simulation exercises will ensure that everyone involved understands the system and any governance gaps can be addressed before an actual emergency.

Recommendation 1. Implement an agile, comprehensive, and multidisciplinary federal science advice framework for emergencies that is aligned with the Federal Emergency Response Plan and the National Risk Profile.

1.1. Clarify science advice governance for emergencies and how it links with operational committees such as the Deputy Minister Emergency Management Committee and the Associate Deputy Minister Crisis Cell.

1.2. Define the role and responsibilities of departmental science advisors as well as those of the Chief Science Advisor of Canada.

1.3. Strengthen departmental and whole-of-government governance structures for science and consider instituting departmental science advisors in all departments involved in emergency management.

1.4. As part of the preparedness framework, request that Public Safety and the Chief Science Advisor co-lead an exercise, in collaboration with relevant departments and agencies, to identify and regularly update science and data needs for various threats ahead of time.

1.5. Update the Framework for Science and Technology Advice (2000) to reflect the evolving science and technology landscape.

Recommendation 2. Take practical steps to improve the science-policy nexus for emergency preparedness.

2.1 Incorporate science advice into regularly held simulation exercises for emergencies.

2.2 Task the Chief Science Advisor to work with relevant departments and agencies to develop science-informed standard documents for early response to major threats, leveraging findings from work on the National Risk Profile. These documents must be kept up to date with respect to scientific information, required expertise, possible cascading consequences and data needs.

2.3 Increase receptor capacity for science advice at the level of decision-makers within the government.

2.4 Create opportunities for scientists to contribute to policy activities.

2.5 Strengthen risk analysis training and scenario modelling within the federal government.

2.6 Enhance understanding of the role of science, such as through online modules featuring case studies from different crises.

B. Data for preparedness and disaster reduction

In an emergency, access to reliable evidence and data is essential for scenario modeling that informs actions as well as for risk and harm reduction. As such, access to interoperable data and sustainable infrastructure for data and sample collection, management and sharing must be in place and up to date.

Recommendation 3. Ensure protocols are in place for high-quality data collection and sharing suitable for risk analysis and scenario modelling as required by major threats.

3.1 Develop and implement interoperable protocols and standard agreements across sectors and jurisdictions that improve timely data and sample collection, storage, sharing, and analysis.

3.2 Strengthen the human, digital and physical infrastructure that interconnects and supports the use of data in emergency management.

3.3 Take steps to further hone data collection towards an all hazards analysis, as to best position the emergency management system to address most hazards.

3.4 Enhance the use of Indigenous Knowledge, as appropriate, for emergency management in a culturally sensitive manner and respecting the OCAP (Ownership, Control, Access, and Possession) principles.

3.5 Implement the Pan-Canadian Health Data Strategy.

3.6 Ensure that Canada contributes to global emergency preparedness and is part of global alert systems.

C. Research and development prioritization and coordination for reducing risk and bolstering preparedness

Risk reduction and preparedness require evidence, tools and the latest technology solutions. To bolster risk and harm reduction, there needs to be a proactive and dynamic process of identifying existing gaps, prioritizing them and coordinating efforts to address the gaps among relevant stakeholders. Efforts should focus on threat reduction, early threat detection and the strengthening of economic, social, health and environmental resilience.

Recommendation 4. Review the existing evidence gaps to support prevention, mitigation and preparedness for major threats and develop prioritization and coordination processes to address gaps.

4.1 Put in place an agile process for data and research prioritization and coordination to address science and data gaps for identified threats.

4.2 Develop principles and guidelines for a well-coordinated federally supported strategy for research, development, and manufacturing required for different threats.

4.3 Embed knowledge translation pathways and rapid feedback mechanisms into research hubs, networks and research funding streams.

II. Use of Science for Emergency Response and Recovery

A. Embedding science advice

Efficient emergency response relies on clear processes and frameworks established in peacetime and tailored to the crisis at hand. Having science at the table from the start is key for establishing what data and evidence are required to inform the operational and policy needs. Considerations for recovery should be included in the response deliberations, and science advice must be thought out from the start as it may impact the response itself. Short- and potential long-term health, social, economic and environmental impacts should be considered. Embedding multidisciplinarity into scientific advice panels minimizes blind spots and anticipates ripple effects from the emergency at hand. This in turn helps inform mitigation and response measures.

Recommendation 5. Embed the process for integrated science advice in the government response from the beginning of an emergency through to recovery considerations, as a means to mitigate further cost burdens on the federal government and on Canadians.

5.1 Empower the Chief Science Advisor to coordinate science advice and set up, in collaboration with relevant departments, transparent and agile advisory groups during national emergencies.

5.2 Ensure science is at the table and integrated into emergency operations at the outset of a national emergency.

5.3 Include appropriate multidisciplinary expertise on advisory panels, considering the emergency at hand and its long-term health, social, economic and environmental impacts.

5.4 Engage First Nations, Inuit, and Métis in the science advisory process.

5.5 To facilitate recovery, data collection, research priorities and related communication and policy actions should address short- and potential long-term health and societal impacts of any high-magnitude crisis.

B. Prioritizing research for actions

When planning research during an emergency, priority should be given to the research needed for the development of policy and tools addressing the response and recovery. Dialogue between operations, policy and science is essential for identification and prioritization of knowledge needs during a national emergency. Further, effective coordination and collaboration should include domestic and international partners as appropriate. Supporting coordinated and collaborative approaches through funding projects within established research networks (centers of excellence, hubs etc.) should be considered when possible, as they leverage partnerships and collaboration over a broader base of expertise in addition to access provided to specialized infrastructure and human and physical resources.

Recommendation 6. Establish a federal research and development prioritization and coordination framework to activate during national emergencies through the recovery phase.

6.1 Set up Terms of Reference for an ad hoc emergency research coordination committee that would bring together science, operations and policy leadership from relevant departments to identify and prioritize research gaps for national emergencies and for recovery considerations. Such a panel could be co-chaired by the Deputy Minister of Public Safety and the Chief Science Advisor of Canada.

6.2 Evaluate Canada's capacity to operationalize early response to the threats of the National Response Profile and adjust it as needed.

6.3 Integrate implementation science approaches into emergency response and recovery at the outset to monitor effectiveness and inform future needs and actions.

6.4 Establish clear and nimble knowledge mobilization processes so that research findings and emergent knowledge can be used to inform science advice, policy, planning and public guidance in a timely manner.

C. Communication that builds trust

Public communication should provide the public with trusted and reliable information about the state of the emergency and the actions required. This means clearly communicating the situation and the rationale behind interventions and public guidance. Uncertainties and potential guidance changes should also be shared as early as possible. Communication strategies need to proactively integrate learnings and best practices from the growing literature on combatting misinformation (e.g. inoculation method, debunking).

Empowering the public to understand and evaluate the reliability of these communications, distinguish the credibility of sources, and recognize experts from non-experts is essential. Improving science literacy is required for fostering an informed citizenry, especially in the context of an emergency.

Recommendation 7. Enhance trust and reduce dis- and misinformation by improving science literacy and societal understanding of policy-making through dialogue, openness and transparency.

7.1 Use behavioural and communication science learnings to tailor communication to distinct communities.

7.2 Make publicly available federal emergency science advisory committee membership, roles, mandates, and activities.

7.3 Disclose scientific evidence used in decision making, and where possible, make the evidence used in decisions accessible.

7.4 Develop a framework that encourages participatory and citizen science in peacetime and in emergencies.

7.5 Continue fostering Open Science practices.

III. Use of Science for Health Emergency Readiness, Response and Recovery

A. The use of science to enhance health system resilience

Many non-health emergencies can create a health crisis. For example, an extreme weather event like a heat dome can increase illness and mortality, especially in vulnerable populations and communities. Wildfires, floods and storms can have profound impacts on communities' health and well-being, whether related to air pollution, water contamination, or evacuations and temporary accommodations. Air pollution has been shown to cause ailments ranging from respiratory, cardiac and digestive issues to premature mortality. On the other hand, floods can promote waterborne infectious diseases in addition to physical and mental stress especially if relocations are required or access to goods and health services are affected.

Given the above, a comprehensive national health risk register should be developed, and health systems need to be strengthened using up-to-date evidence and health innovation. Additionally, some emergencies can lead to longer-term health impacts such as increased cancer risks, earlier onset of chronic disease or other morbidities. Therefore, emergency management must also address health needs during the recovery period. Surge capacity for care and diagnostics, as well as medical countermeasures must be planned. Going forward, the management of Canada's stockpile should address a broad range of risks, including those arising from climate change and potential disruption of supply chains.

Recommendation 8. Develop a comprehensive national health risk register and promote evidence-based actions that strengthen the health resilience of populations and health systems.

8.1 Develop a federal-provincial/territorial framework for a comprehensive national health risk register to identify priority health threats to Canada and use it to increase the health resilience of populations and health systems to emergencies. Such a framework should include prevention, health promotion, protective measures and infection control through physical infrastructure and social behaviour.

8.2 Identify and enhance critical infrastructure, systems, tools and human surge capacity to manage a wide range of health emergency situations, prioritizing those identified by the national health risk register.

8.3 Establish and maintain emergency stockpiles that combat a diverse set of threats and emergencies, recognizing threats from climate-related events, population mobility and loss of natural habitats.

8.4 Develop a federal framework of applied fundamental ethical principles for risk assessment in emergencies.

8.5 Improve ventilation and air quality systems in buildings where people gather and where a large number of animals are housed to minimize respiratory illness and airborne infection.

B. Implementing a One Health approach

The health of people, animals, plants, and ecosystems are interrelated. The effective prevention of, preparation for, and response to emerging pathogens (including as a result of climate change) requires a One Health[1] approach — that is, a multisectoral, transdisciplinary collaborative approach working at local, regional, national, and global levels. Beyond epidemics and pandemics, adopting a One Health approach can help mitigate health impacts from other types of disasters and human activities, such as human exposure to contaminated animal products and human interactions with animal species as a result of changes in land use. Given the global nature of environmental threats and rapid population movement, Canada needs to be connected with international surveillance and research efforts targeting zoonotic and emerging pathogens.

Recommendation 9. Adopt interrelated One Health approaches to effectively detect, mitigate and address disease threats to humans, animals and environments.

9.1 Establish a standing interdepartmental mechanism for the collection, sharing and analysis of data from various sectors to mitigate the health impacts of climate-related disasters and other threats.

9.2 Promote disaster risk reduction efforts such as through preserving biodiversity and reducing deforestation, thus mitigating land use-induced spillovers.

9.3 Increase sampling of wildlife populations as well as soils and wastewater in high-risk environments in order to identify new threats quickly, including animal exposures to toxic agents, novel pathogens and risks of spillover.

9.4 Develop and enable access to practical innovations to enhance biosecurity on farms.

9.5 Use the latest scientific evidence for infection prevention and control strategies, including evidence for the dominant modes of pathogen transmission. Where there is scientific uncertainty or debate, consider the precautionary principle.

1. **One Health** is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent. The approach mobilizes multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development. (Definition developed by the One Health High Level Expert Panel)

C. Using science for prioritizing appropriate tools and medical countermeasures

Different health crises will require different tools from diagnostics to medical countermeasures to personal protective equipment. Science needs to inform the most appropriate choice of countermeasures deployment for the health crisis at hand. Supply chains, logistics, and the human resources required for the varying scenarios must be planned and secured. This includes access to domestic manufacturing and biomanufacturing capabilities as well as scale-up capacities.

The covid-19 pandemic revealed multiple gaps in essential countermeasure tools, including face masks and essential ingredients for diagnostics. Biomanufacturing was a priority gap in Canada that was revealed during the pandemic. For any newly emerging, highly pathogenic virus, there will be a period when a vaccine will not be available, hence the importance of broad spectrum antivirals and other infectious disease therapies. Health crises can also involve non-infectious disease, like air pollution resulting from wildfires or volcano eruptions or toxic spills, and they require different tools and countermeasures. For example, face masks, air purifiers and personal inhalers may be needed as a direct consequence of certain crises. The impact of transportation disruption affecting water, food or energy supply on health must also be addressed.

Recommendation 10. Use science to ensure the readiness and deployment of appropriate countermeasures and protective equipment for the health concern at hand.

10.1 Develop a Canadian strategy for rapid access to and scale-up of medical and non-medical tools and countermeasures for infectious and non-infectious threats.

10.2 Strengthen Canada's research capacity, clinical trials infrastructure and biomanufacturing capabilities, some of which could serve as health surge capacity in emergencies.

10.3 Foster partnerships between private, government, and academic sectors to enhance health security, in line with Canada's international commitment to pandemic preparedness.

10.4 Coordinate with international partners for surveillance and data sharing, including on the effectiveness of tools and measures.

10.5 Proactively address international harmonization of regulatory pathways for diagnostics and medical countermeasures to accelerate deployment of life-saving interventions.

Implementation plan

This report does not contain implementation details for most recommendations because broader engagement within government is needed to prioritize major threats and consider contextualized implementation options. The implementation plan needs to include (i) prioritization and (ii) implementation options for different threats and emergency stages (preparedness, response and recovery).

As a first step, a steering committee led by a small group of deputy ministers (including Public Safety, Public Health Agency, and the National Security and Intelligence Advisor, Deputy Secretary to the Cabinet – Emergency Preparedness, and the Chief Science Advisor) could be tasked with developing a priority plan. As a second step, the implementation options for the priority recommendations could be developed by a time-limited ad hoc Director General (DG)-level Task Force composed of representatives from Public Safety, Privy Council Office, Office of the Chief Science Advisor and line departments (including the Health portfolio, Natural Resources Canada, Environment and Climate Change, Defence Research and Development Canada, and Trasport Canada) or through an existing DG-level Emergency Management Committee with input from department science advisors and experts for review by the DM-steering group and recommendation to the Clerck of the Privy Council.

Conclusion

Canada can and should build on existing science processes, leveraging world-class researchers and infrastructure, to further improve the use of science in emergency management. Science and science advice have a place across all stages of the emergency management cycle, from mitigation, prevention and preparedness to risk assessment, response and recovery.

Establishing a comprehensive and agile federal science advice framework for emergencies, prioritizing reliable data collection and sharing, identifying evidence gaps and coordinating research efforts are important steps to strengthen our ability to mitigate threats effectively.

During emergencies, embedding integrated science advice from the outset and prioritizing research that informs policy and operational decisions are key. This approach can facilitate informed decision-making and help anticipate and mitigate the multifaceted impacts of emergencies on health, society, economy, and the environment.

Mobilizing science into action also requires critical infrastructure and tools, sustainable systems, and trained people to support surge capacity readiness for monitoring, diagnostic and other health and social needs. Science can also support effective communication and policy implementation, both of which are critical for emergency management.

By advancing the integration of science in emergency management, Canada will be better equipped to prevent, mitigate, handle and recover from an increasing array of complex emergencies, thereby safeguarding the well-being of Canadians, protecting our economy, and preserving our environment.

Acknowledgements

This report's recommendations were based on the input from the CSA covid-19 Expert Panel (meeting 48), learnings from the Government of Canada simulation exercises on the use of science in emergencies and looking to international best practices. We want to acknowledge the support from Public Safety and Defence and Research Development Canada for co-organizing the Atlantic Bite exercise (2019) and Arctic Thaw exercise series (2023), as well as all exercise participants from various government departments. The Office of the Chief Science Advisor's team that supported the development of this report include Masha Cemma, PhD, Lori Engler-Todd, MSc, Vanessa Sung, PhD, and Geneviève Tanguay, PhD.

References

Agius. Prevention of COVID-19 in workers: preparation, precaution, and protection. Annals of Work Exposures and Health. (September 2023).

Berry and Schnitter. Health of Canadians in a Changing Climate: Advancing our Knowledge for Action. Health Canada. (February 2022).

Bonell et al. Harnessing behavioral science in public health campaigns to maintain 'social distancing' in response to the COVID-19 pandemic: key principles. Journal of Epidemiology and Community Health. (May 2020).

Canadian Science Policy Center. Science Meets Parliament. (n.d.).

CanCOVID. How Language Shapes Change: Perspectives on the Most and Least Effective Communication Strategies and Tactics during the COVID-19 Pandemic. (February 2023).

Council of Canadian Academies. Fault Lines: Expert Panel on the Socioeconomic Impacts of Science and Health Misinformation. (2023).

Council of Science and Technology Advisors. Science advice for government effectiveness (SAGE): a report of the Council of Science and Technology Advisors. Industry Canada. (1999).

Edelman. Edelman Trust Barometer 2022. (January 2022).

Expert Advisory Group. Pan-Canadian Health Data Strategy: Toward a world-class health data system. Public Health Agency of Canada. (May 2022).

First Nations Information Governance Centre. The First Nations Principles of OCAP®. (n/d).

Gouglas et al. The 100 Days Mission – 2022 Global Pandemic Preparedness Summit. Emerging Infectious Diseases. (March 2023).

Government of Canada. Directive on Open Government. (October 2014).

Government of Canada. Health Portfolio Emergency Response Plan. (November 2023).

Government of Canada. Open Science – Helping make science accessible for all Canadians. (February 2022).

Government of the United Kingdom. The Scientific Advisory Group for Emergencies (SAGE). (n.d.).

Hamilton et al. A systematic review of human behaviour in and around flood water. International Journal of Disaster Risk Reduction. (August 2020).

Haynes et al. What can we learn from interventions that aim to increase policy-makers' capacity to use research? A realist scoping review. Health Research Policy and Systems. (April 2018).

Howell and Brossard. (Mis)informed about what? What it means to be a science-literate citizen in a digital world. PNAS. (April 2021).

Industry Canada. A Framework for Science and Technology Advice. Government of Canada. (2000).

Innovation, Science and Economic Development Canada. Canada's Biomanufacturing and Life Sciences Strategy. Government of Canada. (July 2021).

International Pandemic Preparedness Secretariat. 100 Days Mission. (n.d.).

Jones et al. The Humanities and Health Policy: An RSC Policy Briefing. Royal Society of Canada. (November 2023).

Kruk et al. What is a resilient health system? Lessons from Ebola. The Lancet. (May 2015).

Lewis et al. Charting a future for emerging infectious disease modelling in Canada. University of Victoria. (April 2023).

Lulham et al. Canada in a Changing Climate: Synthesis Report. Government of Canada. (December 2023).

Mubareka et al. Strengthening A One Health Approach to Emerging Zoonoses. Facets. (January 2022).

Natural Sciences and Engineering Research Council of Canada. Emerging Infectious Disease Modelling Initiative. Government of Canada. (June 2021).

Natural Resources Canada. Data related to flood mapping. (n/d).

The Organisation for Economic Co-operation and Development. Scientific Advice During Crises: Facilitating Translational Co-operation and Exchange of Information. (October 2018).

The Organisation for Economic Co-operation and Development. Building Capacity for Evidence-Informed Policy Making: Lessons from Country Experiences. (September 2020).

The Organisation for Economic Co-operation and Development. Scientific Advice in Crises: Lessons Learned from COVID-19. (March 2022).

Office of the Chief Science Advisor. Chief Science Advisor's Meeting on Highly Pathogenic Avian Influenza-A (HPAI-A) – May 23, 2024. (May 2024).

Office of the Chief Science Advisor. COVID-19 Expert Panel. Government of Canada. (January 2022).

Office of the Chief Science Advisor. Departmental Science Advisors Network. Government of Canada. (August 2023).

Office of the Chief Science Advisor. Meeting #48 of the CSA COVID-19 Expert Panel. Government of Canada. (July 2023).

Office of the Chief Science Advisor. Post-COVID-19 Condition in Canada: What We Know, What We Don't Know and a Framework for Action. Government of Canada. (December 2022).

Plowright et al. Land use-induced spillover: a call to action to safeguard environmental, animal and human health. The Lancet Planetary Health. (April 2021).

Public Safety Canada. Emergency Management. Government of Canada. (September 2020).

Public Safety Canada. An Emergency Management Framework for Canada – Third Edition. Government of Canada. (May 2017).

Public Safety Canada. Federal Emergency Response Plan. Government of Canada. (January 2011).

Public Safety Canada. National Risk Profile: Strengthening Canada's All-Hazards Approach to Emergency Management. Government of Canada. (May 2023).

Public Safety Canada. Backgrounder: Future of the National Risk Profile (January 2024).

Salim et al. Air pollution effects on the gut microbiota. Gut Microbes. (March 2014).

Sustainable Development Working Group. One Health: Operationalizing One Health in the Arctic. Arctic Council. (May 2017).

Taino et al. Air pollution, physical activity and health: A mapping review of the evidence. Environment International. (February 2021).

UK Covid-19 Inquiry. Module 1: The resilience and preparedness of the United Kingdom. (July 2024).

United Nations Office for Disaster Risk Reduction. Sendai Framework for Disaster Risk Reduction 2015–2030. (March 2015).

Wellcome. Publishers make coronavirus (COVID-19) content freely available and reusable. (March 2020).

Wensing et al. Implementation science in times of COVID-19. Implementation Science. (June 2020).

Witter et al. Health system resilience: a critical review and reconceptualization. The Lancet Global Health. (September 2023).

World Health Organization. Evidence Synthesis for Health Policy and Systems: A Methods Guide. (October 2018).

World Health Organization. Managing the COVID-19 infodemic: Promoting healthy behaviours and mitigating the harm from misinformation and disinformation. (September 2020).

World Health Organization. Operational framework for building climate resilient and low carbon health systems. (November 2023).

World Health Organization. Tripartite and UNEP support OHHLEP's definition of "One Health." (December 2021).

Wulff et al. What is Health Resilience and How Can We Build it? Annual Review of Public Health. (January 2015).

Xia et al. Canada's Provincial COVID-19 Pandemic Modelling Efforts: A Review of Mathematical Models and Their Impacts on the Responses. Preprint. Social Science Research Network. (June 2023).

Zavaleta-Cortijo et al. Indigenous knowledge, community resilience, and health emergency preparedness. The Lancet Planetary Health. (August 2023).