McGill Faculties of Medicine & Health Sciences and Dentistry

Strategic Research Plan

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Executive Summary

In 2014, The Deans of the Faculty of Medicine and the Faculty of Dentistry engaged in a strategic planning exercise in establishing priorities for research. The resulting strategic research plan (SRP) was originally approved in 2014, revised in 2017, with the current document representing a 2021 update. It is a living document, to account for emerging health challenges and research opportunities.

The SRP’s overarching goal is for McGill to maintain or achieve a high level of excellence in selected areas, while training the next generation of health researchers in a highly competitive and inter-disciplinary research environment. The SRP aims to build strength in fundamental sciences and transfer research results into improved clinical practice and health outcomes and enhanced economic activity. It takes into consideration the respective aims and strengths of all research and teaching units (Schools, academic and clinical Departments, Centers, Networks) and strategic initiatives, inclusive of research institutes based at our affiliated hospitals.

Our research priorities build on areas of excellence to ensure we are agile and responsive to both major and emerging health challenges. They are positioned to stimulate fundable research and innovation. In that regard, the current SRP is aligned with CIHR’s new Strategic Plan (2021-31).

In 2020, the Faculty of Medicine became the Faculty of Medicine & Health Sciences to better reflect the diversity of expertise and the breadth of its core mandates. In parallel, the Faculty of Dentistry initiated a strategic planning phase of its academic and research activities. The current SRP updates build on solid foundations, consolidate successful strategic research initiatives, and re-emphasize the vital importance of current, sustainable core infrastructure and platforms in the realization of the research mission. A new, specific focus is on the strongly emerging and cross-cutting role of digital technologies and data sciences in current and future evolutions of health and clinical care. Another emphasis is the promotion and development of a spirit of entrepreneurship across our Faculties, promoting outreach and collaboration across the university and affiliated partners, to encourage and facilitate the emergence of innovations driven by the scientific approach in response to unmet needs amongst patients and the healthcare system.

The SRP emphasizes the major importance of equity, diversity and inclusion throughout all aspects of research, from initial conception through implementation and ultimately translation to healthcare.

Our Strategic Research Plan highlights major groupings in four health and disease areas:
- Infection, Immunity & Inflammation
- Cancer
- Neuroscience & Mental Health
- Healthcare Across the Lifespan: Development, Rehabilitation & Chronic Diseases

and four cross-cutting strategic priorities:
- Patient-Centered Continuum of Care
- Biomedical & Health Sciences in the Age of Digital Data
- Key Determinants of Health & Disease: Genes, Behavior & Environment
- Precision Approaches to Personalized Medicine
The plan also highlights enabling implementation strategies with an evaluation framework (Part B).

The Faculties’ Standing Committee on Research (SCoR) is mandated to a) activate the plan, b) monitor progress on objectives, c) acquire feedback from the community and d) update the SRP.

1 Introduction

The educational mission of the Faculties of Medicine & Health Sciences and Dentistry is reinforced by a broad, dynamic and highly successful research enterprise that extends from fundamental molecular and cellular biology, to computational biology, to public and population health, to clinical research at the bedside and in the community. This robust research activity within the Faculties of Medicine and Dentistry represents the core of McGill’s research effort, accounting for more than 60% of total research funding to McGill, while supporting undergraduate, graduate and post-doctoral education as well as training of health care professionals.

The goal of a joint strategic research plan (SRP) between the Faculties of Medicine & Health Sciences and Dentistry is to identify and support research excellence in strategic areas, train the next generation of health researchers, and facilitate the translation of new knowledge into beneficial health outcomes for patients, the population of Quebec, and provide key information to policy makers. The strategic research plan assists the Faculties in establishing priorities for recruitment, attribution of space, direct financial support for research activities, as well as help with targeted fundraising.

The Faculties’ SRP must be considered in the appropriate institutional context. It aims to complement the University’s own SRP, providing specific applications of that plan within the Faculties. It does not supersede more focused research plans developed in parallel by individual units, departments, schools or affiliated research institutes from teaching hospitals. Nevertheless, it was not possible for the SRP to represent all areas of excellence in health research at McGill without losing strategic focus. For example, research on health science education represents an important focus within the Faculties and will be strategized by the specific workings of the new Institute of Health Sciences Education created in 2019. The very dynamic and rapidly evolving nature of health research, including the transformative and potentially disruptive effects of technological advances, makes it imperative that the SRP be periodically revised and updated.

The first edition of the SRP (2014) identified the key areas of health and diseases to be targeted, developed a set of strategic areas of research, and designed an implementation strategy. The 2017 revisions identified and coordinated the inclusion of new strategic activities.

The present revision and updates were completed in spring 2021, coordinated by the Deans, the Vice-Dean (Research) and the Associate Deans (Research) of the Faculty of Medicine & Health Sciences and Dentistry. An open call for contributions was issued by the end of 2020; approximately 30 responses were received from individuals and units across our research community. The submissions were reviewed by the Faculty of Medicine & Health Sciences’ Standing Committee on Research (SCoR), featuring representatives from basic sciences and clinical departments, the Faculty of Dentistry and affiliated research institutes.
2 Outline

The present Strategic Research Plan provides a framework in support of research excellence in selected areas. This also includes the scientific training of the next generation of highly competitive and interdisciplinary biomedical and health professionals, in both fundamental and applied disciplines, with a clear motivation for making a difference in health outcomes for individuals, their families and communities.

To ensure feasibility and focus, the SRP puts forward:

i) a concentration on major health and disease areas (Part A),
ii) the fostering of cross-cutting priorities (Part A),
iii) an enabling implementation plan (Part B).

The identified strategic research areas and priorities highlight established or emerging strengths in McGill’s portfolio, bringing together the efforts of multiple groups across the campus, in community clinics and in our affiliated healthcare institutions. The implementation initiatives ensure that these strategic priorities can move forward, with fair measures of impact for units and their researchers.

The major groupings include four health and disease areas:

- Infection, Immunity & Inflammation
- Cancer
- Neuroscience & Mental Health
- Healthcare Across the Lifespan: Development, Rehabilitation & Chronic Diseases.

The cross-cutting strategic priorities are:

- Patient-Centered Continuum of Care
- Biomedical & Health Sciences in the Age of Digital Data
- Key Determinants of Health & Disease: Genes, Behavior & Environment
- Precision Approaches to Personalized Medicine.

Implementation (Part B) leverages existing strengths and supports research assets such as core infrastructure and major units to enable research excellence and encourage a spirit of innovation fueled by patient needs and scientific advances, supporting entrepreneurship, incubation of spin-offs, industry partnerships and commercialization.

3 Major Research Areas

In addition to addressing the most current and significant health issues, our Faculties will advance our research performance in the following four major health and disease areas.
3.1 Infection, Immunity & Inflammation

Background:

The 21st century is witnessing the re-emergence of infectious diseases as a major threat to global health. In that respect, the COVID-19 pandemic that began in 2020 has been an all-too-dramatic illustration of infectious diseases as an agent of global catastrophe. Our generation now has first-hand experience that pandemics disrupt entire societies worldwide, challenge public health systems, education, social interactions and the economy. Everyone everywhere has been affected, with the most vulnerable suffering the greatest consequences: many as patients or relatives, with the trauma of critical care, the suffering from unexpected lingering symptoms, the anxiety of the unknown, and the aggravation of social isolation and distress, especially for the elderly, and the fragility of mental wellness, especially within the younger population. The pandemic has also highlighted the dramatic health inequities and chronic vulnerabilities that exist within our society and that must be addressed.

The causes of past and emerging infections’ increasing threats to global health are multifaceted, from the continuous appearance of new and highly virulent pathogens, such as SARS-COV-2, to the increased prevalence of antibiotic-resistance in microorganisms. Antimicrobial overuse, increased globalization, population mobility, and a changing climate all additionally contribute to the growing threat of infectious diseases.

The COVID-19 crisis also revealed the coming-of-age of groundbreaking technologies for the accelerated development of vaccines, enabled and inspired by decades of fundamental research in molecular and structural biology and in other related fields. This new generation of vaccine technologies holds considerable promise of being transferrable to other existing and future threats to our immune systems, throughout Canada and worldwide.

The COVID-19 pandemic has reinforced the notion that faster, increasingly more affordable genome sequencing technology is transforming many sectors of medicine. This includes immunology and epidemiology–from early virus sequencing and tracking of variants to the delivery of new methods of testing and epidemiologic surveillance. The crisis also highlighted the enabling value, but also the challenges, of fast-paced scientific development. On the one hand, early public sharing of the SARS-COV-2 genome accelerated vaccine and test developments at an unprecedented pace; while on the other, early deposition of non-peer-reviewed preprints contributed to confusing statements from “experts” and challenged public trust in the scientific approach. Relatedly, the pandemic has demonstrated the need to engage in interdisciplinary investigations, addressing issues as far-reaching as the psychology of individuals’ responses to the pandemic and to public health measures, vaccine hesitancy, and the political, economic and social implications of health and healthcare.

In parallel, studies of inflammatory and immune responses to infection and tissue injury are providing novel insights and new therapeutic opportunities in major chronic inflammatory disorders ranging from inflammatory bowel disease, multiple sclerosis, arthritis and periodontal disease to asthma, that are major sources of morbidity and healthcare costs in Canada.

In recent years, we have come to better understand the complex relationship between the host and the microbial world around it. We now recognize that the microbiome plays a central role in the programming and regulation of the immune response and is a major determinant of health and
disease. This strongly emerging view yields unexpected and intriguing hypotheses of the possible direct or indirect contributions of the microbiome and related systems to major, apparently “remote” syndromes in neurodegenerative, cardiovascular and metabolic diseases.

**McGill strategy:**

Since its inception, our SRP has identified Inflammation & Infection as key to the enduring leadership and impact of McGill’s biomedical research. We have fostered efforts built from long-established strengths, taking advantage of the presence of substantial resources in genomics, informatics, epidemiology and population health. For instance, McGill has an established track record in the fields of tuberculosis (e.g., with McGill’s International TB Center), HIV, HPV and other chronic viral diseases, and key parasitic infections such as *Leishmania* and malaria (e.g., via McGill’s Institute of Parasitology).

McGill will continue to grow its leadership and reputation in the broader domains of Infection & Inflammation, by mobilizing its strengths in core related disciplines and by actively encouraging efforts at their interface, in particular with genomics, biostatistics, bioinformatics (including modeling, biobanking, data science) and with other major research areas such as brain and mental health.

The creation and rapid growth of the McGill Interdisciplinary Initiative in Infection & Immunity (MI4) have reaffirmed the ambition and expanded the scope of McGill’s research in the area of infectious diseases. MI4 now also plays a major coordinating role across McGill’s specialized centres and platforms in this area, including the McGill Centre for Research on Complex Traits, the Centre for Viral Diseases, and the McGill International TB Centre, among others. Another transformative element is the new School of Population & Global Health, which is expected to play a leading role in fostering collaborations and facilitating studies of both major and neglected infectious diseases in Canada and abroad. These new resources also represent enabling instruments to strengthen and coordinate present and future efforts in related key areas such as microbiome research, the development of rapid detection tests of infectious pathogens, and vaccine development approaches against infections and inflammatory conditions.

We encourage all efforts along and between McGill’s current strong pillars of fundamental research using cell and disease models, epidemiologic and translational research, and major clinical research assets at the MUHC (including MI4’s Clinical Research platform) and JGH and in several disease-specific campus and hospital-affiliated centers and units supporting clinical trials (e.g., in connective tissue diseases, chronic inflammatory and autoimmune diseases such as inflammatory bowel disease, multiple sclerosis and rheumatoid arthritis). We also anticipate a major catalytic effect driven by the planned Institute for Genomic Medicine on McGill’s genomic and epigenomic research and its translation to personalized medicine. Another major asset is the new FRQS Centre for Structural Biology hosted at McGill, as a crucible of multidisciplinary expertise in this and other major research areas.

Immune diseases provide a unique opportunity to deliver on the promise of personalized medicine. Leveraging existing expertise and infrastructure, innovations in models of care, fundamental and translational research, advanced computational methods and implementation science will advance McGill’s international position in this area.
Along the same lines, continued investment in expertise and infrastructure in oral, skin and gut microbiome research at McGill will strengthen the position of our scientists across life science disciplines to reveal how our microbial selves can inform the diagnosis and treatment of diseases from cancer to neurodegenerative diseases.

McGill researchers are encouraged to pursue their work at the levels of molecules, cells, patients, and populations to discover new mechanisms underlying the development of infectious and inflammatory diseases. They aim to advance novel diagnostics and therapies for these conditions and deliver solutions to the populations that need them the most. Areas of research span viral, bacterial, and fungal disease-burden around the world, and include hospital-acquired infections, antimicrobial resistance, and auto-immune and inflammatory diseases.

We have also learned from the COVID-19 crisis that infections can induce complex syndromes affecting other body systems. For instance, primary clinical symptoms (e.g., respiratory distress) may be accompanied by the unexpected emergence of severe neurological events and acute and chronic challenges to mental health. The complexity of such clinical traits induced by new pathogens needs to be acknowledged, reported and studied. In that respect, the constitution for research purposes of high-quality cohorts of widely and deeply phenotyped patients are key to the identification of biological and other determinants of disease developments and response to treatment. Efforts such as the Quebec COVID-19 Biobank spearheaded by McGill’s Canada Excellence Research Chair in Genomic Medicine serve as blueprints for a more global and systematic research approach at McGill, based on large and well-curated patient cohorts, advanced computational approaches from structural biology to epidemiology to truly enable both personalized and societal interventions against infectious diseases. These approaches hold tremendous potential to generalize and transfer to other major disease areas.

3.2 Cancer

Background:

Cancer remains a leading cause of premature death in the western world and is now a significant global challenge in the developing world. Improved strategies for cancer prevention and early detection are required, in parallel with fundamental advances. These latter include the better understanding of the complex interactions between deregulated genetics, gene expression and a broad range of environmental and behavioral risk factors of cancer development. These aspects need to be inclusive of biological differences and societal disparities in populations that contribute to cancer risk and response to therapy, which are still poorly understood. Despite significant improvements, our ability to successfully treat many cancers has yet to be fully realized. Even in responders, disease management often requires that the cancer is maintained as a chronic condition over prolonged periods of time, leading to unintended consequences.

The recognition that cancers are highly heterogeneous, including in response to therapies, poses significant challenges for the successful implementation of effective diagnostic and therapeutic interventions. An enhanced mechanistic understanding of genetic and epigenetic changes, of post-transcriptional regulations of gene expression, and of the evolving tumor micro-environment as cells move from pre-malignancy to metastatic cancer is required, especially in demographically diverse populations.
With an aging population in Canada, our health care system must further adapt to the increasing likelihood that individuals will present with multiple chronic diseases and co-morbidities (e.g., metabolic and cardiovascular diseases, diabetes, infection/inflammation, immunodeficiency and obesity) which collectively further impact their lifetime cancer risk. It is therefore imperative that McGill researchers from multiple disciplines join their efforts to increase our understanding of these complex interactions, rather than studying each in isolation. In recognizing this, cancer sits at the intersection with deregulated control of our endocrine, metabolic and immune systems.

The impact that the COVID-19 pandemic has had and will continue to have on the entire trajectory of cancer prevention, treatment, and survivorship must be addressed. We must continue to build on the innovations and disruptive technologies stimulated by the pandemic and lead their integration into a changing health care system to improve the life of all Canadians.

**McGill strategy:**

McGill has a strong research community in pediatric and adult oncology, with specific leadership in the basic mechanisms of molecular and cellular cancer pathophysiology, tumor-host interactions, metastatic dissemination, the study of responses and resistance to varied forms of treatments, and in the areas of cancer prevention, cancer genetics, screening, and survivorship. A new research focus has grown in recent years that is reliant on large scale omics-based approaches to integrate our understanding of the pathobiology of cancer with the development of novel markers for refined clinical diagnosis and identification of new therapeutic targets. Cancer research across the McGill ecosystem has enhanced an integrated focus on the patient experience through the entire disease trajectory with improved screening programs, patient-centric care models, targeted and more efficacious therapeutic and e-health innovations, integrated with patient-reported outcomes.

The first priority in this area will be to increase the coordination of leading-edge fundamental and translational cancer research across the McGill community. To this end, the formation of a McGill Cancer Consortium (MC²) will bring together multidisciplinary research strengths within the entire McGill research ecosystem (see section B). Specific areas of focus for MC² will include: (1) a better understanding of the molecular, genetic and post-transcriptional markers associated with the development of all forms of cancer; (2) improved understanding of cancer risk factors; (3) improved methods for screening and early detection; (4) understanding the mechanisms of metastatic spread to specific organs; (5) understanding therapeutic resistance and how it can be overcome; (6) elucidating how an evolving tumor microenvironment contributes to emerging forms of hard-to-treat/resistant cancers and (7) helping cancer patients and their families deal with psychological, emotional and social issues related to the diseases.

The second priority for McGill’s cancer research is to advance personalized cancer interventions focused on cancer vulnerabilities via inherent genetic risk factors, metabolic programming, immuno-profiling, epigenetic alterations, proteogenomics and patient-derived models, including biological material from cancer clinical trials. Coordination between the new McGill Cancer Consortium and McGill’s Genomic Medicine experts will be encouraged. The study of these novel approaches also needs to engage McGill’s strengths in structural biology, digital and molecular pathology and immunoprofiling, computational models and bioinformatics, and population health research. McGill’s clinical trials infrastructure is a current asset but will also need to anticipate and
adapt to new treatment technologies on the horizon and promote clinical translation of McGill discoveries.

The third priority is to mobilize psychosocial oncology and health services research to enhance the experience of patients coping with arduous treatments and taxing side effects while supporting their families. In this respect, the involvement and coordination across all Schools, the new Institute of Health Sciences Education and other McGill strengths in patient engagement studies, patient outcome measures and research on health sciences education are encouraged. These strengths and others will also advance population health research on cancer prevention as a priority.

The sustained growth of McGill cancer research, notably via clinical and prevention trials, requires the collaboration, coordination and cooperation between our campus-based scientists and researchers and healthcare units across our affiliated hospitals (Cedars Cancer Centre and the Cancer Research Program and the RI-MUHC, the Brain Tumor program at The Neuro, the Segal Cancer Centre at the Jewish General Hospital, the cancer program at St. Mary’s Hospital) and relevant research centres and platforms (Rosalind & Morris Goodman McGill Cancer Institute, the McGill Centre for Translational Research in Cancer, CRP-MUHC, the Interdisciplinary Oral Health clinical research platform at the Montreal General Hospital and the Department of Oncology). In this respect, the Rossy Cancer Network (RCN) is an asset for clinical coordination that needs to be leveraged, for the harmonization of treatment strategies and the reporting of outcome measurements, across all McGill teaching hospitals and the Réseau Universitaire Intégré de Santé et Services Sociaux (RUISSS). The RCN also strengthens McGill’s efforts in psychosocial oncology, health services research, palliative care and related fields. The Department of Oncology will continue to play a pivotal role, leveraging the RCN to assist this enterprise.

As for all our key research areas, cancer research will benefit enormously from the advent of large and well-curated diverse patient cohorts linked with clinical trials and real-world evidence, epidemiological studies, robust clinical data, therapy response and patient outcomes. These resources must be supported by data-driven and other computational modeling approaches, including artificial intelligence and other data-driven technology for healthcare and health research. With a large and diverse patient basin and proactive coordination across units, McGill cancer researchers and clinicians are well poised to advance their leadership in this area as well as address disparities in cancer outcomes with respect to multi-disciplinary research opportunities (from genes to society) which includes ‘barcoding’ a cancer patient’s genome for research and individualized care across their lifespan. Here too, data readiness in terms of joint vision, organization and infrastructure will be key for the McGill cancer community to participate in and leverage major opportunities for multicentric collaborations and platform developments for data analytics, such as via the pan-Canadian Digital Health & Discovery Platform (DHDP) funded by ISED in participation with the Terry Fox Marathon of Hope Cancer Centres Network.

Cancer research contributes strategic value to McGill’s efforts aimed at addressing the global health agenda. In close partnership with the new School of Population and Global Health, the Department of Oncology has launched a Task Force on Global Oncology, which has brought together our assets in this area. Our efforts will be articulated with this Task Force to lead international collaborations to expand opportunities for large-scale translational studies and capacity building.
3.3 Neuroscience & Mental Health

Background:

Although considerable progress has been made in the management of stroke and other acute brain injuries, chronic diseases of the nervous system remain a major source of morbidity in all age groups. Central nervous system disease also manifests itself as severe neurological and psychiatric disorders, which account for an enormous burden of disease. With an aging population, the prevalence and burden of neurodegenerative diseases are major concerns for a growing number of patients, their families and the healthcare system at large. Finally, and as noted above, the COVID-19 pandemic will have enduring repercussions on mental health, whose nature and incidence are hard to anticipate presently. Acute and chronic pain, with the opioid crisis as well as other forms of addictions also have considerable individual and societal consequences that challenge health care systems.

Relative to other major disease areas and despite decades of efforts, including major clinical trials, most brain and mental health disorders still have limited therapeutic options. A consequence and concerning trend are the withdrawal of several pharmaceutical companies from neuroscience research and development, which has shaken the landscape of industry-sponsored research in the field, but may also represent opportunities for new models of industry partnerships to emerge.

These current challenges require a better understanding of the underlying neurobiology at the molecular, cellular and systems levels, and in relation to complex symptoms and behavior, the development of objective disease markers, and the improvement of rehabilitation strategies and models of care delivery that better take into account the needs of patients and their families.

McGill strategy:

McGill has adopted a unified approach to chronic brain disease, bringing together psychiatry, neurology, rehabilitation sciences and related clinical disciplines such as nursing and family medicine.

Key aspects of neuroscience and mental health research at McGill, including new faculty recruits, cross-cutting platforms and innovation programs, have been enabled over the past 3 years via the transformative award from the Canada First Research Excellence Fund, entitled “Healthy Brains, Healthy Lives” (HBHL), and a number of large disease-specific philanthropic initiatives in this area. The new research resources enabled by these programs – e.g., HBHL’s NeuroHub portal, the early drug discovery platform at the Montreal Neurological Institute and Hospital (collectively, The Neuro), the open-science practices promoted by the Tanenbaum Open Science Institute (TOSI) at The Neuro – are expected to reach maturity by 2025. With sustainable models of operation and appropriate performance indicators, especially of their adoption and actual impact, they are expected to build capacity for dissemination across other units and disciplines.

McGill has historical and renewed strengths in neuroscience: in particular imaging techniques and their applications to radiology, clinical trials, cognitive sciences and neuropsychology; the genetics of common and rare neurological diseases and the view of neurological and psychiatric syndromes as a continuum; neural circuits, networks and neuronal signaling studied at multiple scales, and the development of transgenic models of complex disease traits. Major research themes
in neuropsychiatry include Alzheimer’s and other forms of dementia, environmental adversity, neurodevelopment, youth mental health and early intervention, sleep and biological rhythms, stress, anxiety, depression, and suicide. New forms of treatments of neuropsychiatric disorders using neuroplasticity-inducing pharmacotherapies and paradigms of psychedelic-assisted therapies are also promising avenues of research that can mobilize a large diversity of McGill expertise.

The Neuro, via new enabling programs in autism (ACAR) and open science approaches from TOSI, and the Douglas Mental Health University Institute and its new research organization are major players in these efforts. They already form a nucleus in fundamental and clinical neuroscience research, and will increase their interactions further in specific aspects of neuroimaging, biobanking and related data science approaches. The growing experience at the Neuro and the Douglas with large, multimodal research data repositories—covering complex issues around consenting patient participants for data sharing, framing data access and sharing policies and enabling new forms of partnerships with industry—will be essential to the strategic goal of building research cohorts across our research network, in a concerted and consistent manner. Future related projects need to build and learn from these early efforts and be inclusive of the diversity of perspectives and specific needs of research users to specify the best possible data management tools.

The neuroscience community at McGill also includes other major centres of expertise and clinical-research integration within the Brain Repair and Integrative Neuroscience Program at the RI-MUHC, the Alan Edwards Centre for Research on Pain as well as in cognitive neuroscience in the Centre for Research on Brain, Language & Music.

3.4 Healthcare Across the Lifespan: Development, Rehabilitation & Chronic Diseases

**Background:**

Demographic pressures and the continuing improvement of acute illness treatments have made wellness in aging and the management of chronic diseases major challenges. Healthy aging, with maximum autonomy, over a prolonged life expectancy is a societal priority. In parallel, important advances and reflections around palliative care and end-of-life have raised awareness of individuals and society. Age-related illnesses often induce different forms of cognitive decline and physical disability in a growing proportion of our aging population. Disability can also be congenital or acquired during the life-course, in the form of physical, sensory, cognitive or mental impairments accompanied by diminished health and reduced quality of life, limitations in daily activities and social withdrawal. Such impairments bear significant physical and mental health consequences for the affected individuals, their families and society at large. More broadly, risk factors such as smoking, diet and obesity, physical inactivity and poor nutrition have an overwhelming negative impact on health at any point in time across the lifespan.

**McGill strategy:**

Managing developmental and chronic conditions across the lifespan is complex: it requires a multidisciplinary approach to prevention before and after birth, treatment and repair, and the development of optimized management (including self-management) strategies with effective health and social policies. Our Faculties feature a solid research portfolio of catalyzers and enablers to address these complex questions. They include the School of Nursing, the School of...
Communication Sciences & Disorders, the School of Physical & Occupational Therapy, and the new School of Population & Global Health. Our Faculties also encourage all forms of partnership among the Schools, clinical departments, specialized divisions and patient organizations. These concerted, trans-disciplinary efforts aim to foster the development and implementation of approaches to improve individual prevention and promote social awareness, advance quality of care, solutions and policies to adapt physical environments, and encourage the development and utilization of measurable patient outcomes. We will promote such research efforts around the critical life periods of gestation and early development, as well as in aging and associated degenerative and chronic diseases; a focus on functional (re)habilitation will also be encouraged and developed.

Developing interdisciplinary strategies and strong potential for influencing institutional policies and clinical practice to prioritize prevention, self-management and modification of behaviors, needs to engage all elements of the community in participatory research and action processes: from health professionals to families, educators, and neighbors. The participatory research group in Family Medicine and at the Ingram School of Nursing will coordinate around this effort. The inclusion of vulnerable populations in related studies and participatory research approaches is essential to maximize the significance and impact of research and knowledge translation outcomes.

McGill will continue to build on research excellence in endocrine and metabolic disorders (e.g., diabetes, osteoporosis, bone and tooth demineralization and calcium homeostasis disorders) and on the comorbid factors that affect wellness spanning the lifetime.

In cardiovascular health, McGill will focus its efforts where it can make distinctive contributions e.g., in congenital heart disease, in hyperlipidemia, atherosclerosis and thrombosis (including vascular calcification), and in hypertension. Emphasis will be placed on the study of immune regulation, risk factors, and impact of behavioral interventions for prevention of cardiovascular risks.

Pain is a significant comorbidity of chronic conditions; awareness about chronic pain as a debilitating, chronic syndrome in itself has grown substantially. With the Canada Excellence Research Chair in Pain Research and new leadership at the Alan Edwards Centre for Research on Pain, the Faculties encourage research efforts on the biological mechanisms of pain, with a particular emphasis on chronic pain and comorbidities affecting mental health. Efforts in this domain also have multidisciplinary facets and will need to bring together clinicians, hospital-based researchers and basic scientists from several departments and divisions.

Research on pain and other mental and physical disabilities caused by trauma will also be encouraged. Improving our ability to both detect and repair related injuries is also a priority area. Trauma research needs to involve innovative diagnostic tools with advanced medical imaging and neuropsychological testing, new surgical approaches in multiple disciplines, emphasizing the role of simulations in medical training, the development of artificial limbs and brain/body-computer interfaces and related technology for patient training and physical rehabilitation, and stem cell and other approaches to regenerative medicine. We emphasize that all these research segments are also pertinent to the other strategic priority areas in our Faculties.

*Healthcare Across the Lifespan* will mobilize McGill’s expertise in health-outcomes and patient-oriented research and encourage joint efforts with other strategic fields such as genomics, cognitive neuroscience and mental health to develop a more holistic approach of these complex conditions.
With this patient-first approach, research and deployment of new technologies will need to be leveraged for all stakeholders. For instance, new tools and apps for patient empowerment such as OPAL\(^1\) developed by researchers at the MUHC have tremendous potential to establish a fruitful feedback loop between patient information and orientation in the clinic, secured and informed patient data collection for research purposes, and the personalized adjustment of clinical interventions.

Research will be extended to community-based clinical settings, permitting large-scale translational research programs that will ultimately promote wellness and better health outcomes across the lifespan. St. Mary’s Research Centre has a leadership role to play in that area. Using an interdisciplinary approach with diverse strengths in Medicine (Internal Medicine, Family Medicine, Epidemiology, Nursing, Physical and Occupational Therapy, Psychiatry) and Dentistry, McGill will collaborate with the healthcare system to build on established excellence in participatory and health outcomes research with an emphasis on knowledge translation and implementation sciences.

4 **Strategic Priorities**

The following sections describe cross-cutting Strategic Priorities inspired by the Major Research Areas detailed above. With the Implementation Strategies detailed in Part B, they aim to highlight key and coordinated approaches to fundamental and applied biomedical and health sciences research at McGill.

In addition, our Faculties will encourage new initiatives to grow McGill’s spirit of innovation in translational science, from "bench to bedside to the community". We see these as opportunities to link between bench and clinical research and patient-oriented, community-based work, which will continue to be a particular strength in our Faculties. We aim to fuel and foster novel research and training programs, and an environment that encourages a renewed spirit of entrepreneurship amongst our trainees and researchers.

4.1 **Patient-Centered Continuum of Care**

The inclusion of diverse patients’ perspectives is increasingly recognized as a gap in biomedical and health sciences research and an important factor for quality improvement of clinical services. These aspects include a vast and complex swath of biological variants, historical heritage and cultural values, whose implications need to be better studied, understood and transferred to the delivery of the best possible healthcare for all. These elements are key factors to understanding and improving health-related behaviors and outcomes.

Patient experience in healthcare consists of the multifaceted interactions between an individual and the organization’s culture and the representations of their respective backgrounds and histories. These interactions influence patient perceptions and responses across the continuum of care. McGill recognizes the significance of these aspects and continues to promote further research to develop and implement evidence-based approaches to probe and consider all aspects of patient experience. Research outcomes are expected to deliver practical information and solutions to the healthcare

\(^1\) [https://opalmedapps.com](https://opalmedapps.com)
system and help them identify when and how to re-engineer their practices when necessary. A key research question surrounding the deployment of working solutions will be to respond to the apparent tension between the respect of the patient experience and the imperative of delivering the best possible care to everyone, with the economic resources available.

McGill will continue to develop innovative approaches to understanding the diversity of patient experiences, of their families and communities and will use this knowledge to improve and optimize the quality of care delivered to patients and their support networks. Efforts in this area are encouraged to engage multiple disciplines, including from outside our Faculties, and to leverage the expertise in our Indigenous Health program. Work in this area must also emphasize awareness and avoidance of all forms of sex, gender, age, cultural, religious and racial bias in research and clinical services. These aspects are of particular importance to this strategic area, but we strongly emphasize their relevance and significance to all other strategic priorities and biomedical and health sciences research practices at McGill.

4.2 Biomedical & Health Sciences in the Age of Digital Data

The ubiquitous surge of information technology, coupled with emerging applications of artificial intelligence and other data science approaches, are bound to transform all facets of healthcare. Simultaneously, biomedical and health sciences research approaches are presently undergoing significant mutations that pose new technological and ethical challenges as we step into the age of digital technology and data. These changes are enabled in part by the constantly increasing precision and volume of the many variations of “omics” data available to researchers, generating biological datasets on an unprecedented scale. With each patient now a big-data source, data from single individuals and from research cohorts hold the promise, combined with the appropriate methodology, of enabling unprecedented levels of sensitivity and specificity in the analysis of biochemical, physiological, and environmental interactions that determine health and disease. McGill continues to encourage a systems approach to understanding biology but also acknowledges the imperative of a paradigm shift surrounding the significance and value of data resources and methods to fully realize this vision. Through specific Strategic and Implementation Priorities and in close collaboration with its affiliated hospitals, McGill will enable its researchers and clinician scientists to maximize the value of data to advance their research agenda.

The sources of biomedical research data in humans and disease models have grown tremendously in diversity, precision and efficiency. We are now truly stepping in the era of multi-dimensional and computational approaches for biomedicine. For instance, whole genome sequencing is increasingly faster, more affordable and of higher quality. Their combination with other techniques, ranging from the nanoscale (e.g., single-cell RNA sequencing, microscopies and other bioimaging methods) to the macroscale (e.g., multimodal medical imaging) and biological modulation methods via e.g., drug delivery, optogenetics or brain stimulation, enable the identification of associative or causal effects in relation to other variables extracted from the environment (e.g., in epigenetics), sensory perception, complex behaviour and symptoms. McGill possesses significant strengths in all these areas, in terms of expertise and core platforms. This Strategic Priority is intended to maximize the value of multimodal research data in response to hard research questions, to enable original approaches and methods, which will lead to fundamental, possibly transformative discoveries, and facilitate the development of innovative tools of potential medical and commercial value.
The constitution of high-quality cohorts from the most inclusive and diverse populations of patients and healthy controls multiplies the potential of such approaches, admittedly at considerably greater data collection and management costs. These latter can be mitigated in part via concerted efforts and the mutualization of data collection, data infrastructure and data curation operations within the McGill network and beyond, and the federation of data collections, research software and computing resources. The multi-dimensional nature of biomedical and health sciences research data extends to complex, sometimes unstructured, sets of data linking electronic medical records with a multitude of systems in clinical divisions, healthcare administration, and surveillance. They are particularly valuable to the study of patient trajectories, their interactions with the healthcare system and their treatment outcomes. McGill has a proven track record in this area e.g., in drug safety research and pioneering realizations such as the recent research data warehouse at the MUHC. This expertise and related resources will continue to grow and disseminate, with the encouragement of researchers to participate in and contribute to the design and deployment of related data technologies and infrastructure.

The potential of multi-dimensional data cannot be realized without active research, training and knowledge translation in computational methods, encompassing a wide blend of applied mathematics, computational aspects of biology, chemistry and physics, many sectors of engineering, and computer science, including databases, artificial intelligence and other data-driven approaches, and software engineering.

Our Faculties have historical and established strengths in these areas, augmented by the ongoing Strategic Initiative in Computational Medicine and the Quantitative Life Sciences graduate program. A particular emphasis will continue to be placed on mathematical and statistical modelling at all scales: from biological systems to populations; hypothesis and data-driven multivariate analytics; dynamical systems theory and methods at all scales of observations: from fractions of a second to the lifespan.

Overall, multidisciplinary scientific, clinical and methodological efforts in all areas related to this Strategic Priority, with measurable impact indicators, and training and knowledge translation strategies, will be strongly encouraged and prioritized.

### 4.3 Key Determinants of Health & Disease: Genes, Behavior & Environment

Diseases result from complex interactions among genetic risk factors, environmental triggers and individual behavior and lifestyle. In rare diseases, a causal genetic component can often be readily identified. In the vast majority of disease conditions though, the involvement of multiple weak genetic effects may be modulated by complex interactions with environmental and behavioral determinants. McGill has established strengths in a multitude of related areas, with a particular emphasis on genomic medicine.

Our Faculties will continue to support research efforts towards gene discovery and treatment in in rare diseases and in common complex disorders, in coordination with the expertise and resources deployed in the Strategic Priority of multi-dimensional and computational approaches for biomedicine. Building on the specific history of the Quebec population, a particular McGill strength will continue to be in the research of genetic determinants causing rare disorders and neglected diseases that affect isolated populations, or that are found in populations with strong founder effects, including ultra-rare disorders of little economic value for the pharmaceutical sector.
Efforts to identify complex polygenic risk scores of more common diseases will be driven by McGill’s CERC in Genomic Medicine. Efforts will be strongly encouraged and prioritized towards the coordination with the Strategic Priority: Biomedical & Health Sciences in the Age of Data to constitute and federate wide and deep patient cohort repositories for research on multiple diseases, with the inclusion of demographic, environmental, geographic and lifestyle data, and behavioral assessments. Here too, these efforts need to be inclusive of the diversity of all population groups in Quebec and Canada, and need to consider the Montreal metropolitan area as a key asset in that respect.

These rich data resources, combined with current technology will enable us to advance our understanding of the mechanisms of epigenetic regulation by behavioral and environmental factors, as a major determinant of health and disease. Multi-dimensional observations at all spatial and temporal scales, coupled with current analytical methods will enable the identification of associations with disease causation, onset, progression, response to treatment and outcomes.

Another related research area concerns studies of the extracellular matrix as a core component of both soft and hard connective tissue integrity and cell signaling. Multidisciplinary studies will be encouraged in this domain, both to better understand fundamental mechanisms and to identify new treatment strategies, for instance in chronic inflammatory conditions.

Another related research area concerns studies of the extracellular matrix in normal cell signaling and in pathological situations. Related multidisciplinary studies will be undertaken of physiological mechanisms disrupted by milieu, and of the mechanisms responsible for immune cell trafficking and sensing of injured, damaged or infected tissues. These represent critical steps in tissue repair and remodeling that are often compromised in patients suffering from chronic inflammatory conditions. Research in these areas will focus on studying the interaction between extracellular cues, their cognate receptors, and their intracellular signaling pathways that together modify cellular metabolism and cell function during normal development and to maintain tissue homeostasis.

The study of complex determinants will extend to research on host-microbe interactions in health, infection, inflammation, development and cancer. These interactions may reveal obvious primary immunodeficiencies, or severe infections, but also be significant in common inflammatory diseases such as inflammatory bowel disease, systemic lupus erythematosus, periodontitis and rheumatoid arthritis. Microbial populations at mucosal surfaces (microbiota) are also suspected to play a role in many unrelated diseases including cancer, diabetes, obesity, and some neurological and psychiatric disorders. Understanding how lifestyle influences microbiota, immune health, obesity, cancer incidence and progression, will necessitate developing outbred models, integrating diet with metabolic change.

On a broader scale, studies (including models) of the socio-economic determinants of health and oral health status, health and oral health trajectories (especially from pre-birth, childhood until the end of adolescence) and health behaviors will also be encouraged. The Department of Family Medicine, the School of Population & Global Health and the Institute for Health and Social Policy as well as the Population Oral Health cluster in our Faculties, and in coordination with other McGill units, are expected to lead these multidisciplinary research efforts. In the greater Montreal area, the St-Mary’s and Douglas research centres are particularly well-poised to lead field work and engage with the community in innovative solutions in that area because of the socio-economically, culturally and linguistically diverse populations served by their partner clinical departments.
4.4 Precision Approaches to Personalized Medicine

We have already highlighted how the advent of large data repositories and biobanks combined with powerful computational approaches and resources enables new multivariate approaches to high-dimensional genotyping and phenotyping for detailed patient stratification. Our Faculties will encourage research in these approaches to enable new prevention strategies and novel clinical options that are specifically adapted to the individual needs of a specific patient. Here too, a particular attention to population diversity is warranted.

The potential of these approaches will be explored for fundamental research and the expansion of clinical trials that integrate discoveries of biomarkers for disease diagnosis, monitoring of its progression and to inform treatment decisions based on individual, quantitative responses as well as discovery and validation of new therapeutic targets. These new biomarkers will play a growing role in the stratification of patients in a new generation of clinical trial designs. Some focus will include studies of rare forms of cancers and cancers for which no therapeutic options or biomarker stratification are currently available. New technologies involving induced pluripotent stem cells, patient-derived xenografts, organoids, as well as integration of pharmacogenomics, metabolomics and highly multiplexed immune monitoring will be leveraged across strategic disease areas.

Complementing the strategic computational approaches detailed above, a range of biological modeling approaches across scales, from molecules to cells grown in vitro and in vivo preparations, behaving systems are required to further the understanding of the cellular and molecular bases of disease. McGill will continue to lead in this domain and will promote approaches based on stem cells both for discovering and testing new therapeutic pathways and drug treatments, and for enabling regenerative medicine approaches via cell replacement in damaged organs and tissues. As already mentioned, McGill has recently established remarkable expertise in induced pluripotent stem cells approaches and related biotechnologies, whose growth and dissemination across strategic disease areas will be encouraged. McGill will also continue to expand its focus on the study of protein structure and function at the atomic level by nuclear magnetic resonance, X-ray scattering and diffraction, cryo-electron microscopy (including tomography) and other biophysical methods that enable elucidation of static and dynamic structures of proteins and tissue structure of medical relevance. Here too, the adoption of advanced bioimaging and new artificial intelligence and data science approaches to solve the complex biological riddles of protein folding, assembly and organization as related to function will be encouraged.

McGill’s unique strengths in electron microscopy research and related infrastructure will continue to play a critical role in the acquisition and implementation of novel correlative electron microscopy infrastructure for the study of new materials and biological specimens (e.g., molecular machines, organelles, extracellular matrices). These technologies will be linked to molecular diagnostics and therapeutic efforts to better understand disease and to design novel treatments. The new McGill-based FRQS Centre for Structural Biology will act as a catalyst in these domains, with a particular focus on structure-directed drug discovery.

Personalized medicine also applies to the health education and psychosocial aspects of disease prevention, of coping with illness and treatment and also of optimal rehabilitation and re-establishment of health and oral health in all dimensions. These efforts will be complemented by studies aimed at enhancing the quality of patient- and family-centered care, involving tailored
interventions in management of disease by bringing together providers from different disciplines, as well as involving families, patients and other stakeholders in participatory research.

Because of its dependence on detailed biological information, personalized medicine will require reconfiguration of the multidisciplinary therapeutic team to include a central role for expertise in bioethics, bio-specimen collection and analysis, live cell banking, also for the purpose of constituting high-quality research cohorts, as explained above. Our Faculties will therefore pioneer interdisciplinary training, research and clinical practice to optimize the implementation of personalized health care.

Along similar lines, in partnership with manufacturers and information technology providers, McGill will work to develop analytical and information technology, both for discovery research and for clinical applications. A particular emphasis will be on enabling patient empowerment and partnership by complementing electronic health records with portals, including wearable devices and smartphone apps, to provide informed access to their clinical data, explain their journey through the clinic, encourage their adoption of personalized wellness approaches to nutrition, sleep quality, and exercise to promote recovery and a heathy lifestyle.

McGill will continue its research into the development and commercialization of devices, novel therapeutics and other approaches aimed at improving health, including mechanical engineering as well as stem cell engineering, to replace neural, osseous, pancreatic and cardiovascular tissue, amongst others (e.g., via stents, pumps, grafting materials, implants, biomaterials). Interdisciplinary initiatives in bioengineering aimed at facilitating the development of innovative materials, devices, and tools and supporting their translation into clinical practice to improve health will be encouraged.

Personalized medicine also needs to be considerate of the socio-economic realities of the health care system. Problems of access to high quality health care in Canada, particularly among vulnerable groups, are well recognized. Furthermore, the changing demographics and cultures, education and finances, health problems and health care needs of people living in Canada, along with the fast-changing health care technologies and communication means of today, represent considerable challenges and opportunities to improve health care delivery. McGill’s health professional schools are well positioned to work together and with their multiple primary health care and community partners to develop and test innovative means to deliver health care to, for instance infants, children and youth, the institutionalized elderly, recent immigrants, the working poor and aboriginal groups.