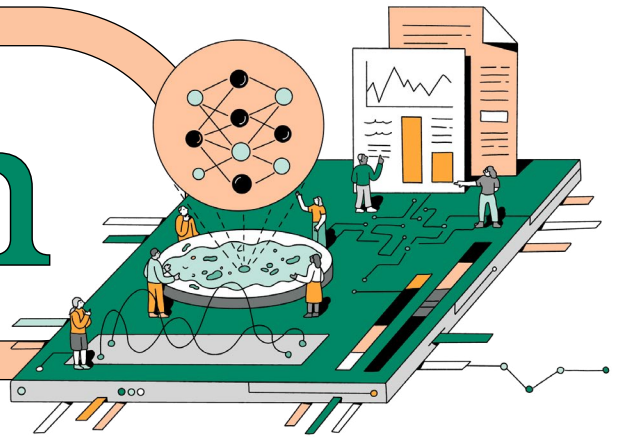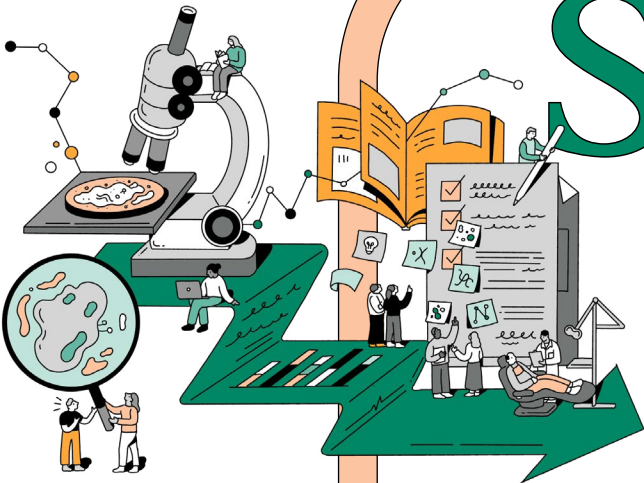# National Oral Health Research Strategy

Advancing the Health of Canadians through Research

2024 — 2030

Canada

NOHRS is a collaboration between:
Canadian Institutes of Health Research's (CIHR) Institute of Musculoskeletal Health and Arthritis (IMHA),
Canadian Association for Dental Research (CADR), Association of Canadian Faculties of Dentistry (ACFD),
Network for Canadian Oral Health Research (NCOHR), Canadian Dental Association (CDA),
Denturist Association of Canada (DAC), Canadian Dental Therapists Association (CDTA) and
Canadian Dental Hygienists Association (CDHA).

Also available on the Web in PDF and HTML formats
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A

Institute Foreword

The Canadian Institutes of Health Research (CIHR) was created by an Act of parliament in 2000 with very clear goals: to foster excellent research, to build capacity for research and to help improve the health of Canadians (and the world). As leaders of one of CIHR's 13 Institutes, we at the Institute of Musculoskeletal Health and Arthritis (IMHA) have the tremendous privilege of working with the oral health community.
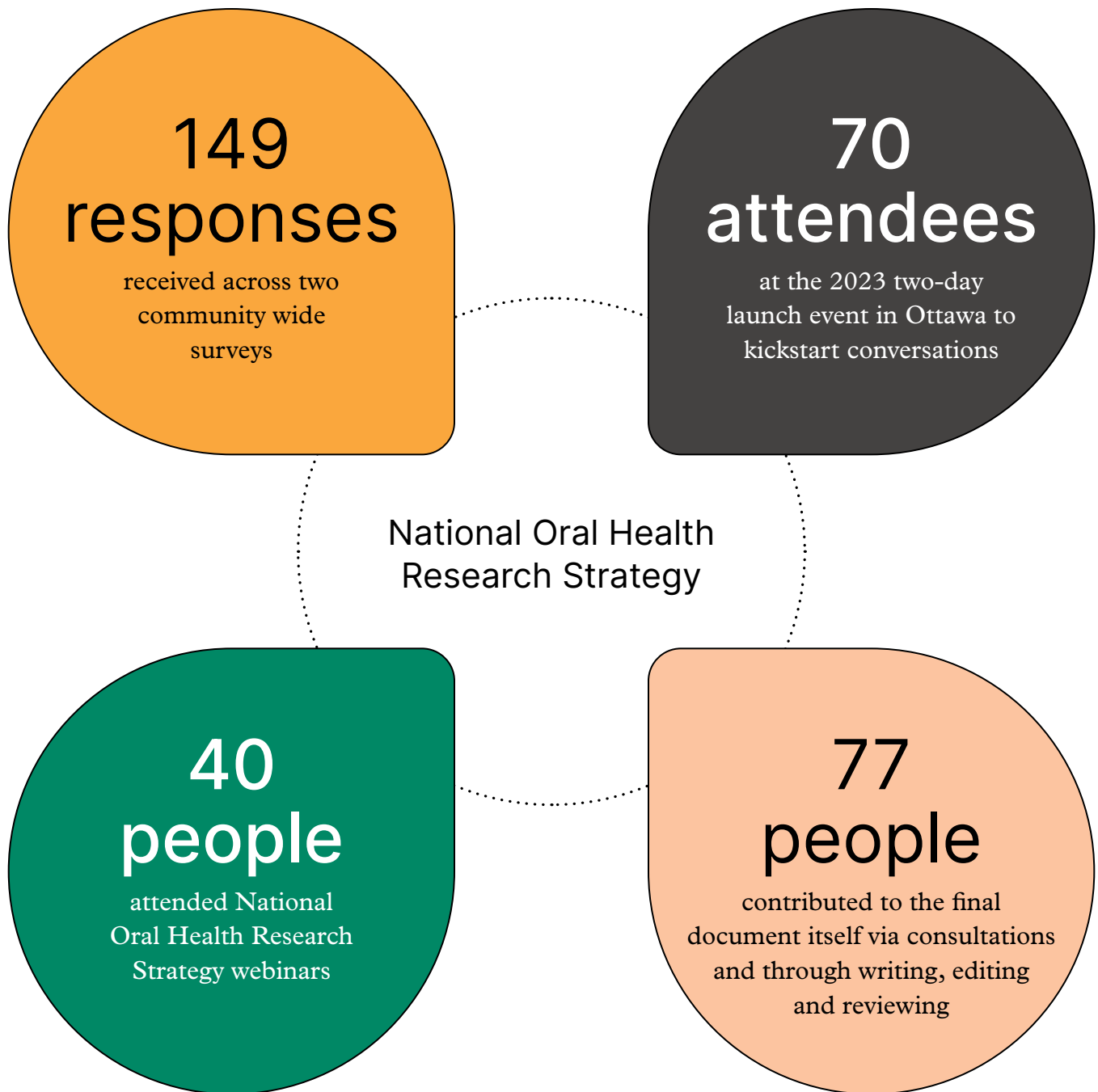
We interpret each of those words--oral health and community--at the broadest end of their definitions. Big tents. If your research crosses into "oral health" we at CIHR-IMHA aim to add value for you. Our "community" is the public, patients and patient partners, caregivers, and what is often referred to as the research ecosystem--trainees, expert personnel, the myriad staff who are essential in the journey from idea conception to health impact. If you believe you fit our mandate, you do.

We commend the oral health community for creating a National Oral Health Research Strategy. Difficult choices were made. We thank you for your commitment—the cumulative hard work exceeded 10,000 hours and involved hundreds of people.

Let's look to the future—where now? If we consider this research strategy to be a map, the Canadian oral health research community has already travelled far. It has a remarkable track record of research that has improved health. This research strategy leads to important and reachable destinations. We at CIHR-IMHA look forward to supporting you as is our responsibility within the CIHR Act.

Dr. Karim Khan, Dr. Hetty Mulhall,
and Dr. Dawn Richards.

Figure 1.
How a community contributed to NOHRS

149 responses received across two community wide surveys

70 attendees at the 2023 two-day launch event in Ottawa to kickstart conversations

National Oral Health Research Strategy

40 people attended National Oral Health Research Strategy webinars

77 people contributed to the final document itself via consultations and through writing, editing and reviewing

B

Land Acknowledgement

The launch event for the National Oral Health Research Strategy was held on March 29 and 30, 2023, on the traditional, unceded lands of the Anishinaabe Algonquin people and this final version of the document is shared at the 2024 Canadian Oral Health Summit, in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq People. We are all treaty people. This National Oral Health Research Strategy document has contributions from across so-called Canada, on land that has been stewarded by Indigenous peoples for thousands of years. As you read this strategy, we would encourage you to reflect on the impact of systemic disadvantages in health, and to consider how person-centred approaches address identity-related inequities in oral health in Indigenous peoples.

Introduction and Rationale

For decades, our understanding of oral health and disease and our practice of oral health care have lagged behind where science directs us. For instance, while extensive scientific evidence has demonstrated the benefits of fluoride in a range of formats to prevent and treat dental caries, this disease remains the most common non-communicable disease on the planet,[1] and surgical removal of diseased tissue and restoration of function and aesthetics remains the dominant focus of care.[2]

For many years, dental care has remained low on the political agenda in Canada and many parts of the world, seeing little policy and program development, clinical or workforce innovation and strategic research planning. In recent years however, there is increasing recognition by governments, health professionals and the public that treating oral disease is both expensive,[3,4] with spending on dental care in Canada reaching $16.4 billion in 2019,[5] and costly in terms of time off work and school. These expenses, and costs are experienced unequally, with inequities in oral health remaining significant and access to dental care very difficult for many.[6]

These increasing costs, inequities in access to oral health care and lack of progress in addressing oral diseases have led governments and international agencies to act. In December 2023, the Canadian government announced the Canadian Dental Care Plan (CDCP).[7] Earlier in 2024, the WHO published its "Global strategy and action plan on oral health

The world is rapidly changing, presenting new challenges to add to existing ones. There are also new policies and opportunities that make this inaugural National Oral Health Research Strategy (NOHRS) both necessary and timely.

2023–2030" (GSAPOH), including a range of measures to reduce the burden of oral disease globally and integrate oral health care into primary medical care and universal health care.[8] At the same time, in Canada, for the first time in 15 years the current, 2022-24 Canadian Health Measures Survey (CHMS) cycle 7, includes clinical, biological, and self-report indicators of oral health.[9] Furthermore, in early 2024, the Canadian government recognized the need to invest in the education and licensing of foreign trained health care professionals, including dentists, so the health care workforce can better address the needs of people living in Canada.[10]

Amid these significant Canadian and international policy developments, the world of science and research is moving fast. As examples, artificial intelligence (AI) is now being investigated and developed as a tool to aid both research and health care[11] and climate change is driving the search for more environmentally sustainable technologies and approaches to healthcare in Canada[12,13] and internationally.[14] In the world of oral health research, and particularly in Canada, we recognise emerging challenges such as the dramatic increase in oropharyngeal cancer incidence,[15] the uptake of tobacco vaping,[16] the large increase in numbers of frail elderly people living in Canada and the challenges this presents for health care,[17] the contribution of Canadian dental care to antimicrobial resistance,[18,19] as well as the need to develop safe, sustainable replacements for amalgam,[20] among many other challenges and trends.

We also urgently need to better understand how "*oral health is health*". For instance, how might the mouth be the "canary in the coal mine" for heart disease, obesity, diabetes, or arthritis? Or how do poverty and sugar interact to cause oral and other chronic diseases and how can we intervene to prevent that happening? And how are the oral and gut microbiome related to inflammatory pathways and multiple manifestations of chronic disease? Answering such questions means integrating oral with other health, conceptually, in care provision and in research.

In short, the world is rapidly changing, presenting new challenges to add to existing ones. There are also new policies and opportunities that make this inaugural National Oral Health Research Strategy (NOHRS) both necessary and timely. This NOHRS will inform governments and decision-makers, funding agencies, researchers and their organizations, health care practitioners, the public and others to focus both on emerging, priority issues for Canadian society and on innovative methodological and technological approaches to address these issues. The oral health research community in Canada is a small but dynamic group and this NOHRS can help expand its numbers and skills, as well as its integration with other health research and ultimately support improving [oral] health and reducing inequities among people living in Canada.

D

NOHRS Objectives

The National Oral Health Research Strategy is a research strategy, rather than a strategic plan or an implementation plan. It has two objectives:

1 To galvanize the community

For all who are interested in oral health research as a means to improve oral health and oral health care, we encourage collaboration around the strategic priorities we have collectively developed. This strategy is a call to us all to get involved, take the lead, and create collaborations, teams, projects, and opportunities to achieve our goals over the coming months and years - hence the purposeful use of the collective "we" and "our" throughout the document.

2 To leverage our strengths

We seek to advance existing fields of strength, such as pain, craniofacial biology, and public health, to foster and nurture new research fields and leaders, and to create infrastructure to support the strategic priorities we have identified.

The significant investment of resources in oral health in Canada occurring now, coupled with calls to action and change in the field around the world, create an outstanding and unparalleled opportunity; it is our responsibility to seize this moment. For example, to complement the CDCP and the 2022-24 CHMS cycle 7, Statistics Canada is investing substantial resources in collecting new data to support evaluation of the CDCP program, monitor the oral health of people living in Canada and evaluate how the oral health care workforce can better address the diverse population's health care needs. Globally, the previously mentioned WHO GSAPOH calls for countries to have a national oral health research strategy. At this point, the National Institute of Dental and Craniofacial Research (NIDCR) in the USA has published its strategic plan[21] and the National Institute for Health and Care Research (NIHR) in the UK has published a list of oral and dental research priorities.[22] This Canadian NOHRS addresses the GSAPOH objective for national research strategies and is a call to the Canadian community and our international peers to contribute to this national and international effort to improve oral health for all.

E

Process

The National Oral Health Research Strategy (also referred to as 'this Strategy' below) is a collaborative initiative led by the Canadian Institutes of Health Research's (CIHR) Institute of Musculoskeletal Health and Arthritis (IMHA) under the leadership of Dr. Karim Khan, in partnership with various Canadian oral health professional organizations and research/academic institutions. The Strategy was co-created by the oral health research community, health researchers from other disciplines, professional bodies, and patient and public partners.
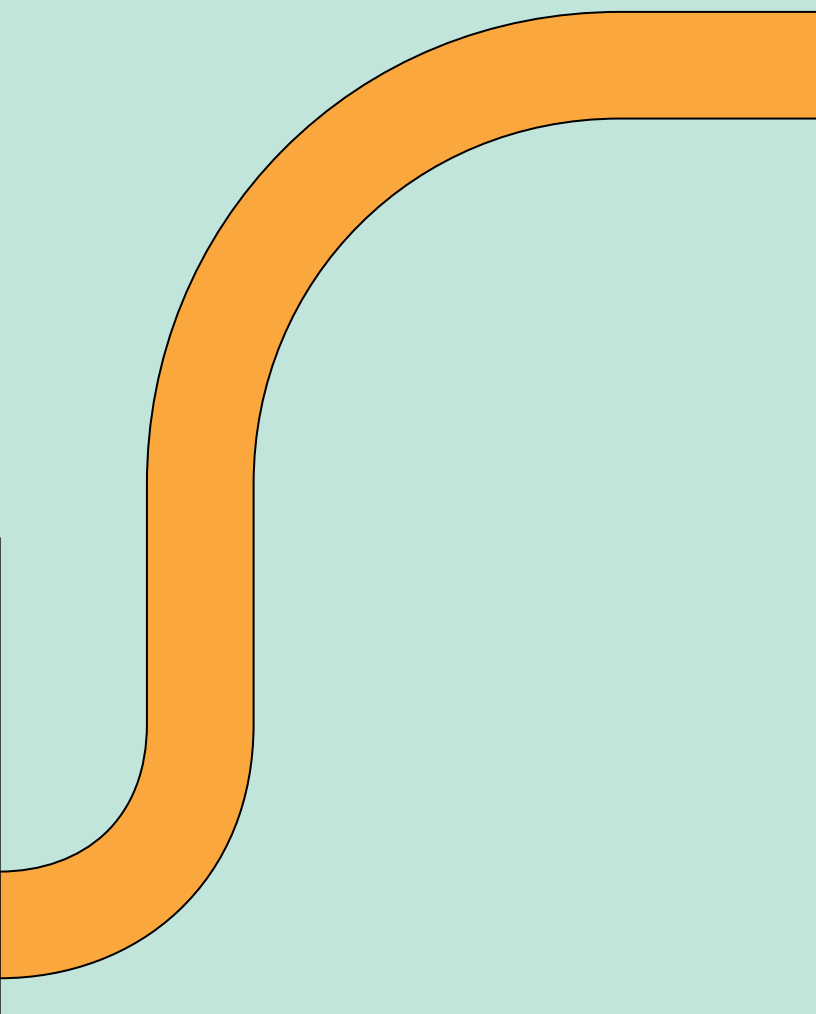
Summer 2022

Initiating NOHRS

We convened a broad community committed to improving oral health to discuss potential research themes with the goal of establishing research priorities. The planning committee comprised representatives from CIHR-IMHA, the Canadian Association for Dental Research (CADR), the Association of Canadian Faculties of Dentistry (ACFD), and the Network for Canadian Oral Health Research (NCOHR).

March 2023

Launch Event, Ottawa

Seventy participants, including patient and public partners, health researchers from various fields, and individuals experienced in working with diverse communities engaged in sessions that set the scene for the development of this Strategy.

Autumn 2022

Open Call

An open call for participation was shared through various channels, including the CIHR-IMHA website, e-blast, and social media.

April 2023

"What We Heard" Report

Following the March 2023 meeting, a steering committee comprising representatives from CIHR-IMHA, CADR, ACFD, NCOHR, and national oral health professional associations, and chaired by Dr. Paul Allison and Dr. Leigha Rock, developed an Executive Summary and a "What We Heard" (WWH) Report, which summarized the discussions and proposed next steps from the launch event.

April - July 2023

Community Feedback Round 1

To ensure inclusivity and gather feedback, the Executive Summary and WWH Report were shared with the launch event attendees for comments. Feedback which included research priorities, proposed edits, and missing perspectives was considered for subsequent versions of the documents. Broader community feedback was then also sought through a survey distributed widely and publicly, including on IMHA's website. This further informed the development of the Strategy.

August 2023

Six Writing Teams Convened

Writing teams were formed around the six priorities. Team members were selected based on responses to an open call for expressions of interest. The steering committee reviewed these submissions and proposed co-chairs and team members. An emphasis was placed on incorporating diverse perspectives, including Indigenous expertise.

July 2023

Steering Committee Agreed On Six Working Priorities

This process resulted in the steering committee agreeing on six research priorities which emerged as core to this Strategy: access to oral health care; artificial intelligence; inequities, identities and oral health; omics; knowledge mobilization and implementation science; and environmentally sustainable interventions in oral health care.

Fall 2023

Initial Development of the Strategic Priorities

The writing teams were asked to develop a short summary of issues relevant to their strategic priority and to identify up to three examples of important research topics within their priority. Team co-chairs participated in monthly meetings to develop interim drafts and provide updates.

November 2023
Patient and Public Consultations

Patient and public engagement consultation sessions with representatives from the writing teams were conducted to gain further insights and perspectives. These were facilitated by Dr. Dawn Richards and Dr. Hetty Mulhall.

April/May 2024
Finalizing NOHRS

The final draft underwent review by internal and external partners and was finalized and approved by the Steering Committee in May 2024.

January 2024
Development of Draft 1

Each team's summary document and research priorities were submitted by early January 2024, and a first draft of the NOHRS was completed by the end of January 2024. This version was translated into French and both language versions were distributed for broad community feedback during March and April 2024. This process included seeking formal reviews from several specifically identified international reviewers as well as distribution to the oral health and broader communities via multiple channels, plus English and French language webinars.

June 21 2024
Halifax, NS

Final Version of NOHRS Launched at the Canadian Oral Health Summit

F

Guiding Principles

People

Equity, diversity, inclusion, and accessibility (EDIA)

We will include the most diverse range of people in our work, whatever their roles, whether they be community representatives, study participants, students, health professionals, decision-makers, researchers, or others. We recognize that there are groups who have been marginalized from all elements of research and we will work to begin to address those inequities and exclusions.

Patient and community engagement

We strive to include people who will use and benefit from the results of our research, whether as members of the community, patients in hospitals or community clinics, and/or their carers, the media, and others. We need this input at all stages of our research, to co-create the best possible research projects whose findings contribute to improved health for all.

Capacity building

All elements of the work emerging from this plan will integrate the recruitment, training and retaining of excellent people and leaders in research so that the next generation is better placed to perform the work of this plan and future related work. Understanding and addressing Canada's oral health-related research workforce needs is an important aspect of examining Canada's health care workforce needs more generally. Broad research and education collaborations within the country as well as with researchers and entities outside of Canada will build capacity.

Ideas

Oral health is health

History has separated caring for the mouth from caring for the rest of the body. The reality, however, is that the social determinants and pathological processes related to oral and general health, and the approaches in medical and dental care are broadly the same. Furthermore, as outlined by the WHO's GSAPOH, we need to integrate oral health care with general medical care.[8] This principle of re-integrating the mouth with the rest of the body in all manifestations of research and health care will drive our work.

Health promotion and disease prevention

The focus of the work coming from this Strategy will be on promoting health and preventing disease. The principal oral health problems experienced by people living in Canada are preventable chronic problems: dental caries, periodontal disease, tooth loss and oral cancer. Research needs to provide and implement solutions to promote good oral health, prevent oral diseases and reduce the need for treating disease that has already occurred.

Environmental sustainability

The European Regional Office of the WHO defined a vision for an environmentally sustainable health system as being a health system that improves, maintains, or restores health, while minimizing negative impacts on the environment and leveraging opportunities to restore and improve it, to the benefit of the health and well-being of current and future generations.[14] We extend that definition to cover the research driven by this plan i.e. our research will aim to be environmentally sustainable.

Science

Open science

We believe strongly in the principles of open science and will work to ensure that all elements of research (e.g., protocols, data, findings, and impacts) are accessible and used widely. We will adhere to the FAIR principles (findable, accessible, interoperable, and reproducible).[23]

Collaboration and Integration

We all have experiential expertise and some of us have formal and informal training in a range of disciplines, fields, professions, and other domains of knowledge relevant to health and research. We will engage and collaborate with people from a wide background and diversity of such experiences and integrate their expertise to enable the highest quality research and to ensure that such work is translated to decision-makers, and then to interventions including treatments, legislation, and policy.

Science-informed health decisions

We believe strongly in the use of science and the highest quality evidence to support health care, health policy and other health-related decisions at all levels. We will also recognize that all forms of research can make strong contributions to evidence-informed decisions, including quantitative, qualitative, and mixed methods, crossing fundamental, translational and applied research pillars.
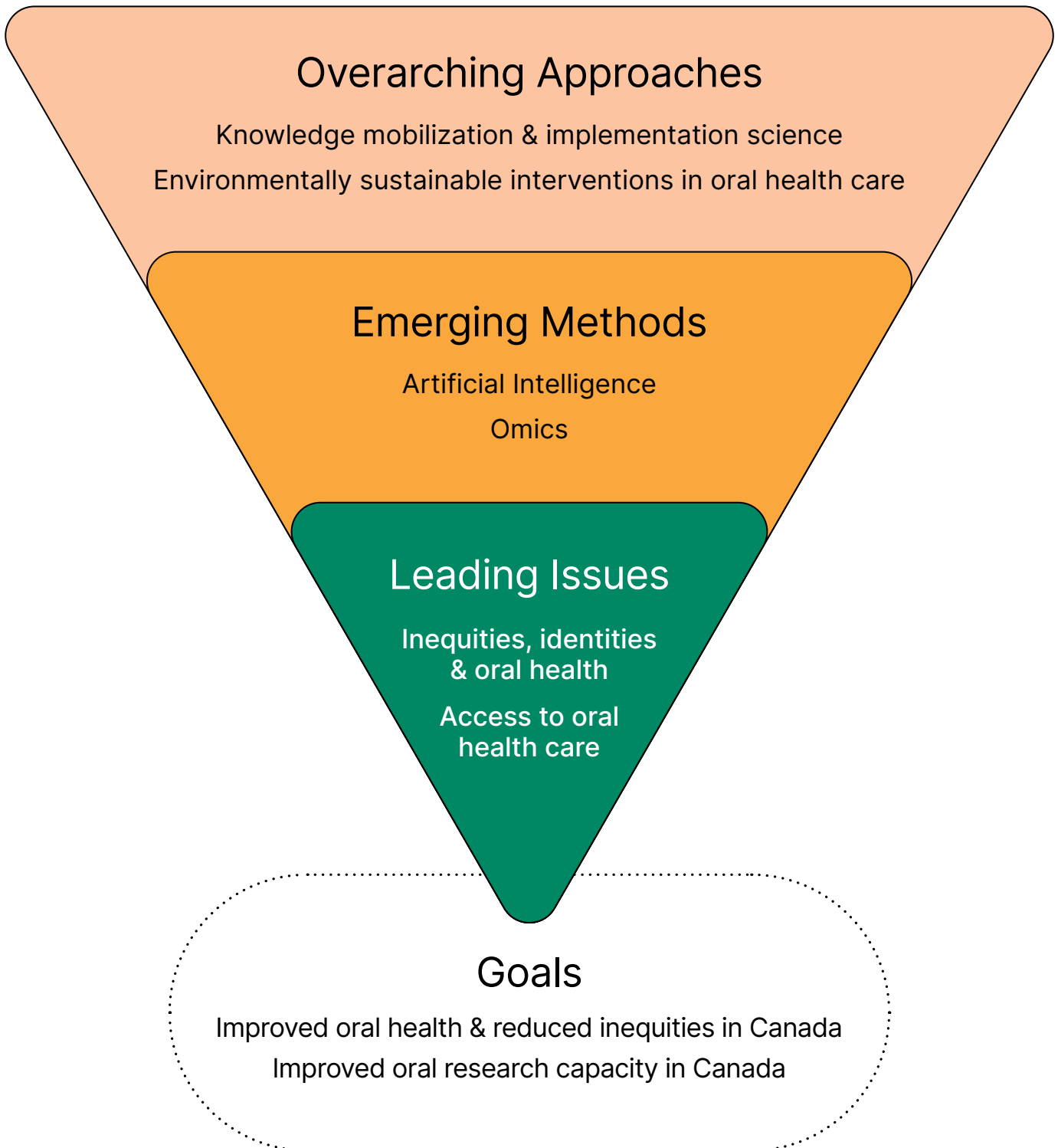
Strategic Priorities

From the broad consultation process used to develop this Strategy, six priorities emerged. Using these, we created three groups of two priorities each (see figure 2).

- Leading issues:
  - access to oral health care
  - inequities, identities and oral health
- Emerging methods:
  - artificial intelligence in oral health
  - omics and oral health
- Overarching approaches:
  - knowledge mobilization and implementation science [KM/IS]
  - environmentally sustainable interventions [ESI] in oral health care

With this framework, as well as the guiding principles in mind, we present our strategic priorities below. As a high-level strategy document, the priorities cover a broad range of topics and methodological approaches. We offer examples of research topics for each priority area, but these are intended as exemplar, rather than exclusive; the same holds for the Strategy goals (Section H). Furthermore, some of our priorities can readily overlap and some specific research topics fit multiple priorities. For instance, AI could readily be used to investigate identity and health, while understanding issues faced by people with disabilities* is relevant to the access priority but could also have implications for KM/IS and be the subject of ESI. Deciding precise directions will be for the research teams implementing this NOHRS.

*We recognise that the words we use to describe individuals with disabilities matter. We acknowledge two major linguistic points of view to address disability. Putting the person first, as in "people with disability," is called people-first language. It is often used to reduce the dehumanization of disability. The other is known as identity-first language, as in "disabled people." Many use this style to celebrate disability pride and identity or simply because they prefer this. There is no consensus on which is the more respectful style. In this Strategy, we "use these two styles interchangeably to acknowledge and respect the individual preferences of an exceptionally diverse group of people".

Rahman L. Disability Language Guide. The Stanford Disability Initiative Board. July 2019.
Available from: https://disability.stanford.edu/sites/g/files/sbiybj26391/files/media/file/disability-language-guide-stanford_1.pdf

Figure 2.
National Oral Health Research Strategy Framework

Overarching Approaches

Knowledge mobilization & implementation science

Environmentally sustainable interventions in oral health care

Emerging Methods

Artificial Intelligence

Omics

Leading Issues

Inequities, identities & oral health

Access to oral health care

Goals

Improved oral health & reduced inequities in Canada

Improved oral research capacity in Canada

1

Leading Issues

1.1

Access to Oral Health Care
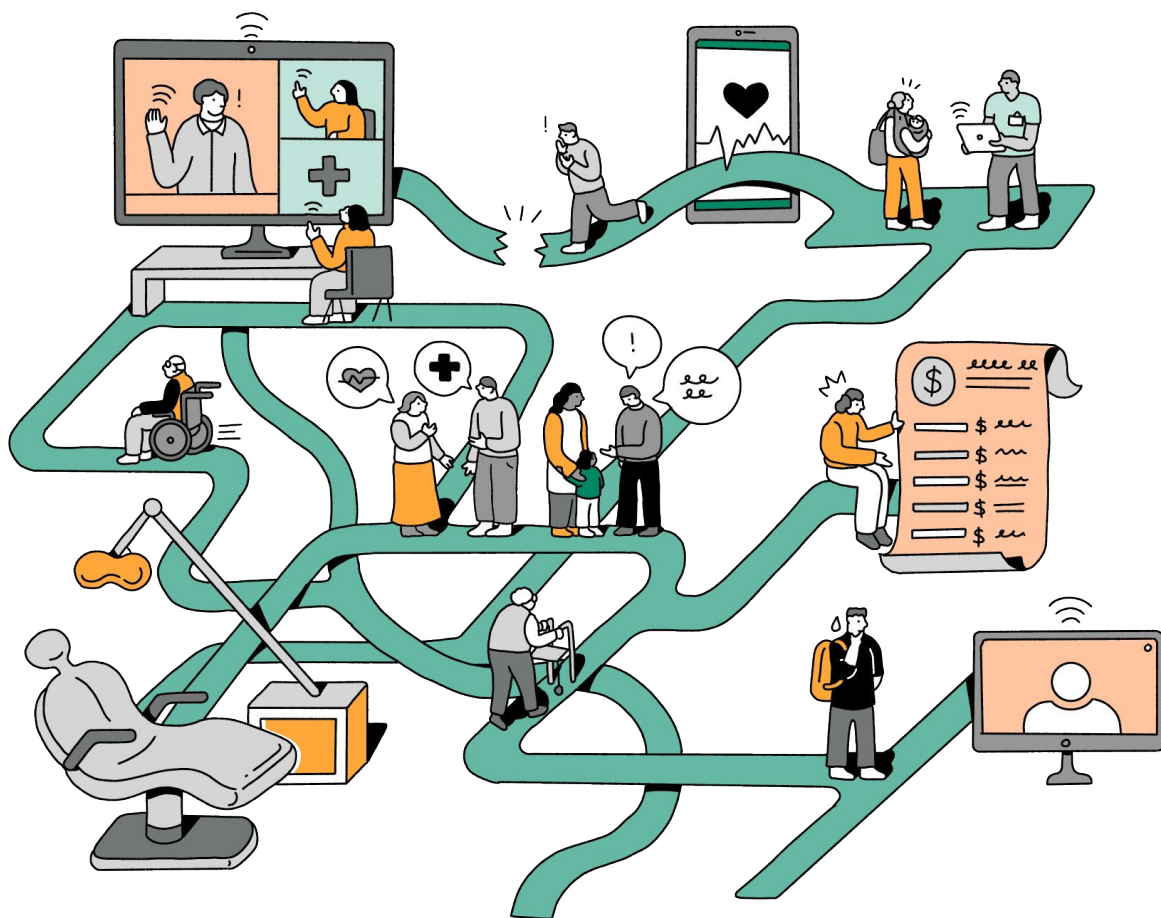
nequitable access to oral health care in Canada is currently a major problem for a broad range of marginalized populations such as Indigenous peoples, people living and working with low incomes, disabled people, those in rural and remote communities, seniors living at home or in long-term care facilities, infants, recent immigrants and refugees.[6,24,25] In 2022, 35% of Canadians reported a lack of any dental insurance coverage and approximately 24% reported avoiding the dentist due to cost.[26] Further barriers include distance and transport, workforce and facility availability and acceptability, workforce training, accommodations for diverse clientele, such as people with disabilities.[27] We must develop and evaluate interventions to address these multiple barriers, particularly given recent federal government initiatives such as the introduction of the CDCP[7] and the focus on Canada's health care workforce.[10]

Priorities for Research on Access to Oral Health Care

a

Evaluate the development, implementation and impact of programs and policies addressing access to oral health care in Canada.

Examples include:

- Developing a collection of appropriate indicators of access to care and related concepts to be used in evaluations of a broad range of programs and policies.

- Evaluating existing dental care policies, and programs in federal, provincial, territorial, municipal and other governmental jurisdictions.

- Evaluating the CDCP roll out in the coming years.

b

Develop and test innovative approaches to providing oral health care that address access challenges experienced by marginalized groups.

Examples include:

- Developing and evaluating the training, skills, and care provision of a broad range of oral health care providers in settings that facilitate access to care for marginalized groups.

- Evaluating the competency of the workforce to address the oral health care needs of all people living in Canada, including marginalized groups.

- Recruitment strategies to diversify the workforce to better address the oral health care needs of all people living in Canada.

- Innovative interventions and materials such as teledentistry, new glass ionomer cements, social prescription, and health care navigators, for the provision of oral health care among marginalized groups.

C

Evaluate strategies that integrate oral health care with primary medical care.

Examples include:

- Incorporation of screening for oral health problems by oral and non-oral health care providers in preschool, schools, long-term care settings, primary care, and other settings.

- Delivery of preventive care (e.g., fluoride, fissure sealants, smoking cessation) by oral and non-oral health care providers in preschool, schools, long-term care settings, primary care, and elsewhere.

- Participation of oral health care providers in primary care teams, addressing a range of non-communicable diseases.

In 2022, 35% of Canadians reported a lack of any dental insurance coverage and approximately 24% reported avoiding the dentist due to cost.

1.2

Inequities, Identities and Oral Health

We want to understand how identity-related determinants, such as sex and gender, race and ethnic culture, biological and social age, geography and housing and other biological, social, and ecological indicators, interact to determine oral health and inequities in oral health.

nequities in oral health across the Canadian population have been well documented.[6,28-30] The NOHRS has a significant focus on research geared to comprehending and tackling health inequities. Research topics in this priority aim to identify, understand, and address inequities in oral health status and care. They emphasize the influence and interaction of various social and biological determinants of health and apply person-centred approaches and innovations to research and care to reduce these inequities. We want to understand how identity-related determinants, such as sex and gender, race and ethnic culture, biological and social age, geography and housing and other biological, social, and ecological indicators, interact to determine oral health and inequities in oral health. We seek to investigate and understand oral health at every life stage, the interconnectivity of oral health and health, and the role of improved care in promoting healthy aging for all people living in Canada. Furthermore, population-based surveys with oral health data, as well as longitudinal cohort studies and research networks incorporating the collection of biological, physical, clinical, and self-report data including oral health indicators, are critical to addressing this priority.

Priorities for Research on Inequities, Identities and Oral Health

a

Investigate identity-related determinants of inequities in oral health and in the delivery of oral health care, and focus on equitable, person-centred solutions to address these identity-related determinants and population-based indicators.

Projects may explore:

- Biological and social identities' interaction to determine oral health and care in those with substance-use disorders and/or mental health disabilities.

- Person-centred approaches to address identity-related inequities in oral health in Indigenous peoples as well as newcomers to Canada.

- Oral health care access experiences among people with different mental, physical, social, and other abilities and disabilities.

- Incorporation of biological and social age, sex and gender, race and ethnic culture and geography into research proposals such that research participation is reflective of the diversity of Canada.

b

Investigate inter-relationships among biological, social, and other identity indicators as determinants of oral health across the life course.

Projects may explore:

- Interactions among infant and early childhood biology, sex and gender, and race and ethnicity that determine oral health and non-communicable diseases in adulthood.

- Impacts of poor oral health on health and frailty in older adults.

- Relationships among living situations, frailty and aging, and their influences on older peoples' oral health and health.

- Recognition of inherited craniofacial conditions and disorders as examples of biological identity indicators and understanding how society affects the health of people with them.

C

Use a lifespan and life course approach across all identities to prevent and treat oral and craniofacial disease and dysfunction and to promote oral health and healthy aging.

Projects may explore:

- Preventive potential of infant, childhood, and adolescent interventions on health-related problems in adults.

- Interventions with infants, children, and adolescents with inherited disorders to support social fulfillment in adulthood.
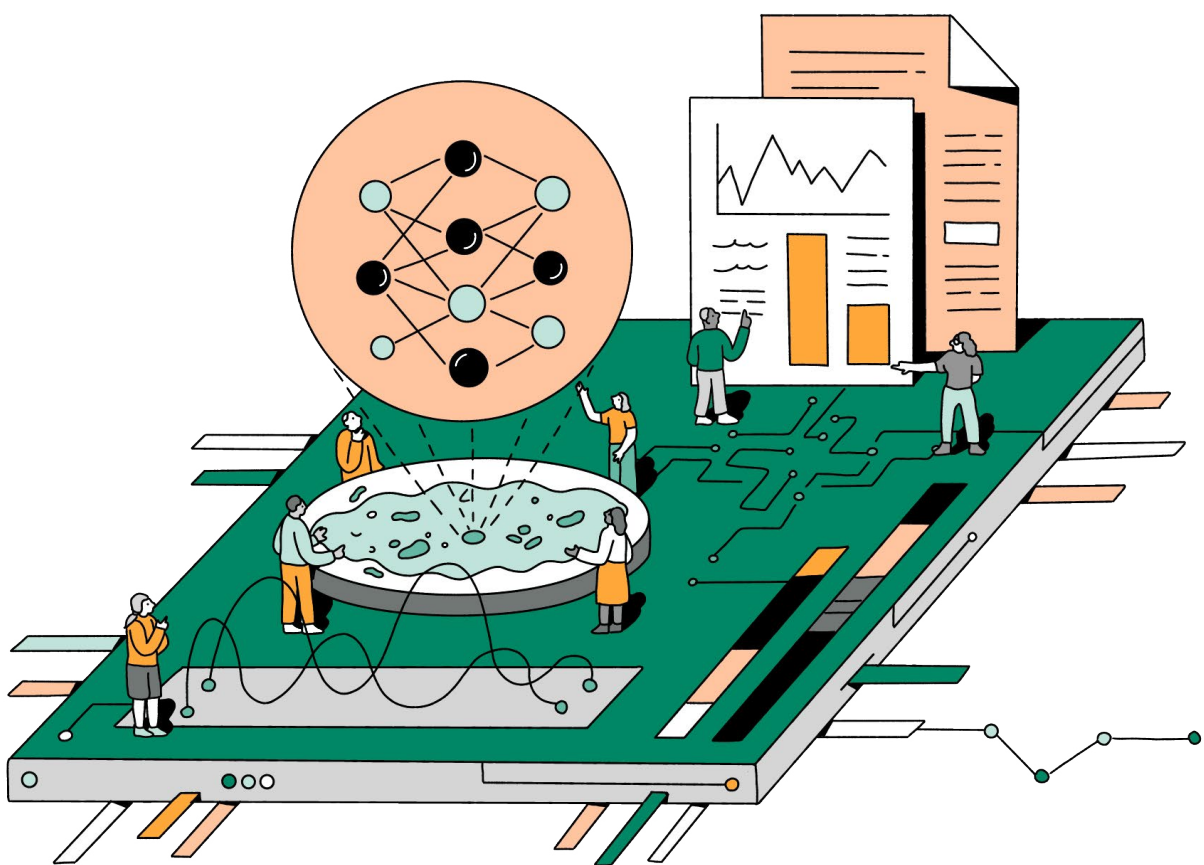
2

Emerging Methods

2.1

Artificial Intelligence in Oral Health and Oral Health Care

Artificial Intelligence (AI) is dedicated to creating intelligent machines capable of executing tasks that typically require human intelligence.[31] This innovative technology has been widely applied in various sectors, including in general healthcare and, increasingly, oral health.[32-35] AI's integration into oral health is a revolutionary change that will transform dental care.[36,37] AI-driven tools in dentistry are being rapidly adopted. Potential AI applications are extensive: assisting in creating dental prosthetics or refining orthodontic treatment plans; improving diagnosis of complex disorders; and streamlining the management of patient records and treatment histories.[38-41]

The integration of AI in oral health care must be approached responsibly with a focus on sustainability, inclusivity, and human-centred design.[42-44] AI systems need to be developed with environmental considerations and the diverse needs and values of different patient populations in mind. In addition, it is acknowledged that the robustness and sustainability of data science for oral health will depend largely on resources from the Canadian government.

Human-centred AI should augment rather than replace human expertise and assist the oral health system and its professionals. Regulatory bodies, including Health Canada, must ensure the safe and effective implementation of AI in oral health. Regulations must be developed to ensure that AI applications meet strict privacy, safety, accuracy, and ethical standards. We have heard patient and public partners emphasize that adherence to appropriate regulations is essential for maintaining public trust and ensuring that AI is used to benefit both patients and practitioners.

Priorities For Research on AI in Oral Health and Oral Health Care

a

Ensure that the oral health field is AI-ready. AI-readiness refers to the state of preparedness to effectively utilize AI technologies. This applies to researchers, clinicians, patients, regulators, and policy makers. AI should be used effectively, responsibly, and ethically.

Examples include:

- Establishing ethical and secure data management practices.

- Identifying and removing barriers to standardizing AI-ready oral health data via federal, provincial, and territorial collaboration.

- Developing sustainable and collaborative research networks and data infrastructures including open datasets for benchmarking.

- Investing in training and AI literacy among diverse groups of interested people including researchers, clinicians, patients, and policy makers.

b

Develop AI-based tools responsibly and evaluate them rigorously. AI needs to serve humans ethically, transparently, accountably, and in alignment with human values. Industry, researchers, regulators, and policy makers must develop AI-based tools collaboratively.

Project foci may include:

- Integration of multimodal data (e.g., images, scans, patient records, smart sensors) in AI tools.

- Issues of ethics and fairness in AI-based tool development and implementation.

- Uncertainty, causal reasoning, trustworthiness of AI-tools and their impact.

- Bias in AI and strategies for addressing it.

- Equity, diversity, and inclusivity in AI tool development and implementation.

- Privacy protection and information security in AI applications while adhering to standards of practice in healthcare (e.g., HIPA, PIPEDA, PHIPA compliance).

- Enhancements of human-AI collaboration via participatory designs.

- Environmental risks and benefits of AI-based tools.[45]

C

Implement and measure the impact of the application of AI in oral health and in oral health care.

Researchers will need to:

- Shift from data-centric to problem-centric (solution focused) research (e.g., development of a spatially specific workforce planning tool, taking into account sociodemographic and morbidity-based demand parameters as well as changes in the workforce, work capacity, etc.).

- Develop and validate instruments to measure and to improve patient-oriented outcomes.

- Implement and assess AI's impact on clinical workflow and acceptability to providers and patients.

Human-centred AI should augment rather than replace human expertise and assist the oral health system and its professionals. Regulatory bodies, including Health Canada, must ensure the safe and effective implementation of AI in oral health.
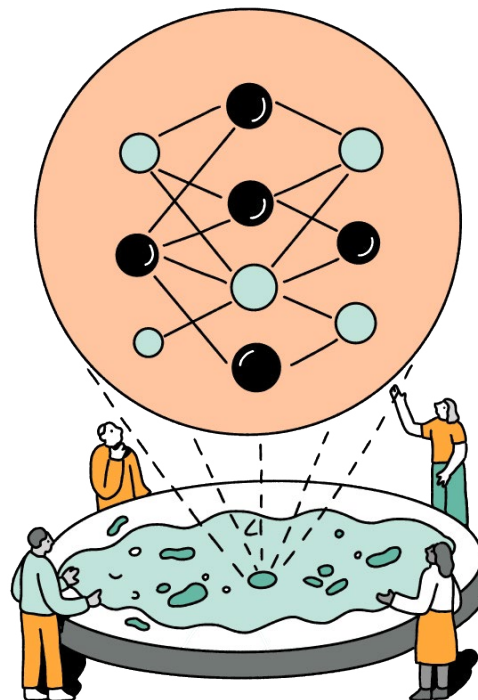
2.2

Omics and Oral Health
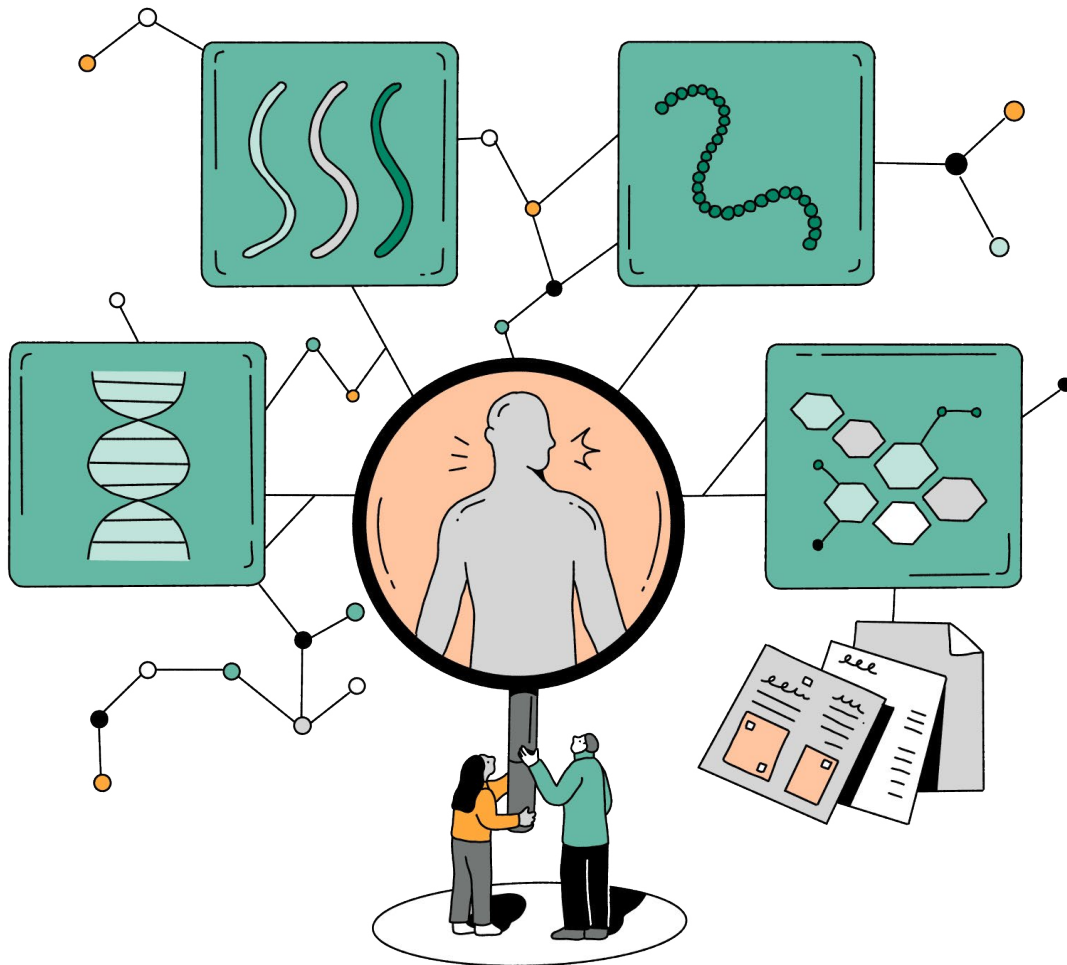
Omics can provide a powerful and comprehensive approach to personalized patient care, where patient-specific intervention and treatment options can be created.

Omics is a branch of science that aims to identify, characterize, and quantify all biological molecules involved in the structure, function, and dynamics of a cell, tissue, or an organism. Omics approaches enable the generation and analysis of large unbiased datasets with millions of individual data points that can lead to the formulation of hypotheses and theories. The clinical utility of omics technologies is rapidly evolving to provide unprecedented, data-driven patient care. As a result, omics can provide a powerful and comprehensive approach to personalized patient care where patient-specific intervention and treatment options can be created.

The oral cavity is particularly suitable for omics studies. It is easily accessible, allowing for non- or minimally invasive collection of biological materials. Cheek swabs, tissues excised during routine surgery or biopsy, extracted teeth, and saliva can all be used to characterize and improve oral and general health at both the individual (e.g., personalized medicine) and population levels. Saliva contains a diverse array of hormones, enzymes, antibodies and genetic materials that have been transferred from the bloodstream via various transfer mechanisms.[46] As a result, saliva, often called the "mirror of the body",[47-49] has been used extensively to diagnose and monitor disease activity and progression in dentistry, medicine, and pharmacotherapy.[50-53]

The 2022 - 2024 CHMS Cycle 7 provides a special opportunity for oral health research using omics technologies.[9] Researchers will be able to link physical measures and self-reported oral health data with biological specimens (including blood, urine, and saliva) that have been collected on a representative sample of people aged 1-79 years living independently in Canada.

Priorities For Research on Omics in Oral Health

a

Invest in the development of omics focused capacity and infrastructure.

We need:

- A Canadian 'Oral Health Repository' available to federal, provincial, and local governments, dental schools, and biomedical scientists. As clinically annotated biological specimens become molecularly characterized through individual publicly funded research projects, researchers, academic institutions, and government agencies need to work together to create a central atlas of multi-omics data which can be used by researchers from diverse disciplines and multiple institutions for secondary analysis to answer complex questions in our ability to diagnosis, treat, and prevent disease.

- A coalition of government agencies, academic institutions, and hospital centres throughout Canada to identify emerging trends in Canadians' oral health via the use of omics and big data.

- A program of training in omics technologies and the use of omics approaches in delivering precision patient care. This program is necessary to develop highly qualified personnel who understand basic biological mechanisms at the root of oral health disorders.

b

Prioritize research that aims to identify risks and omics-based biomarkers for disease and conditions at early, more treatable stages. The development of omics tools can potentially create new tools to provide diagnosis and prognosis and to guide precision treatment.

Examples include:

- Developmental and structural disorders of the craniofacial complex (e.g., uncovered genes and molecules that may be involved in orofacial clefting, or to understand salivary molecular patterns in patients with enamel hypomineralization).

- Cancers (e.g., can omics be used to identify potentially premalignant and malignant oral diseases and conditions at early, more treatable stages?).

- Connective tissue disorders. (e.g., can omics be used in omics-based stratification for personalized therapeutic approaches in scleroderma or Sjögren's syndrome?).

- Chronic disease and the oral microbiome (e.g., how do oral bacteria, fungi and/or viruses link to systemic health?).

C

Use omics as an approach to addressing oral health diseases in priority populations. Canada has several vulnerable and priority populations that suffer a high burden of oral disease and inequities. Omics technologies could contribute to understanding the biological variation that contributes to poorer oral health in these populations.

Examples include:

- Combining omics with AI approaches to leverage electronic health records and other types of existing data to investigate health disparities and advance health equity.

- Integrating multi-omics and clinical data analysis (e.g., deep phenotyping) to advance precision medicine and reveal pathophysiology of craniofacial diseases and developmental biology.

- Prioritizing Sex- and Gender-Based Analysis Plus (SGBA Plus) that aims to identify potential sex and gender differences in diseases.
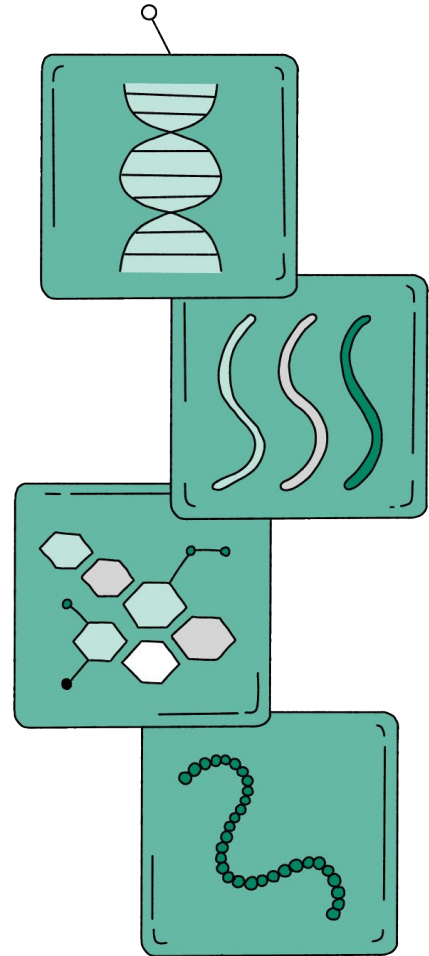
3

Overarching Approaches

3.1

Environmentally Sustainable Technologies and Interventions in Oral Health Care

The impact of human activity on planetary health is undeniable.[54] Additionally, it is now common to recognize climate change and environmental degradation as foundational to human health. Climate change brings stresses to health systems that need to be anticipated and planned for.[55] The effects of planetary health on population health and individual well-being are clear in terms of "infectious diseases, non-communicable diseases, traumatic injuries, mental distress, and illness".[56]

The effects of health care on planetary health cannot be ignored either. It is estimated that health care contributes about five per cent of annual national carbon dioxide emissions.[57] The World Dental Federation and representatives from national dental associations and the dental industry have recognized that oral health care contributes as well.[58] For instance, a study of dentistry's carbon footprint in England demonstrated that examinations (27.1% of footprint) followed by amalgam/composite restorations (19.3%) and scale and polish
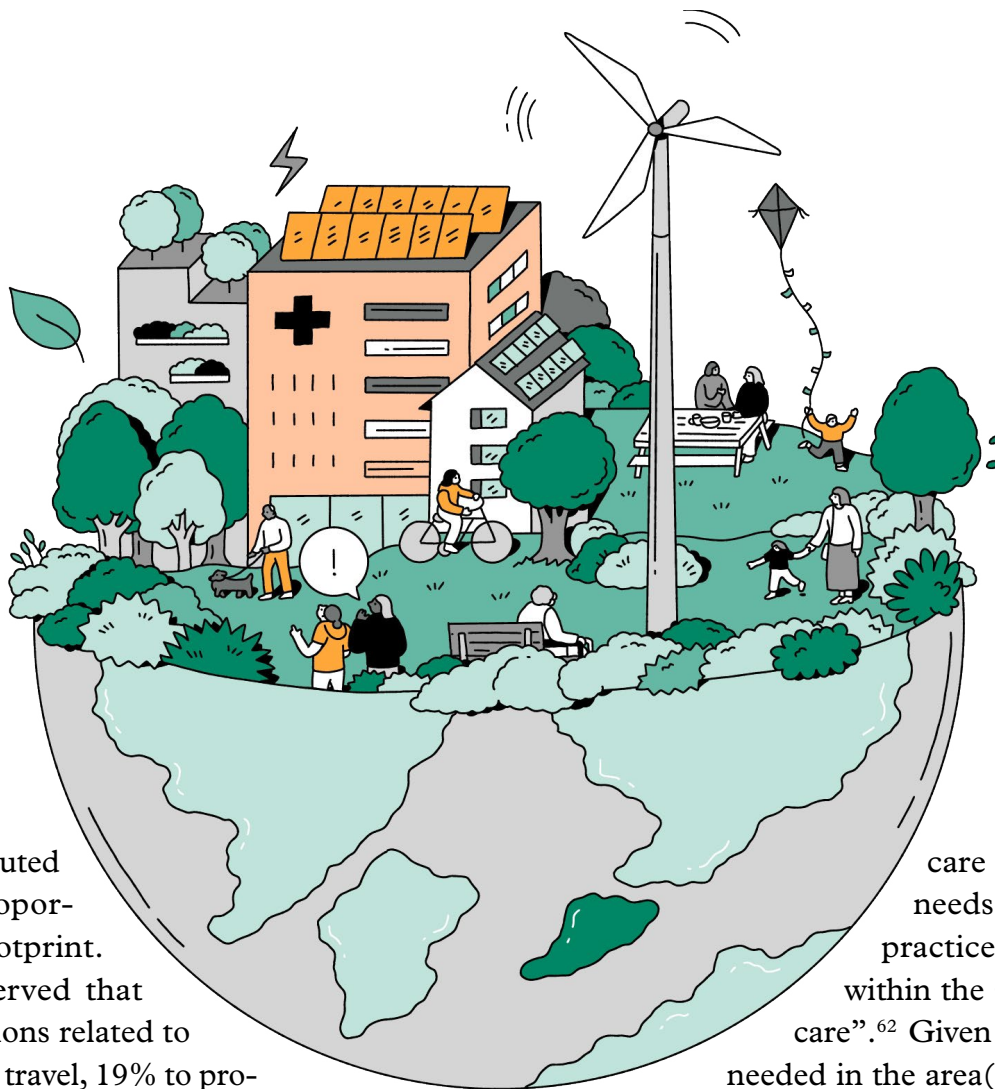
(13.4%) contributed the highest proportions to this footprint. They also observed that 64.5% of emissions related to staff and patient travel, 19% to procurement and 15.3% related to energy use.[59]

Additionally, there is a growing Canadian stewardship for the phasing out of amalgam. The Minamata Convention,[60] a world-wide agreement which Canada ratified in 2017, aims to reduce environmental dangers by gradually banning dental amalgam use globally. The "Canada-Wide Standard on Mercury for Dental Amalgam Waste" outlines best management practices that can be used to mitigate the potential environmental impact of the mercury content found in dental amalgam.[61] The potential environmental impact of the mercury content found in dental amalgam can be managed through the implementation of best management practices and through the development of novel materials design, innovative technologies, and lab-based research.

As Duane et al. argue, "Healthcare systems need to fundamentally change to enable systems to deliver appropriate, affordable, and sustainable health care [and] dentistry needs to change on a practice-wide level and within the system of health care".[62] Given this, research is needed in the area(s) of sustainable technologies and interventions in oral health care. Here, we define sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs".[63] In turn, we believe that dentistry is sustainable or "green" when it is fiscally, socially, and ecologically responsible. Also, in developing sustainable materials, processes, and policies, it is important to focus on disease prevention and health promotion, as these strategies will reduce dentistry's carbon footprint compared to the current treatment orientation.

In short, oral health care needs to be environmentally sustainable at the micro-, meso-, and macro levels. This includes improving infection prevention and control regimes; reducing, reusing, recycling dental instruments, materials, and waste; minimizing unnecessary care; and/or allocating resources toward equity and preventive care.

Priorities for Research in Environmentally Sustainable Interventions in Oral Health Care

a

Manufacture existing or develop new dental materials and equipment that meet environmental sustainability definitions and standards, while maintaining or exceeding quality of care and facilitating health promotion and disease prevention. We need to develop, implement, and evaluate dental materials, equipment and processes that are "green."

Examples include:

- Developing dental materials that are less toxic to the environment and equipment whose manufacturing process is less harmful and more energy efficient.

- Developing processes (e.g., 3-D printing) that contribute to reducing dentistry's carbon footprint while improving quality of care.

- Developing, promoting, and incentivising preventive dental care as a means to reduce dentistry's carbon footprint.

b

Develop novel dental clinic operational interventions that meet environmental sustainability needs. We need to develop, implement, and evaluate existing and new "green" operational interventions at the dental clinic level, which are safe, feasible, effective, and sustainable.

Examples include:

- Developing safe alternatives to single use and plastic equipment, while upholding infection prevention and control standards.

- Reducing, reusing and/or recycling personal protective equipment and dental clinics' solid waste.

- Making clinic designs and infrastructure more energy efficient.

- Using teledentistry, AI and digital technology to reduce patient and staff travel and generally reduce the carbon footprint of dental clinics.

- Developing minimally invasive dental approaches that can reduce dental clinics' carbon footprint.
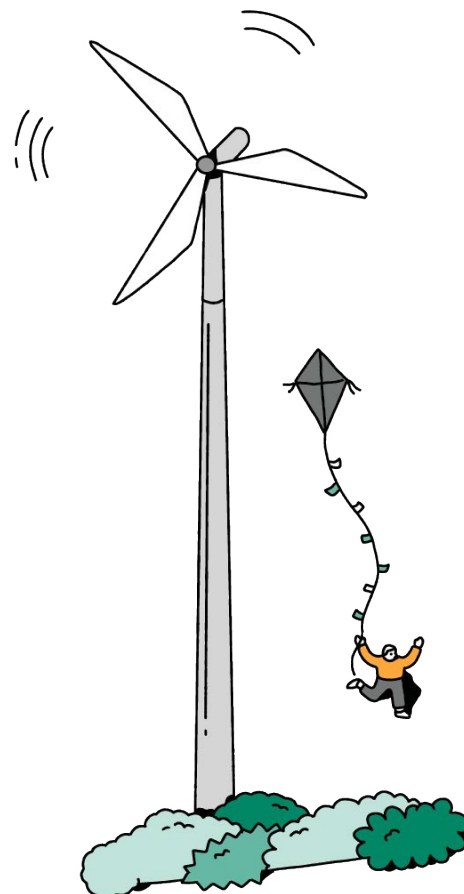
The effects of health care on planetary health cannot be ignored (...) It is estimated that health care contributes about five per cent of annual national carbon dioxide emissions.

C

Ensure that oral health care systems meet environmental sustainability needs. We need to develop, implement, and evaluate existing and new "green" system-wide interventions.
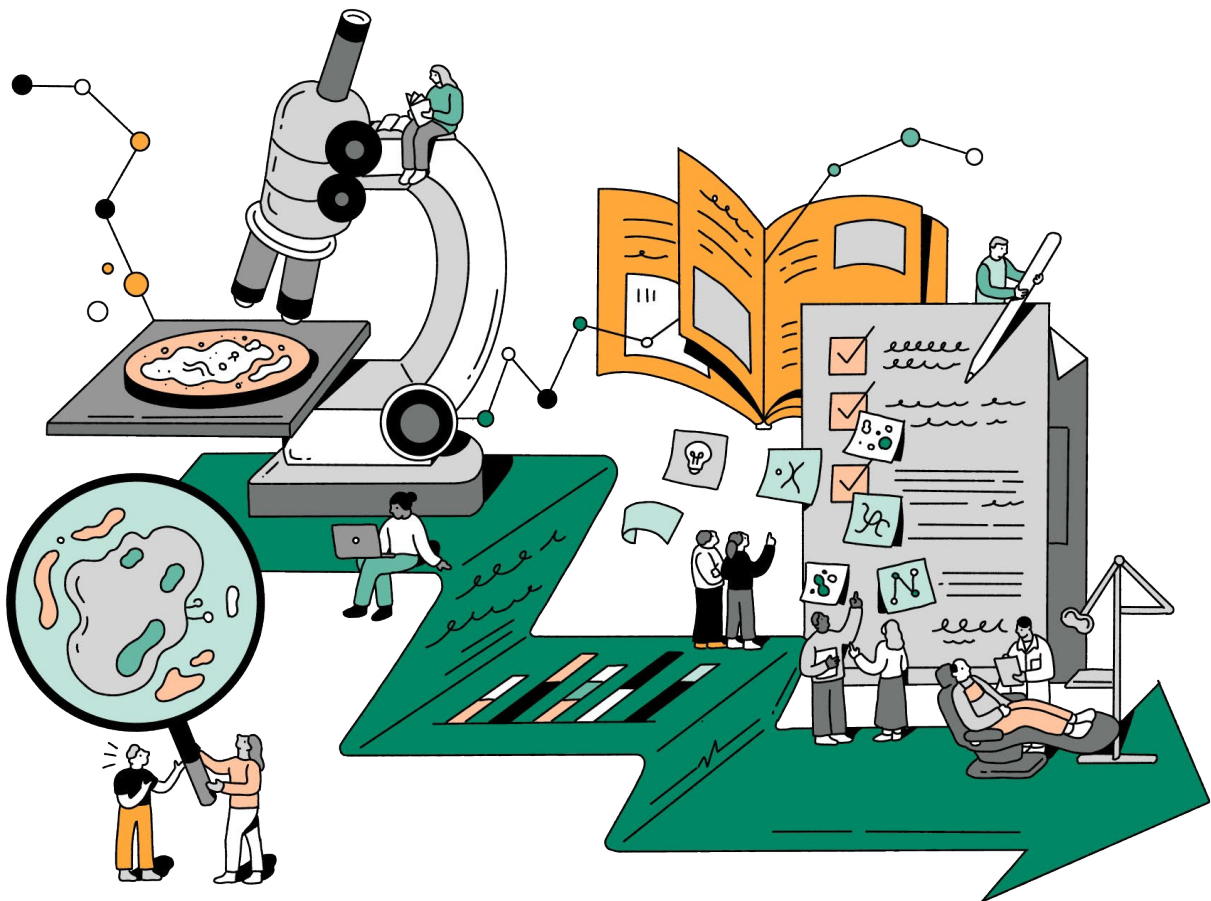
Examples include:

- Creating legislation, policy, and/or guidelines to drive sustainability in oral health care. As a baseline, investigating what is the carbon footprint of Canada's oral health care system nationally and sub-nationally.

- Evaluating sustainability initiatives through health economic sustainability impact analyses and exploring the effectiveness of existing and alternative service delivery models and interventions that drive change.[58]

3.2

Knowledge Mobilization and Implementation Science to Improve Oral Health and Oral Health Care

Research has significantly contributed to enhancing oral practices and public health.[64-73] Despite this progress, the incorporation of research evidence into clinical practice, referred to as the evidence-to-practice or the know-do gap, is estimated to take an average of 17 years.[74] This gap has been further emphasized by the rapid emergence of new technologies and innovations in oral health practices, alongside recent changes in national and international oral health policies and recommendations.[75] In addition to the delay in benefiting patients and society at large, the evidence-to-practice gap has historically disproportionately affected marginalized populations, leading to increased health inequities.[75] Therefore, there is an immediate need to promote the integration of scientific evidence into oral health practice and policy in order to strengthen oral health care systems[76] and to ensure that knowledge users are aware of and can actively incorporate research findings into their decision-making. This can be facilitated through advancing knowledge mobilization (KM) and implementation science (IS) in oral health research.

KM encompasses the production and utilization of research results in a dynamic and iterative process that ultimately aims to benefit users and society, informing decisions about practices, programs, education, training, and policies.[77] KM is guided by the principles of patient/citizen engagement[78,79] to ensure that knowledge development is relevant and useful for the diverse end users. KM aims to get the right information to the right people in the right format at the right time to influence decision-making.

Similarly, IS is the study of methods and strategies that facilitate the uptake of evidence-based or evidence-informed research findings into regular use to improve the quality of health services across multiple settings.[80] The integration of KM and IS into oral health research, collectively referred to in this document as KM/IS, is crucial for addressing challenges and opportunities in oral health care and oral health care systems, including, but not limited to, the integration of fundamental research findings into translational and applied research, the uptake of evidence-informed clinical practices and policies, the implementation of technological innovations including teledentistry, Artificial Intelligence, virtual reality, and environmentally sustainable oral health care.[58,59,81,82] The overarching goal of KM/IS in the context of oral health research is to ensure the systemic uptake of the best available evidence into routine oral health practices and systems, and to discontinue practices or policies that lack the support of current scientific evidence and/or those that are harmful to the environment. KM/IS is thus integral to advancing research, practice, education, policy, and the impact of Canadian oral health research.

Priorities to advance KM/IS in Canadian oral health research

a

Identify the multi-level barriers and facilitators that influence the implementation of oral health innovations

Examples include:

- Identifying theories, models, and frameworks to guide and understand how resources, infrastructure, and context, including economic and political factors, influence the implementation of oral health innovations.

- Characterizing the individual and environmental factors that influence the adoption, sustainability and scale-up of oral health innovations.

b

Evaluate KM/IS strategies and outcome measures.

Examples include:

- Promoting data sharing to embrace open science so that researchers can replicate and validate studies while ensuring that end users can readily access research results.

- Understanding how to work with knowledge users, promote partnerships and incorporate KM/IS considerations to maximize the success of adoption, sustainability, and scalability of interventions.

- Investigating how to advocate for evidence-informed practices and policies on multiple fronts and engage policymakers and policy entrepreneurs to influence implementation.

C

Build capacity in KM/IS research for oral health researchers, patients/families, community organizations, policymakers, oral health care providers and organizations.

Examples include:

- Training the oral health workforce in evidence-informed practices and critical appraisal of the scientific literature to foster the sustainability and the scale-up of oral health innovations.

- Incorporating KM/IS concepts in oral health education to achieve a workforce that is capable of understanding, implementing, and educating patients on evidence-informed oral health innovations.[83]

- Ensuring new knowledge, treatments, policies, and other interventions are relevant for and used by and with marginalized groups.

The overarching goal of KM/IS in the context of oral health research is to ensure the systemic uptake of the best available evidence into routine oral health practices and systems, and to discontinue practices or policies that lack the support of current scientific evidence and/or those that are harmful to the environment.
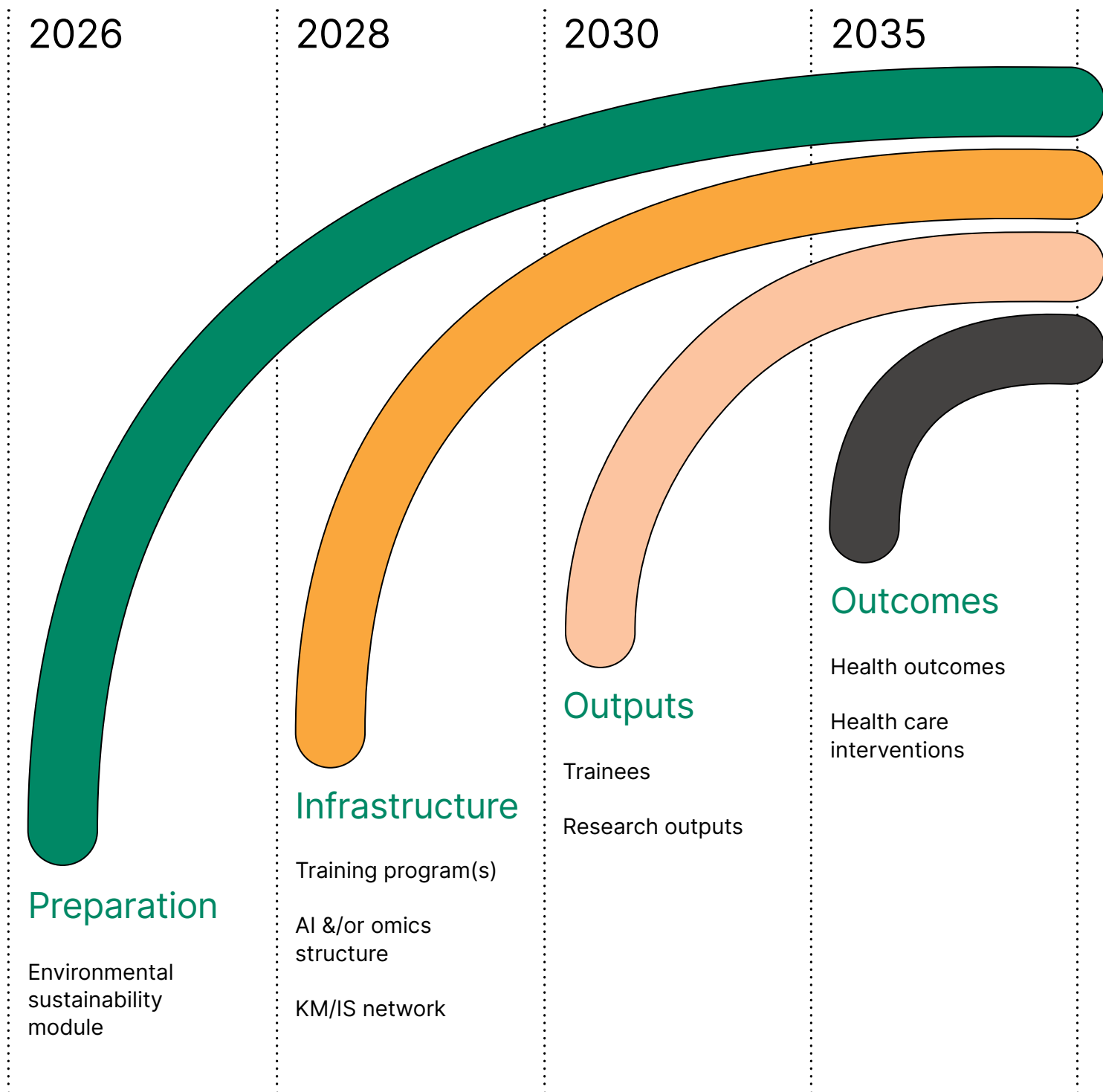
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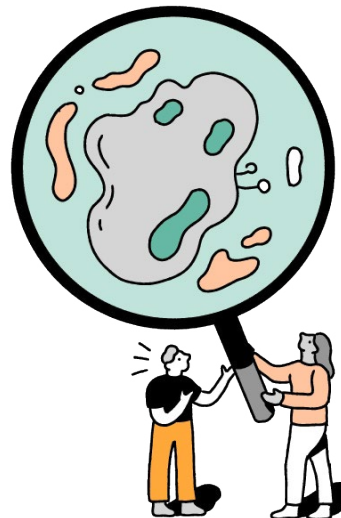
Our Strategy's Goals & Measures of Success

The NOHRS is intended to galvanize our community into action to build our research workforce and infrastructure, and to generate new knowledge to help improve the oral health of people living in Canada. These strategy goals incorporate our guiding principles and combine breadth to permit flexibility for those of us taking the next steps, and specificity to point us in certain directions. In short, we want our community to engage with these goals, creating diverse teams, collaborations and projects that will address them in a broad array of approaches. It is also important to understand that the goals are not necessarily mutually exclusive – for example a program created to train people in a certain field could also integrate creation of relevant infrastructure and performance of relevant research, thereby addressing a range of goals outlined below.

Figure 3.
Timeline for Measures of Success

2026

2028

2030

2035

Preparation

Environmental sustainability module

Infrastructure

Training program(s)

AI &/or omics structure

KM/IS network

Outputs

Trainees

Research outputs

Outcomes

Health outcomes

Health care interventions

Goals and Measures of Success

By 2025
Preparatory activities and infrastructure

To galvanize the communities interested in acting on this Strategy, we will have:

- Broadly disseminated the NOHRS.
- Presented NOHRS at meetings and conferences.
- Published a range of peer-review, lay media and other versions of NOHRS.
- Engaged a broad range of academic, professional, community and other organizations encouraging them to participate in the NOHRS roll-out.
- Formed NOHRS implementation and working groups to oversee relevant activities.

By 2026
Preparatory infrastructure

We will have created an Environmental Sustainability training module that is widely available in the oral health research and broader health research communities.

By 2028
Infrastructure

We will have at least two training programs in place in the fields of data science, omics, AI, KM/IS or environmental sustainability that incorporate health promotion and/or disease prevention plus "*oral health is health*".

We will have identified and created KM/IS frameworks that are used in oral health research proposals and projects, including:
- The use of standardized guidelines for reporting implementation studies.
- Knowledge dissemination and publication of research results in multiple languages and/or the language of the community where the research takes place, for example in Indigenous languages.

We will have established a KM/IS network of fundamental scientists, applied researchers, health professionals, community representatives, patients, policy experts and decision makers that enhances knowledge mobilization and implementing oral health research findings.

All research in the field of oral health will address environmental sustainability issues in project/grant proposals and in reports of research work.

We will have built alliances with key governmental (e.g. Statistics Canada, Health Canada, and provincial public health agencies) and other agencies to promote collecting, analyzing, and using large, national, and regional data sets to enable understanding and addressing identity-related oral health inequities and barriers to oral health care.

By 2030
Outputs

We will have the first trainees emerging from the new training programs in data science, omics, AI, KM/IS or environmental sustainability in place in Canadian research institutions (including universities, government and/or private sectors) practicing the skills they have learned in their training programs.

The KM/IS network will have helped specific examples of knowledge generated by research moving along the knowledge translation pathway towards improving the understanding of oral health and disease and/or improved oral health and oral health care.

We will have the infrastructure in place to have groups of researchers working with practitioners using AI to answer complex oral health research questions aimed at improving the oral health of people in Canada.

We will have created access to multiple databases to enable omics researchers to address complex oral health questions.

We will have leveraged existing biobanks and supporting data (e.g., the Statistics Canada Biobank[84]) and/or developed at least one oral health specific repository and supporting database.

...and outcomes

There will be a practicing integrated KM/IS network that has contributed to health promotion, disease prevention and/or improved oral health.

We will be storing data of research findings in a public domain.

There will be specific examples of new environmentally sustainable materials, devices, practices, and policies in promoting oral health and/or preventing oral disease.
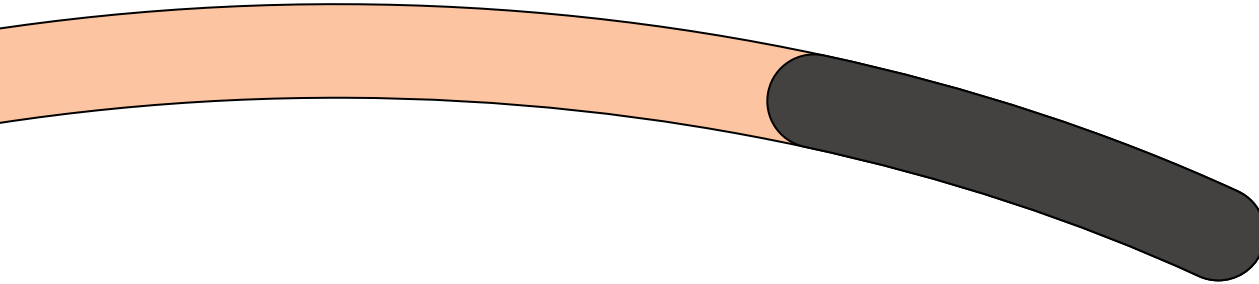
By 2035
Outcomes

We will have research findings showing the economic and health benefits of strategies to improve access to oral health care for a range of groups.

We will have contributed to a better understanding of the biological, social, and other determinants and causes of health and disease among people living in Canada.

There will be a group of researchers working with practitioners developing, implementing, and using environmentally sustainable materials, devices, practices, and policies in health promotion and/or disease prevention in Canada.

Our AI infrastructure will have generated/led to/provided information that has demonstrated improved health promotion, disease prevention and oral health of people in Canada.

Our omics infrastructure will have generated/led to/provided information that has demonstrated improved health promotion, disease prevention and oral health of people in Canada.

We will have created new environmentally sustainable materials, equipment or processes that promote health and/or prevent disease, while reducing Canadian dentistry's carbon footprint.
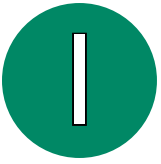
Moving Forward

We have outlined our Strategy's goals and measures of success and linked them to a timeline, and it is important that the community now acts on these items in an efficient and organized manner.

This document outlines a strategy—it is not an implementation plan; the next steps are in the hands of the oral health research community. This community needs to be proactive, get organized and move forward with this plan. To help those of us who decide to step forward, take the lead and participate, we are proposing "quick wins" (i.e., goals that can be achieved quickly and demonstrate we are moving forward), "best buys" (i.e., goals that can be achieved efficiently, making a strong impact with relatively few resources) and finally, "game changers" (i.e., goals that will completely change the way we work or look at the world). Our suggested goals for these three categories are intended to stimulate reflection on the way forward; individuals who take the lead may decide to address different goals.

Figure 4.
Moving NOHRS Forward

Quick wins

The National Oral Health Research Strategy will have been acknowledged and, where appropriate, adopted by all relevant research and health professional organizations.

We will have created a NOHRS implementation plan, with relevant working groups and oversight.

We will have created a sustainability training module and/or have leveraged existing modules[85] that are widely available in the oral health research and broader health research communities.

Best buys

We will have established a Knowledge Mobilization and Implementation Science network of fundamental scientists, applied researchers, health professionals, community representatives, patients, decision makers that enhances knowledge mobilization and the implementation of the findings of oral health research.

Game changers

We will have at least two training programs in place in the field of omics, artificial intelligence, knowledge mobilization and implementation science or sustainability that have contributed to improved access to care and/or reducing inequities in oral health related to identity.

We will have created new materials, equipment or processes that promote health and/or prevent disease, while reducing dentistry's carbon footprint.

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