Research at St. Michael’s Hospital

January 1st, 2019

An overview of Research at St. Michael’s Hospital over the last 10+ years, highlighting organizational structure, strategic priorities, research productivity, impact, and key considerations moving forward.
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1. Executive Summary

This report provides an overview of research, primarily focusing on how we are organized, how we operate, our key partnerships, our growth trajectory (largely over the last ~10 years), the impact of our research, challenges and potential opportunities moving forward.

In 1999, the hospital published its “Inspired!” strategic plan. This plan focused mainly on the growth of teaching and research and was the first strategic plan where Research was prioritized at the executive and Board levels. In 2000, Dr. Arthur Slutsky was recruited as the first VP Research (VPR). At the time, annual funding from MRC/CIHR was ~$1M, and our scientists were publishing ~400 scientific journal articles per year. The hospital was housing researchers across 6 separate sites, core facility equipment was outdated and recruitment was challenging.

In the hospital’s 2004 “Reaching New Heights” strategic plan, there was a clear commitment made to build a new research centre and planning/fundraising took place between 2005 and 2010 for what would eventually be the Keenan Research Centre (KRC) and the Li Ka Shing Knowledge Institute (LKSKI). Between 2005 and 2011, several key individuals were recruited including Andreas Laupacis (Executive Director of the LKSKI, in 2006), Muhammad Mamdani (Director, Applied Health Research Centre, in 2007) and Sharon Straus (Knowledge Translation Research Program Director, in 2008) and others. The KRC and LKSKI were officially opened in May of 2011 and research and education programs moved into their new home.

Organizational Structure and Governance: The VPR holds overall accountability for research and reports to the President & CEO. The VPR also provides quarterly reports to the Research & Education Subcommittee of the Board. A Research Leadership Committee (RLC) comprises the VPR, the Executive Director of LKSKI, the Director of the Keenan Research Centre for Biomedical Science (KRCBS) and selected Senior Scientist(s). It is a decision making body addressing strategic and operational research issues. The RLC established the KRCBS Executive and the LKSKI Executive Committees. These committees (along with other activity focused committees) set directions and objectives for their respective portfolios. Since 2012, the research leadership has developed 5-year and 3-year Research Action Plans, with annual objectives that feed into the hospital's strategic plan and corporate objectives.

Research Centre and Programs: Research programs are divided into 2 overarching umbrellas: the KRCBS which comprises 64 Scientists focusing on basic and translational research, and the LKSKI which comprises ~180 Scientists focusing on clinical, population health, and health services and policy research. The KRCBS’s basic science research is organized into 3 platforms: (1) Trauma, Critical Care and Inflammation, (2) Cardiovascular Disease, Diabetes and its Complications, and (3) Hematological and Immunological Diseases including Cancer.

Cross cutting themes were established to better integrate basic science with the clinical activities within the hospital. There are currently five cross-cutting translational themes: (1) Neuroscience Research Program, (2) Critical Illness and Injury Research Centre (CIIRC), (3) CardioLink, (4) Centre for Research and Therapeutic Development in Fibrotic Diseases (“Scar Wars”) and (5) Hematology-Immunology Translational Research Collaboration (HITRC).
The LKSKI research programs and centres include:

1. Centre for Urban Health Solutions
2. Knowledge Translation Program
3. Centre for Global Health Research
4. Applied Health Research Centre
5. Li Ka Shing Centre for Healthcare Analytics Research and Training
6. Centre for excelLence in Economic Analysis Research
7. The Evaluation Centre for Complex Health Interventions
8. Rescu
9. The International Centre for Surgical Safety
10. Centre on Drug Policy Evaluation
11. Centre for Depression and Suicide Studies

Research Metrics: In order to understand the growth and quality of research at St. Michael’s, it is important to look at how various measures of growth and activity have changed over time.

<table>
<thead>
<tr>
<th></th>
<th># Scientists</th>
<th># Research Staff</th>
<th>Total Funding</th>
<th>CIHR Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>160</td>
<td>486</td>
<td>$46.2 M</td>
<td>$7.6 M</td>
</tr>
<tr>
<td>Current</td>
<td>209</td>
<td>977</td>
<td>$78.1 M</td>
<td>$15.1 M</td>
</tr>
</tbody>
</table>

Our ability to source Tri-council funding (funding from the federal granting agencies CIHR, NSERC and SSHRC), is an important indication of how well we are doing as a research enterprise. Within the Faculty of Medicine at the University of Toronto, St. Michael’s Hospital has had the largest growth in tri-council funding amongst the 6 larger affiliated hospitals.

Salary awards are an area where St. Michael’s excels. These awards are very competitive and are valuable from a prestige perspective, as well as providing funding. SMH is ranked 8th for the total number of CIHR Salary Awards for all institutions (Universities and Hospitals) and has the highest number of such awards of any research hospital across Canada.

Scientific publications are also an important indicator of productivity. Since 2008 the total number of publications has grown by 75%. Journal quality is often measured by the impact factor (IF), with the most influential journals having higher impact factors (e.g. Science has an IF of 37.21, Lancet is 44.00, and NEJM is 72.41). Over the past decade, the number of publications with IF greater than 13 has grown from 24 to 113.

Awards and honours are a way to recognize the outstanding work and contributions of our scientists and physicians. In 2014 we adopted a proactive approach to nominate individuals for various awards. We now have 10 Scientists in the Royal Society of Canada (Fellowship or College), 22 in the Canadian Academy of Health Sciences, 4 Researchers that have been named in the Top 40 under 40, and 7 researchers that have received the Order of Canada.

The hospital’s intellectual property commercialization activity dates back ~10 years (data is unavailable before this time). Over the past decade we have filed an average of ~5 patents per year and a total of 11 companies have been established.

Infrastructure and Operations: Research currently occupies close to ~200,000 sqft across the hospital and external sites. Approximately ~140,000 sqft of this is within the LKSKI with ~55,000 offsite. Research space has grown by 25% in the last ~6 years. Over the course of the last 10 years, the hospital has created a centralized facility to support the activities of the basic science community. Located on floors 4 to 7 of the KRC, the Research Core Facility (RCF) is a multi-
user facility offering significant financial savings and operational efficiencies by pooling equipment into a centralized core.

The Office of Research Administration (ORA), with a staff of ~30 people, co-ordinates and manages all aspects of research operations, providing leadership and assistance with research finance, contracts, grant applications (including managing the internal peer review program) and human resources. The Research Ethics Board (REB) is responsible for ensuring that research involving humans meets current ethical standards. The REB reports directly to the Research and Education sub-committee of the Board, and is supported by the Research Ethics Office, which receives ~400 REB submissions per year.

The IP management and commercialization activity of the hospital is overseen by the VPR Office. The Director, Strategy & Commercialization oversees the activity with support from a part-time Commercialization Manager as well as the ORA contracts team and external IP/legal counsel (as needed). Over the last 5 years, SMH established a pre-awards team responsible for Grants, Awards and Strategic Projects. On average, the team is actively leading and/or supporting 50-60 grant submissions and ~30 award nominations per year. This team also works on all special projects that fall within the VPR portfolio.

In 2012, in the face of a looming operational deficit challenge facing the Research Institute (largely due to increased research growth following the LKS Foundation gift), the Executive Vice-President commissioned an administrative and operational review of Research. Key findings and recommendations from this review are included in the Appendix.

Research Training Centre (RTC): The RTC aims to build an outstanding, internationally-recognized training environment and in so doing provides graduate students, post-doctoral fellows (PDFs) and other research trainees with a stimulating, high-quality training experience. The RTC currently supports more than 200 graduate students and Fellows by providing strong mentorship, financial support, and advice/guidance on career development.

Internal Collaborations: The St. Michael's Hospital Foundation has been incredibly supportive of research and provided critical funding for infrastructure and research advancement: Keenan Research Centre and Li Ka Shing Research Institute, establishing the Krembil Cell Facility, the Translational Innovation Fund and Angels Den, initiation of the Research Innovation Council/Circle, and fundraising for specific research priorities.

The Communications and Public Affairs Department leads the external and internal promotion, branding and communications of scientists and their work. The department supports key priorities, profiles researchers work, and promotes the celebration of Research successes, awards and grants. This collaboration has resulted in numerous research stories garnering national and international coverage, two successful Research Months, and more awareness within the enterprise of ongoing work and achievements.

Research and Education have a strong collaborative relationship. Over the last 5 years Education has recruited 4 Scientists that conduct education research. These Scientists hold full Scientist privileges and support from Research.

External Partnerships: St. Michael's Hospital has entered into several strategic external relationships. The hospital's partnership with Shantou University began in 2008 was fueled by the donation from the LKSF, and is focused on two key areas: 1) The Li Ka Shing summer student program and 2) Li Ka Shing Centre for Healthcare Analytics Research and Training.
SMH is a founding member of **MaRS Innovation** (MI) which provides commercialization support to SMH, with a focus on start-up company formation. Currently, a part-time commercialization manager provides support for the hospital’s growing commercialization portfolio.

In 2013, St. Michael’s Hospital and **Ryerson University** entered into a 20 year co-operation agreement to establish a joint centre for biomedical research called the **Institute for Biomedical Engineering, Science and Technology (iBEST)** as well as a biomedical incubator, called the **Biomedical Zone**. Under this agreement, the hospital leased approximately 14,000 sqft of research space to Ryerson. The Institute and the Zone each have their own governance and the operating budget of both is shared between the host institutions.

iBEST is organized into four research themes (Biomaterials Tissue Injury & Repair, Biomedical Delivery Systems, Biomedical Imaging & Therapy, and Healthcare Analytics & Applications) with 50 collaborating scientists. The Biomedical Zone offers students unique experiential learning opportunities. The Zone occupies ~2,000 sqft and includes shared space for 10-12 individual start-ups, collaboration/meeting space, as well as a micro-fabrication/3D printing facility. The Zone runs many innovative programs aimed at facilitating interaction/partnership between clinicians, students and start-up companies.

**Impact of Our Research**
Highlighting the impact or our research (beyond just publications) is critically important since our goal is to improve patient care, strengthen our communities and improve our health care system. Examples of impactful projects are highlighted in the full report and in Appendices 12 & 13. These include impact on drug policy, response to the opioid crisis, improving health services accessibility to vulnerable populations, improving indigenous health, improving mobility for seniors, and surgical safety, just to name a few.

**Challenges & Mitigation Strategies**
Over the coming years St. Michael’s Hospital will need to consider challenges related to 1) funding sustainability, 2) space, and 3) retention and recruitment of top talent.

There are two major challenges with respect to **funding**. The first relates to funding to run the research enterprise. Currently, the budget is ~$13 million, which supports scientist salaries, core research facilities, maintenance/replacement of equipment, research administration and leases to house offsite researchers. We currently lease about 55,000 sqft of office space at a cost of ~$1.6M/year. This represents about the annual cash flow deficit of research operations. To date the shortfall has been taken from reserves, but this cannot continue indefinitely.

This is also a difficult funding environment for our researchers. We have been fortunate that our tri-council funding has increased substantially over the last 10 years; since fiscal 2006-2007 CIHR funding has increased 77%. National CIHR success rates have hovered around 15% over the last few years, and several salary award programs (e.g. the CIHR New Investigator Award) have been disbanded, hence putting increased pressure on institutions.

Research sustainability poses several risks to the hospital, a key one being retention and recruitment of top talent. Various mitigations strategies have been implemented to address these ongoing issues, including cost reduction/recovery strategies, increased collaboration with the SMH Foundation, and providing pre-award support to researchers to increase competitiveness.
Research space has grown ~25% since 2012 and the demands for growth continue as researchers obtain funding. Our Facilities team have analyzed our growth based on historical figures (last ~5 years) and projected that if we continue on our current growth trajectory, we would need 1 additional wet bench floor and 3 additional dry bench floors over 10 years.

A critical component of our research enterprise is the talent - the superb individuals who work here. To date we have been able to recruit world class scientists even though our pay scales and our start-up packages are not as high as other sister institutions in Toronto, and our space constraints make it difficult to find adequate space for our research personnel. One major reason we have been able to attract such great people despite these challenges is the collaborative culture that exists in the LKSKI and KRC. This has largely been based on our recruitment strategy which has to been to recruit for the smartest researchers, and then to hire based on personality, from this cohort. However, this approach has it limits. There is a strong concern that if the sustainability and space issues discussed above are not adequately addressed, we will have trouble retaining and recruiting the best talent in the future.

Opportunities Going Forward
In our first year as Unity Health Toronto, an integrated network with St. Joseph’s Health Centre and Providence Healthcare, we have begun to consolidate and streamline processes and policies, including the Research Ethics Board, and the Office of Research Administration. There are also opportunities for network-wide research collaborations in areas such as intensive care, emergency department, oncology, pediatrics, neuroscience and palliative care.

There are also major opportunities related to current and ongoing big data projects at the hospital. Along with IT, the Li Ka Shing Centre for Healthcare Analytics Research and Training (LKS-CHART) has developed an enterprise data warehouse at SMH. The centre: 1) works with hospital administration on high priority initiatives to inform decision-making, 2) works with clinical leadership to inform optimal clinical practice, 3) works with researchers to conduct research that will improve efficiencies in hospital operations, advance patient care, and advance healthcare analytics methodology, and 4) provide mentorship to trainees interested in healthcare analytics. The Centre is engaged in more than a dozen projects with increasing interest from clinicians and administrators. Discussions are currently underway to determine the best strategy to increase LKS-CHART’s activities across the Network and explore ways to monetize some of its outputs. Ongoing support for the LKS-CHART is critical.

The General Medicine Inpatient Initiative (GEMINI) is another big data project with significant momentum. This is a retrospective cohort study involving 7 large hospital sites at 5 UofT’s affiliated hospitals. GEMINI data has become a rich research resource that has attracted significant attention from other hospitals and government organizations. A recent collaboration with Health Quality Ontario aims to extend GEMINI’s data extraction methods to the 30 largest hospitals in Ontario. When completed, it will form one of the largest data-driven quality improvement networks in the world.

There are ~10 different groups with interest in biobanking. Planning is currently underway to recruit a Manager with a three year mandate to establish an institutional biobank, to synergize efforts and provide more effective and efficient support for our translational scientists.

Over the last 2 years, the research enterprise has increased its focus on gender equity. A study conducted by Dr. Straus addressed gender disparity (included in Appendix 14) led to the establishment of guidelines that promote gender equity. We have an opportunity across the Network to expand our gender equity initiatives to address inequities in other underrepresented
groups including visible minorities, racialized persons/persons of colour, indigenous people and members of sexual minority groups. Research is fully committed to developing an equity, diversity and inclusion action plan.

2. Introduction

This report provides an overview of research, primarily focusing on how we are organized, how we operate, our key partnerships, our growth trajectory, largely over the last ~10 years, our strengths including the impact of our research, and challenges and potential opportunities moving forward.

A Brief History of Research at St. Michael’s Hospital

In 1999, the hospital published its “Inspired!” strategic plan, which presented the hospital’s goals and directions over the next several years. This plan was developed in a more stable financial environment (with the previous 1992 plan, primarily addressing directions that helped the hospital recover from debt and respond to financial pressures). The “Inspired!” plan focused particularly on the growth of teaching and research at St. Michael’s Hospital. In fact, this was the first strategic plan where Research was prioritized at the executive and Board levels. Just prior to the strategic planning process, the Hospital Leadership had commissioned an External Review of Research in recognition of this fundamentally important part of the organization. The review committee’s recommendations largely informed the Research Directions within the “Inspired!” plan, with a first important goal being the creation of a leadership position to drive the research vision of the organization.

Excerpt from “Inspired!”: “The 1990’s have brought major changes to the research landscape. St. Michael’s Hospital must significantly advance this aspect of its Mission, if we are to realize our Vision. Research has become a specialization in and of itself in major academic hospitals....... St. Michael’s Hospital embraces the development and growth of research as an essential component of the future of our Hospital.”

In July 2000, Arthur Slutsky was recruited to the position of VPR and two years later, the hospital published its first Research Report, which introduced the hospital’s research priorities (Critical Care Medicine; Inner City Health; and Health, Illness & Society) and presented profiles of stellar new recruits and their programs of research. At the time, total yearly funding from MRC/CIHR was less than $1M, our scientists were publishing ~400 scientific journal articles per year, and it was increasingly clear that research growth could not be sustained without additional space and infrastructure. The hospital was also housing researchers across 6 separate sites, core facility equipment was outdated and recruitment was challenging.

The Keenan Research Centre and the Li Ka Shing Knowledge Institute
In the hospital’s 2004 “Reaching New Heights” strategic plan, there was a clear commitment made to build a new research centre. A business case was drafted, internal approvals were obtained, and extensive planning and fundraising took place between 2005 and 2010 for what would lead to the establishment of the Keenan Research Centre (KRC) and the Li Ka Shing Knowledge Institute (LKSKI), housing the research and education programs. Having secured key donations from the Patrick & Barbara Keenan Foundation and the Li Ka Shing Foundation, the hospital secured commitments from both the Provincial and Federal Governments for the construction of the KRC and LKSKI. Between 2005 and 2011 (official opening of the LKSKI), research recruited several key individuals including Andreas Laupacis (Executive Director of the LKSKI, in 2006), Muhammad Mamdani (Director, Applied Health Research Centre in 2007) and Sharon Straus (Knowledge Translation Research Program Director in 2008). The program funding from the Li Ka Shing Foundation was instrumental in recruiting and establishing world class research programs in knowledge translation and the Applied Health Research Centre (AHRC), an academic clinical trials coordinating centre which has grown to 65 staff managing approximately 165 active studies during the past fiscal year.

To help guide the growth of research, an International Advisory Committee was established in 2008 to provide advice to the President and CEO of St. Michael’s Hospital and the Research Leadership about the quality of the activities and the realization of LKSKI’s articulated vision. The LKSKI Advisory Committee was comprised of highly regarded internationally recognized experts from across the world. The Committee met annually in Toronto from 2008-2011 during the LKSKI’s steep growth phase and the Hospital and Research Leadership benefitted greatly from the Committee’s advice during this period of rapid growth. The KRC and LKSKI were officially opened in May of 2011 and research and education programs moved into their new home.

In 2012, the focus of the research leadership shifted to integration and coherence, and building sustainability and partnerships; hence it was determined that Research would mostly benefit from individual programmatic reviews versus an Institute-wide advisory committee. Hence, the Advisory Committee was disbanded in 2013. Currently, the Centre for Urban Health Solutions has its own advisory committee.

**OUR RELATIONSHIP WITH UofT AND TAHSN**

St. Michael’s Hospital is a full member of the Toronto Academic Health Science Network (TAHSN) which is comprised of the University of Toronto (UofT) and 13 fully affiliated academic hospitals. The hospitals and the University share a joint mission of health and biomedical related education and research. An affiliation agreement exists between the University and all fully affiliated members. The current agreement is effective as of January 2017.

The work and mandate of TAHSN is directed and governed by a committee comprising the Chief Executive Officers from each member hospital, the University of Toronto Health Science VPs and Faculty Deans. TAHSN also maintains close relationships and partnerships with MaRS, the Ontario Hospital Association (OHA), the Council of Academic Hospitals of Ontario (CAHO) and the Toronto-Central Local Health Integration Network (TC-LHIN), all of whom participate as guests on the committee. The vision and direction established by the TAHSN consortium is supported by a number of standing sub-committees including the TAHSN Research Committee (TRC). The VPs of Research participate on the TRC which meets monthly. This Committee serves to enhance the partnership between the University and its affiliated teaching hospitals by:
Collectively planning for and implementing resources to sustain the research mission of TAHSN
Developing policies that will support and enhance the research activities of TAHSN and the University with particular emphasis on the health faculties
Promoting and implementing a TAHSN/University identity at provincial, national and international venues

We have a close working relationship with UofT’s VP Research & Innovation Portfolio on all funding and awards matters. Our researchers have appointments within the Faculties of Medicine, Public Health, Nursing, Pharmacy and Applied Science & Engineering and we are well connected with the administrative centres of these Faculties, especially when recruiting/appointing hospital-based Scientists, Research Chairs, and pursuing strategic funding, partnerships and award nominations.

3. Organizational Structure & Governance

Organizational Structure

The organizational structure for research is illustrated in Figure 1. The Vice President of Research holds overall accountability for research across the Network and reports to the President & CEO of Unity Health Toronto. The Executive Director of the LKSKI is responsible for all “non-basic science” programs and centres while the Director of the Keenan Research Centre for Biomedical Science (KRCBS), is responsible for all basic/translational research activity. The majority of our Scientists are affiliated with a Research Centre, Platform or Program (with appointed Directors responsible for their overall direction). Several years ago, we introduced “cross cutting” programs such as the Neuroscience Research Program and the Critical Illness and Injury Research Centre with a goal of better integrating and enhancing collaborations between scientists and clinicians at the hospital. There are currently five cross cutting programs/centres in priority areas, with a potential for establishing more in the future.
**Research Governance**

The Research Leadership Committee (RLC) is the most senior research committee. RLC membership includes the VP Research (Chair), the Executive Director of the LKSKI, the Director of the KRCBS, and selected Senior Scientist(s). It is a decision-making committee addressing strategic and operational issues pertaining to research. The committee also assists the VP Research to optimize links and communication among researchers, research programs, research administration and hospital administration. The RLC reports to the Research & Education Subcommittee of the Unity Health Toronto Board, and provides quarterly reports to this committee.

To support its various activities, the RLC has established the KRCBS Executive Committee and the LKSKI Executive Committee. These committees are responsible for setting directions and objectives for their respective research portfolios, monitoring progress in meeting strategic directions, reviewing/approving policies, providing advice on resource allocation, providing an advisory role for fundraising priorities, and ensuring strategic alignment with the network’s corporate priorities and directions.

There are also a variety of research committees that are focused on specific activities such as the Research Reappointments Committee (responsible for reappointment reviews), the Research Training Committee (responsible for all matters related to students and postdoctoral fellows), the Research Retreat Committee (responsible for planning and executing the annual research retreat), the Research-Month Committee (responsible for planning and executing Research Month at the hospital) etc. These committees bring forward items that require KRCBS Executive, LKSKI Executive and/or RLC input or approval, on an as needed basis (Figure 2).
Research Policies

Research is regulated by the network’s corporate policies. In addition, research has developed and/or adopted (i.e. from the University of Toronto) specific policies and guidelines that pertain to the conduct of research (e.g. Research Conflicts of Interest, Guidelines for Naming Research Groups). A detailed list of all policies and guidelines can be found in Appendix 1. In the case of policies/guidelines that are “research-specific”, the development of and updates to these documents fall under the purview of the Office of Research Administration. All research-specific policies and guidelines must be approved by the Research Leadership Committee before being implemented.

4. Research Strategic Planning

To date, research has aligned its strategic planning activities to coincide with the hospital’s strategic planning process and timelines. As mentioned in the introduction, in 1999 Research officially became recognized as a core business of the hospital and has been a key component of all subsequent strategic plans. During the 2010 strategic planning process (which led to Quality Care through Knowledge Strategic Plan 2011-2014), Research was in the midst of moving from disparate locations into the KRC and LKSKI. Given the scale of this move and the rapid growth in research in the previous ~5 years, the Research Leadership elected to conduct a full research planning exercise at the beginning of January 2011. The overall goal was to develop an operational “Research Action Plan” to guide the growth of research over the next 5 years, with the following specific objectives:

1. Review our research priorities and identify how we can strengthen them and increase the quality of our research activities
2. Identify ways in which we can collaborate better within LKSKI
3. Identify how to strengthen the translational nature of our basic science research by augmenting interaction with clinical programs at St. Michael’s
4. Review our current research training activities and identify how we can strengthen them
5. Review research operations and infrastructure and identify what is required to increase the quality of our research

The Committee that drafted the Research Action Plan (RAP) reported to the Research & Education Subcommittee of the Hospital Board and ultimately presented a final 3-year document which was approved on April 1, 2012. The progress on RAP objectives is monitored by the VP Research office and progress reports are presented to the Research Leadership Committee bi-annually and to the Research & Education Subcommittee of the Board annually. Since 2012, the RAP has continued to inform the hospital’s strategic planning and corporate objective setting processes. In 2015, a revised 3-year RAP was developed (Appendix 2) and has been extended by one year (into 2018-2019) (Appendix 3). This was done in anticipation that Research will be participating in a network-wide full strategic planning exercise during the 2018-19 fiscal year.

5. Research Centres and Programs

Research at Unity Health Toronto (and formerly St. Michael’s Hospital) is comprised of two major components: the Keenan Research Centre for Biomedical Science (KRCBS) research programs focusing on basic and translational science research, and the Li Ka Shing Knowledge Institute research programs focusing on clinical, population health, and health services research. The Institute as a whole fosters an environment in which inter-professional teams collaborate to bring established best practices and research discoveries to patients faster than ever before.

This section of the report provides an overview of the priority centres and programs at the hospital (as outlined in Figure 1). The section is split into two: A) Keenan Research Centre for Biomedical Science (including all platforms and cross cutting themes) and B) Programs/Centres that fall within the Li Ka Shing Knowledge Institute (i.e. non-basic/translational research).

A. Keenan Research Centre for Biomedical Science (KRCBS)

The Keenan Research Centre for Biomedical Science (KRCBS) led by Dr. Ori Rotstein is housed in the west wing of the Li Ka Shing Knowledge Institute, also known as the Keenan Research Centre, and represents the basic science research of Unity Health Toronto. KRCBS’ mission is to generate new knowledge relating to fundamental mechanisms of organ dysfunction with a major focus on translation into patients. There are 64 basic and translational scientists working within this Centre. Out of this group, 35 scientists are clinicians who devote the majority of their time (70% or more) to their research programs. This research was born out of St. Michael’s clinical strengths (critical care and trauma) as well as research strengths in cardiology, nephrology, diabetes, respirology and neurotrauma, and has been expanded over the past 10 years to include research platforms with direct relevance to the most severely ill patients within those disease specific areas. Programs include research on mechanisms and novel therapies for acute organ dysfunction from the heart to the brain, and address the needs of patients with multiple organ system failure due to disease or injury. The Centre’s basic science research is organized into three distinct platforms:

- Trauma, Critical Care and Inflammation (Platform Director: Dr. Andras Kapus)
• Cardiovascular Disease, Diabetes and its Complications (Platform Director: Dr. Philip Marsden)
• Hematological and Immunological Diseases including Cancer (Platform Director: Dr. Heyu Ni)

i. Trauma, Critical Care and Inflammation Platform
There are 17 Principal Investigators affiliated with this Platform; their labs are located on the 4th floor of the Keenan Research Centre. The overarching goal of this platform, led by Dr. Andras Kapus, is to understand the biology of acute organ injury and the mechanisms through which it leads to death or chronic injury, and to prevent or reverse these deleterious processes. Major topics under this umbrella include sepsis, acute respiratory distress syndrome (ARDS) and other forms of lung injury, intensive care unit-acquired muscle weakness (ICAW), hypoxic and anemic stress, the respiratory effects of opioid overdose, traumatic brain injury, diseases associated with increased endothelial permeability (including flu) or epithelial dysfunction, as well as mechanisms of dysregulated wound healing and its main manifestation, organ (lung, kidney) fibrosis. In this domain the Platform contributes to technical solutions through state-of-the-art engineering (e.g. optimal ventilation strategies to prevent ventilation-induced lung injury), new cell-based therapies (e.g. stem cell treatment of acute lung injury) and new drug target identification. Importantly, the Platform has strong collaborative bonds with the Critical Illness and Injury Research Centre (CIIRC) and with ScarWars, a program dedicated to fibrosis research.

The scientists of this platform have made significant contributions to and are dedicated to pursuing research in the following areas:

a) Molecular and cellular characterization of sepsis, the genetic characterization and stratification of patients in terms or their susceptibility to sepsis and recovery potential. Development of therapies to prevent and cure sepsis and multi-organ dysfunction;

b) Characterization of ischemia/reperfusion injury and the associated immunmodulatory processes and development of therapies based on these mechanisms;

c) Exploration of the mechanisms underlying ventilation-induced lung injury (VILI);

d) Development of new ventilation protocols and techniques to minimize VILI and promote optimal ventilation;

e) Development of new therapeutic modalities in acute lung injury, including stem cell therapy;

f) Deciphering the mechanism of respiratory suppression by opioids and prevention of this deadly complication;

g) Characterization of the molecular pathways in traumatic brain injury and genetic stratification of healing patterns;

h) Identification of key mechanisms and potential therapies in ICU-acquired weakness.

i) Understanding the basic mechanisms underlying endothelial hyperpermeability and altered transcellular transport, and developing correcting strategies;

j) Identification of major mechanisms underlying cellular lipid (cholesterol) homeostasis in health and disease;

k) Exploration of the pathobiology of the epithelium under inflammatory conditions and characterization of the role and remodeling of epithelial junctions in disease;

l) Characterization of transcriptional reprogramming during fibrosis and the investigation of the role of the cytoskeleton in this process; identification of major fibrosis-inducing transcription factors and developing methods to target them.
ii. Cardiovascular Disease, Diabetes and Its Complications Platform

The 5th floor platform, led by Dr. Philip Marsden, is focused on cardiovascular disease, diabetes and its complications. The 18 Clinician Scientists that make up this platform come from various disciplines ranging from cardiology, vascular surgery, endocrinology, ophthalmology, nephrology and others. The group is thus able to approach diseases of the cardiovascular system, as well as other complications of diabetes, from a multifactorial perspective. Together, the teams varied expertise in basic science, translational research, clinical research, and knowledge translation allows a synergistic research environment.

The platform research areas include cardiology, cardiac surgery, aortic surgery, diabetes and vascular surgery. The scientists of this platform are focusing on the following priority areas:

a) Identifying epigenetic or chromatin-based pathways that are relevant to how the endothelial phenotype is regulated in health and disease;
b) Investigating non-coding RNA and control of cell identity in glioblastoma and neural stem cells;
c) Leading clinical trials through the CardioLink platform in atrial fibrillation, aneurysm and cerebral protection, diabetes and secondary prevention, valvular heart disease, and critical limb ischemia;
d) Developing innovative treatments for diabetes and kidney disease;
e) Exploring the role of pathological extracellular matrix accumulation and the pro-sclerotic cytokine transforming growth factor beta, with a focus upon translating discoveries into therapies in humans;
f) Regenerative medicine in the areas of diabetes and cardiology through the Krembil Stem Cell Facility;
g) Investigation of the mechanisms of atherosclerosis;
h) Exploration of adipokine biology and its relation to diabetes and cardiovascular disease;
i) Through the establishment of the Zebrafish Centre for Advanced Drug Discovery (ZCADD), they have launched over 10 zebrafish-based drug development projects targeting many neurological, cardiovascular, inflammatory diseases, diabetes and cancer;
j) Investigation of endothelial function, damage and repair;
k) Understanding the mechanisms of primary cilia dysregulation in cardiovascular disease.

iii. Hematological and Immunological Diseases including Cancer Platform

The 4th floor platform focuses on hematological and immunological diseases and is led by Dr. Heyu Ni. The 14 investigators that make up the platform have research interests ranging from metabolic diseases such as lipid metabolism, diabetes and nutrition, to immunological disorders and various forms of cancer. The platform has several priorities: 1) maintain and establish world leading research groups targeting major human diseases including thrombosis (e.g., myocardial infarction, stroke, deep vein thrombosis), cancer, bleeding disorders, and immunological diseases; 2) train and educate graduate students, postdoctoral fellows and other trainees; 3) translate research discoveries to clinical practice (from bench to bedside) including the development of new drugs and diagnostic reagents/tools; 4) establish international collaborations.

Examples of research projects within this platform include:

a) Platelet biology and immunology including thrombosis, hemostasis, blood coagulation, autoimmune thrombocytopenia (ITP), fetal and neonatal alloimmune thrombocytopenia (FNAIT), and the mechanisms and action of intravenous IgG (IVIG) therapy in ITP and FNAIT;
b) Investigation of the mechanisms of lipoproteins and lipid metabolism;
c) Identification of biomarkers (novel microRNAs and kallikreins) for prostate and glioma cancers;
d) Understanding the mechanisms of glaucoma and related injury and loss of neurons, to stimulate discoveries to prevent blindness;
e) Ground-breaking research using stem cell therapy to accelerate healing from musculoskeletal injuries including bone healing from fractures and ligament/tendon healing for sports injuries;
f) Investigation of the pathogenesis of neurodegenerative diseases;
g) Study of role of GABA in various autoimmune diseases;
h) Understanding the role of nutrition (folic acid, vitamins, etc.) in the development and progression of cancer.

B. CROSS-CUTTING THEMES

Cross cutting themes were established several years ago with a goal of better integrating the basic science of the KRCBS with the clinical activities within the hospital. There are currently five cross-cutting translational themes:

- **Neuroscience Research Program** (Director Dr. Tom Schweizer)
- **Critical Illness and Injury Research Centre (CIIRC)** (Co-Directors Dr. John Marshall & Dr. Claudia Dos Santos)
- **CardioLink** (Director Dr. Subodh Verma)
- **Centre for Research and Therapeutic Development in Fibrotic Diseases (“Scar Wars”)** (Co-Directors Dr. Richard Gilbert & Dr. Andras Kapus)
- **Hematology-Immunology Translational Research Collaboration (HITRC)** (Co-Directors Dr. Michelle Sholzberg & Dr. Alan Lazarus)

iv. The Neuroscience Research Program (NRP)

The NRP, headed by Dr. Tom Schweizer, spans basic and clinical research, and was built on the well-established clinical excellence of St. Michael's in the areas of neurotrauma, suicide and depression, multiple sclerosis and other neurodegenerative diseases. By mobilizing researchers in the areas of fundamental neurobiology, neuroimaging, clinical trials and knowledge translation, this Program works to unravel the mysteries of the brain and brain health.

The NRP is comprised of a number of research groups:

a) Neurotrauma (NT) research group conducts research in traumatic brain injury, stroke, and neuro-oncology, through the use of animal models, clinical trials, cognitive assessments, and knowledge translation.

b) The Suicide and Depression (SD) group facilitates research and clinical initiatives, leading to a greater understanding of the causes and prevention of suicide. Through clinical research, scientists with the program are currently investigating neuroimaging or molecular biomarkers of suicide risk and suicidal ideation, links between traumatic brain injury and suicide risk, and neuroimaging of reward circuitry and the relationship to suicide risk.

c) Neurodegenerative (ND) studies involve both basic science and clinical applications. The team works on identifying the basic mechanisms that lead to these diseases, improving diagnostic procedures and pharmacological management. In terms of Alzheimer’s disease and Parkinson’s disease, our scientists are interested in neuropathology, neuro-optics, neuroimaging, neuropsychiatry and clinical drug trials.
With the hospital having the largest Multiple Sclerosis centre in the country, the NRP has a large concentration of patients that facilitates clinical drug trials and research in this population.

The NRP have many ongoing projects including:

a) The Concussion Ontario Network is being led out of St. Michael’s to utilize neuroinformatics to enhance clinical care and translation. This has been partially funded by the Ontario Brain Institute, has established an independent website (https://connectontario.wordpress.com), and is actively seeking large scale funding;

b) The investigation of neural correlates of driving in several populations, including Alzheimer’s, MCI, stroke, brain tumours, and concussion. In addition, they are starting a pilot study to investigate the effects of marijuana on driving behaviours and brain activity. These studies use driving simulators and fMRI;

c) The Canadian Biomarker Integration Network for Depression (CAN-BIND) aims to find clear and objective ways of matching the right treatment to the right patient for various types of depression, as well as identify biological risk factors for attempted suicide;

d) To develop a novel Alzheimer Disease Amyloid Screening Tool through a partnership with Isologic;

e) St. Michael’s is also participating in a number of studies including the Toronto Dementia Research Alliance (TDRA), the Ontario Neurodegenerative Disease Research Initiative (ONDRI) and the Brain Eye Amyloid Memory (BEAM) study.

Some major accomplishments of the NRP include completion of the Ministry of Transportation Ontario funded project evaluating and advising on current policies for drivers aged 80+, development of the Depression Quality Standards for the province of Ontario and establishment of the Human Eye Biobank for Research (HEBR) - containing more than 2,000 eyes accessible to scientists around the world for study.

v. Critical Illness and Injury Research Centre (CIIRC)

The CIIRC, co-directed by Dr. John Marshall & Dr. Claudia dos Santos, builds on the leading role our hospital plays in the care of critically ill patients in Toronto and across Ontario, and our international reputation in critical care research. CIIRC brings together more than 30 basic and clinician scientists with internationally recognized expertise in acute lung injury, sepsis, trauma and resuscitation. The research programs within the centre are designed to advance mechanistic understanding, develop diagnostic tools and generate therapeutic options for the critically ill. By bringing together this unique and diverse cohort of researchers in the areas of fundamental lung biology, translational research, clinical trials and knowledge translation, CIIRC works to understand the biology of critical illness, discover novel treatments and ultimately enhance the survival and quality of life of people suffering from critical illnesses.

CIIRC is divided into three main pillars:

I. Acute Lung Injury – research into the causes, consequences and therapy of acute respiratory distress syndrome (ARDS).

II. Sepsis and Resuscitation – studies span a spectrum of research from patient-centred studies that seek to understand the best care of patients in our critical care units here at St. Michael’s, to whole animal and cell models of infection and inflammation.

III. Trauma/Resuscitation – studies focus on ways to decrease systemic inflammatory response syndrome and improve outcome and quality of life for patients who have sustained multiple traumas.
Currently CIIRC is working on:

a) A St. Michael’s-led collaboration to develop an omics-based therapeutic stratification system for critical illness, called Precision Medicine in Intensive Care (PreMedIC) program;

b) A St. Michael’s secretariat for the International Forum for Acute Care Trialists (InFACT) is being established, InFACT is a global collaboration of 33 investigator-led acute care research groups and research institutes from around the globe;

c) The Canadian Adaptive Platform Trial in Intensive Care (CAPTIC) program is led by St. Michael’s to develop Canadian capacity to conduct platform trials;

d) The Critical Care Knowledge Accelerator (CCKA) which aims to develop a platform for integration of basic, translational and clinical information, to include Biobank and INFOVENT. This will work collaboratively with the LKS-CHART to integrate the biobank with patient information;

e) An active clinical research program through the Critical Care Research Unit with close to 20 RCTs including Canadian Critical Care Trials Group, St. Michael’s investigators, and industry leaders.

vi. **CardioLink**

Spearheaded by Dr. Subodh Verma, with strong support from Dr. David Mazer and Dr. Peter Jüni, CardioLink is an innovative research network that brings together broad based expertise in heart and vascular surgery and perioperative medicine with the mission of carrying out rigorously conducted clinical trials to evaluate interventions for patients undergoing or are at risk of requiring heart or vascular surgery.

To date, CardioLink has designed 9 key trials with involvement of 15 scientists to address unanswered clinical questions about heart and vascular surgery, the prevention of these types of surgery, or management of patients post-operatively. The results of these trials will provide evidence to change guidelines and affect patient lives. For example, monitoring for atrial fibrillation after cardiac surgery may lead to fewer strokes (SEARCH AF). Hiring chiropodists to support diabetic patients on dialysis with high risk of developing diabetic foot ulcers will prevent limb amputations (ENABLE). Prescribing an inexpensive medication will result in reduced morbidity and mortality in patients with peripheral limb ischemia (EXTINGUISH). CardioLink will provide the evidence to allow surgeons to decide on the appropriate surgical technique when repairing a mitral valve (CAMRA), or knowledge of which method of cannulation to use in patients having aortic surgery who require deep hypothermic circulatory arrest to reduce adverse cerebrovascular outcomes (ACE).

CardioLink has engaged more than 100 researchers in centres across Canada and internationally. In a very short period of time the platform has seen 3 clinical trials through to the late stages of recruitment with one more trial ongoing. The first of these trials is set to report primary findings in 2018. The other trials are in the mature stages of protocol refinement or working towards ethics approval.

vii. **Centre for Research and Therapeutic Development in Fibrotic Diseases (“Scar Wars”)**

The Centre for Research and Therapeutic Development in Fibrotic Diseases, otherwise known as “Scar Wars” is comprised of 5 scientists and spearheaded by Dr. Richard Gilbert and Dr. Andras Kapus. Almost half of our hospital’s patient population suffer from diseases that are characterized by fibrosis (i.e., chronic organ or tissue scarring), be it chronic kidney disease, heart failure, pulmonary interstitial fibrosis, cirrhotic liver disease, myelofibrosis or arthritis. Scar Wars not only develops new strategies for investigating the causes and pathobiology of fibrosis-
related diseases, but is also pioneering new ways of assessing and treating these major causes of morbidity and mortality in our community.

Currently the Scar Wars team is focusing its efforts on some notable projects included the establishment of a clinical-research interface. The vision for this project is to link the Principal Investigators (PIs) researching fibrosis with the clinicians who see patients with diseases caused by it. With this model, clinicians will be able to directly contribute to research and the PIs will have a much-needed clinical perspective on what they are doing. There is also work underway to develop the world’s first biobank of fibrotic tissues where clinical information will be merged with the molecular information derived from tissue samples. This theme also aims to target and discover new therapeutics using information derived from the molecular interrogation of fibrotic tissues. This information will then be used to develop new interventions that specifically block those pathways.

One of the other aims of the Scar Wars program is to assess the extent of fibrosis by using advanced imaging techniques such as MRI. That way, patients can be tested to assess the extent of organ fibrosis and their response to anti-fibrotic therapies.

viii. Hematology-Immunology Translational Research Collaboration (HITRC)
Co-Directed by Dr. Michelle Sholzberg and Dr. Alan Lazarus, this collaborative group is composed of approximately 50 clinical and basic science researchers who have an interest in the investigation of blood and immune system responses and how they relate to various medical and surgical conditions. Their priority is to foster innovative and effective translational research partnerships in fields relating to hematology and immunology, with research focus on:

a) Inherited disorders of hemostasis & associated sequelae/complications;
b) Bleeding from trauma and surgery;
c) Hematologic autoimmune disorders (e.g. immune thrombocytopenia, acquired hemophilia)
   a. Biobank and clinical database development
   b. Biomarker/therapeutic target identification, prognostication, therapeutics development

This research theme is in its early stages, with the past couple of years spent developing and fostering the translational research interests of its members. The HITRC researchers are currently working on a number of projects including:

- The Tamiflu Study to determine the impact of oseltamivir on mean platelet glycoprotein sialylation in patients with immune thrombocytopenia;
- A prospective biobank and database including patients with immune thrombocytopenia to identify clinical and biological characteristics of ITP patients;
- IRON MOM; a pragmatic, cluster randomized controlled trial evaluating the IRON Mom educational toolkit and its impact on mean antenatal hemoglobin in women presenting to labour and delivery across Ontario;
- A Bleeding Assessment Tool (Self-BAT) Study to determine if the score on the Self-BAT is an accurate predictor of major bleeding in the seven day perioperative period;
- Acquired hemophilia – plans are underway to develop the first Canadian database and the first international biobank for acquired hemophilia since its pathophysiology is largely unknown;
- The Monoclonal IVIg replacement initiative examines how to proactively replace IVIg with a recombinant product.
C. THE LI KA SHING KNOWLEDGE INSTITUTE (LNSKI)

The LNSKI houses the “dry bench” research efforts of the hospital, including clinical research and health services and policy, population health, global health and knowledge translation research. Dr. Andreas Laupacis was the Executive Director of the LNSKI between 2006 and 2018 and upon stepping down in March 2018, Dr. Patricia O’Campo has become the Interim Executive Director. There are ~180 clinical and dry bench researchers working within the following LNSKI research programs and centres:

1) Centre for Urban Health Solutions (Director Dr. Stephen Hwang)
2) Knowledge Translation Program (Director Dr. Sharon Straus)
3) Centre for Global Health Research (Director Dr. Prabhat Jha)
4) Applied Health Research Centre (Director Dr. Peter Jüni)
5) Li Ka Shing Centre for Healthcare Analytics Research and Training (Director Dr. Muhammad Mamdani)
6) Centre for excelLence in Economic Analysis Research (Director Dr. Wanrudee Isaranuwatchai)
7) The Evaluation Centre for Complex Health Interventions (Director Dr. Sanjeev Sridharan)
8) Rescu (Director Dr. Laurie Morrison)
9) The International Centre for Surgical Safety (Director Dr. Teodor Grantcharov)
10) Centre on Drug Policy Evaluation (Director Dr. Dan Werb)
11) Centre for Depression and Suicide Studies (Director Dr. Sidney Kennedy)

ix. Centre for Urban Health Solutions (C-UHS)

The Centre for Urban Health Solutions (C-UHS) led by Dr. Stephen Hwang is an interdisciplinary research centre whose mission is to improve the health of those who are disadvantaged and to increase health equity. The Centre, originally known as the Centre for Research on Inner City Health (CRICH), seeks to improve the health of marginalized populations and to reduce barriers to accessing services essential to health. The Centre develops, implements, and evaluates interventions within health care and social service systems and at the level of public policy. From 2004 to 2015 the Centre was directed by Dr. Patricia O’Campo, during which time it garnered international reputation for addressing health inequities through research that supports social change. Some of this work included:

- Supporting the Housing First initiative through the “At Home/Chez Soi”;
- Providing Fairer access to cancer care through collaboration with Cancer Care Ontario, Peel Public Health, Punjabi Community Health Services and other community members;
- Creation of BioDiaspora.com (now BlueDot) to understand how infectious diseases spread across the globe making us more prepared for the next pandemic;
- Evaluation of HIV testing and treatment options, including identification of high risk populations, evaluation of prophylactic treatments, and understanding barrier to treatment.

Currently, there are 28 scientists working at the C-UHS, many of whom are also clinicians. C-UHS members have specialized expertise in areas such as clinical epidemiology, social
epidemiology, health economics, biostatistics, health geography, health services research, population health, program evaluation and knowledge translation.

The Centre also includes two specialized units:

- **Well Living House** led by Dr. Janet Smylie: a group of Indigenous health researchers, health practitioners and community grandmothers who are working together to improve the health and well-being of Indigenous infants, children, and their families through applied knowledge work.
- **The Survey Research Unit** led by Dr. Tatiana Aratangy: undertakes large-scale qualitative and quantitative research in multiple languages and using a range of techniques.

The priority focus of C-UHS is the design and testing of solutions to complex public health issues such as chronic homelessness, addictions, HIV infection, poverty, Indigenous health and intimate partner violence. The Centre is also interested in strengthening community based (partnered) research methods including trials to build a trusted evidence base for informing public policy and funding decisions.

A major fundraising campaign is underway to fuel the work of the Centre and position the Hospital, the Centre and its scientists as contributors to effective and sustainable change. Currently the Centre is working on a number of significant projects:

- The Navigator Project to support people who are homeless with complex medical conditions, a population who are admitted to hospital four times more often than the general population whose discharge into the community poses serious challenges.
- Free provision of essential medicines to people who have difficulty paying for them themselves.
- Evaluation of Indigenous cultural competency training programs for healthcare professionals.
- The Model Schools Pediatric Health Initiative that pilots and evaluates a school-based healthcare delivery model for Toronto’s most vulnerable and underserved children.

The Centre has also accomplished some major impacts with its research work in the areas of improving the health care system’s access to high quality data related to health equity, addressing barriers and gaps in the health care system, improving services for people dealing with homelessness and housing instability and indigenous Health (see Section 10: Research Impact).

x. **Knowledge Translation Program (KTP)**

Dr. Sharon Straus was recruited to St. Michael’s Hospital to become founding Director of the Knowledge Translation Program in 2008. The goal of the Knowledge Translation Program (KTP) is to improve quality of care by developing, implementing and evaluating strategies that bridge the knowledge-to-practice gap, and to research the most effective ways to translate knowledge into action. The program uses an integrated knowledge translation approach whereby knowledge users (i.e. patients, caregivers, health care providers, managers and policy makers) are involved throughout the process from conceptualization through to study completion and dissemination of its results. The KTP consists of two teams:
- **Knowledge Synthesis Team (KST)** is committed to finding the best available evidence by conducting studies such as scoping reviews, rapid reviews and systematic reviews that have the potential to improve health outcomes and inform important policy decisions.

- **Team for Implementation, Evaluation and Sustainability (TIES)** aims to advance the science and practice of research update through working with a diverse range of health system stakeholders at local, national, and international levels.

The KTP is working on a number of significant projects including (to name a few):

- A CIHR-funded team grant in the creation of KT frameworks and tools that consider gender and intersection of other factors such as race and age;

- A CIHR-funded SPOR Evidence Alliance to create a rapid learning health system with the objective to establish a national, coordinated alliance in support of systematic reviews, guidelines development and knowledge translation;

- A project with the Canadian Task Force on Preventative Health Care (CTFPHC) and the Public Health Agency of Canada to disseminate clinical practice guidelines that support primary care providers in delivering preventive health care;

- Capacity building initiatives such as Partners in Research (PiR), which is an online course for patients, caregivers and researchers to learn how to work together to improve health research and health care; and Practicing KT, which is an evidence-based course on how to implement evidence in health care. We have also created workshops on mentorship and gender equity that have been used worldwide.

The KTP has succeeded at making an impact on policy over the last decade (see Section 10: Research Impact). The KTP has grown significantly over the last 10 years from six to 78 people and has trained 100 individuals. The program hopes to continue to advance the science and practice of KT through their work on scaling and sustaining KT interventions; developing and testing KT tools; advancing knowledge synthesis methods of complex interventions; advancing the science of patient-oriented research and patient engagement; and building capacity and supporting career development.

**xi. Centre for Global Health Research (CGHR)**

The CGHR, directed by Dr. Prabhat Jha, is co-sponsored by St. Michael’s Hospital and the University of Toronto’s Dalla Lana School of Public Health. Founded in 2002 on the principle that effective health initiatives must be supported by reliable, evidence-based research, CGHR’s mission is to lead high-quality public health research that advances global health for all, with particular attention to the world’s poorest populations. Current projects at CGHR are designed to generate and disseminate evidence of the major causes of premature mortality among the global poor. Research areas include maternal and child health, tobacco control, health policy and economics, and gender inequalities.

One of the major projects for the CGHR is the Million Death Study (MDS), one of the largest studies in the world on causes of mortality. This is an ongoing study that is conducted in India where in collaboration with the Registrar General of India, the MDS will eventually monitor 23 million people in 3.2 million nationally representative households in India from 1998-2023. Any deaths that occur in these households during this period will be assigned a probable cause, as determined by a method called verbal autopsy.

CGHR is now seeking funding to implement a transformational plan to capture the causes of deaths in 25 low and middle-income countries by 2025, using novel methods to measure mortality. In addition to Canada, India, Mexico, and the US, the CGHR has expanded its scope.
to include Ethiopia, Mozambique, and Sierra Leone, and intend to include South Korea, Colombia, Brazil and South Africa. More countries will be added later.

Some of the program’s ongoing projects include:

- Artificial Intelligence for Verbal Autopsy (partnership with Google Deep Mind, and Prof. G. Hirst, Dept. of Computer Science, UofT);
- Geospatial and Analytical Epidemiology (Dr. Patrick Brown, new joint recruit to St. Michael’s and the UofT Dept. of Statistics);
- Child Health and Infectious Disease (led by Shaza Fadel, partnership with the WHO, Johns Hopkins University and others);
- Global Tobacco and Alcohol (partnership with Prof. Sir Richard Peto, U of Oxford);
- District Evaluation Study on Health (DESH)-(Partnership with Tata Trust, India);
- Disease Control Priorities Network (Partnership with Prof. Dean T. Jamison, UCSF);
- India Study of Health Adults (ISHA) (Partnership with Dr. Rajesh Dikshit, Tata Memorial Centre, Mumbai).

While expanding the MDS model to other countries, starting with Ethiopia and Mozambique, these new locations will be the first members of the Statistical Alliance for Vital Events (SAVE), a consortium dedicated to improving vital statistics coverage worldwide and directing evidence-based health policy using that data.

The CGHR has published over 125 publications related to MDS to date, in high impact medical journals (e.g. NEJM, The Lancet and BMJ) and approximately 7 books and/or reports. The CGHR has also implemented a Massively Open Online Course (MOOC) called Death 101 via the University of Toronto which was launched in 2015 and updated on February 1, 2018. This course offers a quantitative approach to understanding how studying death translates in better health for living. It will be used as the basis for a new Global scholarship program and Summer Institute called the Queen Elizabeth-SAVE Advanced Scholar program, starting in June 2018. And finally, the CGHR has obtained a University of Toronto Connaught Global Challenge Award to advance mortality statistics over the next two years.

xii. Applied Health Research Centre (AHRC)
Launched in 2009 and originally led by Dr. Muhammad Mamdani, the AHRC is an Academic Research Organization (ARO) with expertise in clinical study design, pragmatic methodology, and biostatistics. In 2016 Dr. Peter Jüni was recruited from Switzerland to become the current Director. The AHRC has grown to a team of ~60 people and has managed more than 100 multi-site, national, and international clinical trials, observational studies, and qualitative studies. The centre employs industry-leading web-based secure database technology, which incorporates advanced data validation and reporting tools. The AHRC has grown to be one of the largest AROs in Canada, and is a one-stop service for patient-oriented clinical research.

The AHRC’s priorities are to continue serving as a leading provider of methodological support, which includes quantitative and qualitative study design, statistical design, and protocol development, in addition to study, site and/or data coordination. A quality-driven ARO, the AHRC seeks to lend its expertise in pragmatic clinical trials to improve patient outcomes and impart policy changes at all levels of government.

The AHRC is currently engaged in/looking to engage in:
- Ongoing development of the AHRC’s statistics and methods team, and with the addition of the AHRC’s Associate Director, Dr. Bruno da Costa, build a Musculoskeletal Research Group;
- Coordination of large registries (e.g. TargetKids!) resulting in key publications, and studies that utilize methods co-developed at the AHRC;
- Continue support of students and trainees through the Professional Experience Year (PEY) program at UofT, facilitating PhD and Post-Doctoral opportunities, and administering courses through the Institute of Medical Sciences (IMS) and the Institute of Health Policy, Management and Evaluation (IHPME);
- Develop the Resuscitation Registry & Research (R3) program, which will be taken nationwide through the CanROC project;
- Build capacity around quality – helping the AHRC move beyond monitoring for a wider focus on privacy, IT/database, policies, and delivery of quality training.

Some major accomplishments to date include:
- Successful collaboration with CLEAR, BreakThrough, TAHSN, Mayo Clinic. It is a proud MaRS EXCITE partner for methodology, and a designated Research Centre of OSSU-SPOR;
- Contribution to many peer-reviewed, high-impact journal publications for groundbreaking studies (e.g. TRICS-III, EMBRACE);
- Successful procurement and implementation of REDCap, and was the first to self-host Medidata RAVE. Will soon self-host a first-in-class electronic data capture (EDC) system.

xiii. Li Ka Shing Centre for Healthcare analytics Research and Training (LKS-CHART)
LKS-CHART was established in 2016 under the leadership of Dr. Muhammad Mamdani and was officially launched in 2018. It was made possible by a large donation from the Li Ka Shing Foundation. The Centre is a service-based data science team that is building an integrated repository of high-quality data which will catalyze communities of management and clinical leaders to make transformative changes that improve patient outcomes and health system efficiency. The Centre houses data scientists who leverage the Enterprise Data Warehouse (EDW) of the Hospital using advanced statistical tools to address real world challenges faced by senior management and clinical leadership through the use of data.

St. Michael's Enterprise Data Warehouse is Canada’s most advanced hospital data warehouse, and includes 19 source data systems, containing 17,340 data elements from 500,000 patients.
The LKS-CHART brings together highly trained data scientists in diverse fields such as computer science (machine learning), epidemiology (biostatistics), engineering (operations and simulation modeling), and business (financial analytics) to apply scientifically rigorous methods to generate data-driven insights into ‘real world’ challenges facing clinical leaders and hospital decision makers (see Figure 3 for clinical subject areas). As a service-based centre, LKS-CHART engages clinicians and decision makers from the start, focusing on the questions that matter most to them. Combining proven study templates with standardized data extraction and analysis algorithms, these teams turn around insights within days. The LKS-CHART then works with leaders, managers and implementers to turn these insights into action. The same rigorous approach is then taken to evaluate the outcomes of these interventions to ensure they are making a difference.

Questions posed to the LKS-CHART come from senior management and clinical leadership and end-users are engaged throughout the analytics process. Where possible, analytics projects are tied to intervention implementation with the goal of improving patient outcomes and/or hospital efficiency.

LKS-CHART is currently working on a number of projects using the emergency department (ED) data as a pilot project. For example, a model to project ED volumes 3 days in advance showing >90% accuracy has recently been completed. Further, a user-friendly mini-simulation model to model performance of hospitals with respect to changes in variables that drive funding has been completed and is currently being used by Improvement Project Management Office (IPMO) for planning purposes.
Other ongoing projects include developing a model to predict when ED wait times and ED length of stay will both reach critical levels in the ED, simulation model to inform bedmapping decisions. Another project uses forecast data and discrete event simulation and a model to predict length of stay and discharge disposition for patients undergoing elective knee and hip procedures.

xiv. Centre for excellence in Economic Analysis Research (CLEAR)
The Centre for excellence in Economic Analysis Research (CLEAR) was established in 2012 under the direction of Dr. Jeff Hoch, with Dr. Wanruudee Isaranuwatchai taking over the leadership in 2015. The goal of CLEAR is to improve efficiency of the health care system by generating economic evidence to help when choices among different health interventions/innovations need to be made. This is accomplished by conducting, appraising, and explaining economic analysis of health care interventions/innovations to support researchers, practitioners, and policy-makers in decision-making process. By comparing both the costs and effectiveness of health care interventions, or by showing the potential economic impact of a health condition, the centre develops economic evidence to inform resource allocation decisions, enabling more efficient use of resources.

CLEAR has collaborated with researchers and decision-makers in various areas to help communicate the value of health initiatives using economic evidence. Examples of collaborative projects include:

- Cancer Care Ontario (CCO) – determined the value for money of cancer treatments such as magnetic resonance-guided brachytherapy and ambulatory models of care for cancer patients;
- Local Health Integration Network (LHIN) - studied the economic impact of mental health and/or addiction initiatives;
- Canadian Agency for Drugs and Technologies in Health – studied potential role of economic evidence in the cancer drug funding process;
- Patient Advocacy – led workshops for patient advocacy groups on how economic evidence could assist in the drug reimbursement decision-making process;
- Health professionals – numerous projects with clinicians, nurses, and hospital administrators (e.g. examined the economic impact of home-based palliative care; and examined the economic impact of expanding a HPV vaccination program to boys to prevent oropharyngeal cancer).

CLEAR has been involved in >40 economic analysis projects; many of those were with groups who came back for subsequent projects.

xv. The Evaluation Centre for Complex Health Interventions
Led by Dr. Sanjeev Sridharan, the Evaluation Centre for Complex Health Interventions was established in 2010, with a mission to work with policy-makers, planners and implementers to integrate evaluation approaches and evaluative thinking to understand the impacts of policy and programmatic interventions.

Key areas of focus have included:
- Evaluations of projects related to global health, poverty reduction strategy, health inequities and integrated care;
Building evaluation capacities with partners such as the China National Health Development Research Centre and the Ontario Brain Institute.

In 2018, Dr. Sridharan accepted a position with the Bill and Melinda Gates Foundation in Delhi, India, where he will lead the monitoring, learning and evaluation of Gates’ investments in two large initiatives: reducing maternal and neonatal mortality in India’s largest state Uttar Pradesh and an ambitious effort to redesign the health systems in India. Hence, the Centre is currently focusing on wrapping up existing projects with no plans for continued work under new leadership.

xvi. Rescu

Rescu is the largest program of its kind in Canada with a focus on deriving and evaluating processes of care and timely interventions that improve outcomes for patients who suffer out of hospital life threatening trauma and cardiac emergencies. Led by Dr. Laurie Morrison, the program includes 13 Investigators from St. Michael’s Hospital, Sunnybrook Health Sciences Centre, North York General, Queens University, the Hospital for Sick Children and Department of Engineering at the University of Toronto.

Rescu specializes in randomized controlled trials (RCTs), systematic reviews, meta-analyses, and derivation and validation of decision rules pertaining to out of hospital resuscitation. Rescu collaborates with investigators, Emergency Medical Services (EMS), Fire operators, and 37 academic and community destination hospitals across Southern Ontario. These EMS agencies respond to over 600,000 patient requests for care per annum. Patients are randomized in the pre-hospital setting and Rescu collaborates with critical care, trauma, neurology, neurosurgery, anesthesia and neuropsychology to collect in-hospital data and understand the long term consequences of drugs, devices and out of hospital processes of care, as well as with the Applied Health Research Centre to coordinate the day-to-day administration of the projects and grants.

Current projects include:

- CanROC: a national network based on a population based resuscitation registry of cardiac arrest and life threatening trauma in 10 Provinces across Canada;
- A randomized controlled trial in early sepsis management moving the administration of antibiotics out of the emergency department and into the field;
- Partnership with the harm reduction community, the St. Michael’s simulator lab, the Hospital’s Emergency Department, Family and Addiction Services and the Ontario College of Art and Design (OCAD) to develop a more intuitive naloxone kit which could be used by people who use opioids, family members and friends to help save a life after opioid overdose.

Some major accomplishments of Rescu include:

- Translation of the scientific findings of a decade of research in cardiac arrest into the day-to-day care at the bedside and curbside. The impact of this was a doubling of survival after cardiac arrest in Southern Ontario. This significant accomplishment was recently published in Circulation Outcomes;
- Development of a model that will help guide the placement of automatic defibrillators in the community such that they are accessible for use during out-of-hospital cardiac arrest.
- Development of a model to use drones to deliver defibrillators for the public to use in remote regions;
• Collaboration with William Osler Health System which has resulted in the completion of the largest pragmatic trial of implementation of remote ischemic conditioning in acute myocardial infarction. The trial moved the application of remote ischemic conditioning from the ED and the Catheterization Lab into the pre-hospital setting. Collaborating across disciplines moves the therapy into the hands of those that can provide it in a timely and effective manner.

xvii. The International Centre for Surgical Safety
The International Centre for Surgical Safety is led by Dr. Teodor Grantcharov. Comprised of 15 PIs (5 from St. Michael’s and 10 national/international) this Centre is a hub for research and development, analytics and the design of effective interventions, with a focus on reducing perioperative errors and adverse events and improving patient safety nationally and globally. The Centre’s objective is to generate ground-breaking evidence regarding human and technology performance, safety threats and resilience supports during surgery and increase the understanding of the complex factors that influence patient outcomes. The goal is to develop targeted interventions, technologies, training and practice to save more patient lives based on evidence produced in the operating room (OR).

Currently the centre is working on a number of projects including:
• Establishing a model of a safer operating room by developing, evaluating and facilitating the national and international implementation of novel technology and related concepts;
• Improving patient safety and reducing healthcare costs through analysis of hazard patterns and risks during surgical interventions;
• Developing educational tools, programs and policies for future surgeons;
• Creating recommendations and protocols for reporting safety issues to improve the culture of safety reporting in hospitals worldwide.

In the past year, the Centre has grown significantly with 10 major academic centers joining the surgical safety network in 2018. Further, the program has initiated and is leading several multi-institutional trials investigating the impact of targeted, multi-disciplinary interventions on quality of surgical performance, safety outcomes and clinical costs.

xviii. Centre on Drug Policy Evaluation (CDPE)
The Centre on Drug Policy Evaluation (CDPE) (formerly the International Centre for Science in Drug Policy) is led by Dr. Daniel Werb and conducts research on drug policy and drug-related outcomes. The CDPE includes a network of scientists and academics from all global hemispheres committed to improving the health and safety of communities and individuals affected by illegal drugs. The team conducts systematic research assessing the scientific evidence on drug policy effectiveness (i.e., systematic reviews and meta-analyses), intervention and implementation science (e.g., street drug checking services, integrated supervised injection services), and epidemiologic research on the prevention of injection drug use initiation.

The major priorities of the CDPE are to:
1. Become a primary source for rigorous scientific evidence on the impacts of illegal drug policy on community health and safety;
2. Conduct public education campaigns and other forms of knowledge translation to communicate the urgent need to develop evidence-based drug policies.

Examples of current projects include:
• Launch of drug checking services (DCS) at 3 sites in Toronto, providing people who use drugs with information on the composition and potency of their street drugs to allow for more educated choices about their drug use and increase their capacity to avoid toxic substances. CPDE will conduct an evaluation of the impact of these 3 sites;
• An international cross comparison of policies about illegal drugs to identify the various indicators that different countries use to assess their effectiveness in combatting the adverse effects of illegal drugs on the community;
• An international systematic review of scientific literature on the health and social impacts of implementing drug decriminalization or legal regulation.

Some major accomplishments of the CDPE include:
• Led the implementation and evaluation of an innovative street drug checking service in Toronto, which consists of a networked set of hospital labs and frontline agencies. It also employs mass spectrometry equipment to provide street-involved people who use drugs with highly reliable information regarding the composition of the illegal street drug supply. This intervention is the first of its kind and is fully funded for five years;
• Generated several policy briefs and reports that have provided guidance to policymakers on the development of evidence-based drug policies. CDPE policy briefs have been used as the basis for Canada’s member state position statement at the UN Commission on Narcotic Drugs;
• Convened a group of over 200 policymakers, public health officials, law enforcement professionals, researchers, people who use drugs, and community organizers at the Canada’s Drug Futures Forum event to discuss the future of illegal drug policy in Canada. From this event, a report was compiled of all the recommendations that were discussed to serve as a roadmap to improve Canada’s policy response to illegal drugs over the coming ten years.

xix. Centre for Depression and Suicide Studies
The Centre for Depression and Suicide Studies is a clinical and academic program designed to investigate and integrate projects that define the best treatment for people with depression, suicidal behaviour and related challenges. It focuses on prevention and early intervention, and strives to improve public policy and clinical practice. The Centre works as part of a network of over 60 researchers and clinicians across five provinces in Canada, including British Columbia, Alberta, Ontario, Quebec and Nova Scotia.

The Centre is home to the Arthur Sommer Rotenberg (ASR) Chair in Suicide & Depression Studies at St. Michael’s Hospital and the University of Toronto (www.asrlife.ca). It is also the coordinating centre for the Canadian Biomarker Integration Network in Depression (CAN-BIND), sponsored by the Ontario Brain Institute (OBI) with additional support from the Ontario Research Fund (ORF), the Canadian Institutes for Health Research (CIHR) and other granting agencies. The Centre uniquely unites research and clinical efforts for two interconnected mental health issues- depression and suicide. It facilitates the efficiency and growth of not only local, but national and international research projects to enhance new discoveries and treatment interventions for depression and suicide while creating a stronger investment in mental health issues.

Research and clinical initiatives include:
• Integrating Data: the Centre is facilitating a number of biomarker studies that combine diverse types of data, including clinical outcomes, genetic and epigenetic markers, functional brain imaging, and mobile health data;
Delivering Innovative Care: Skills for Safer Living (SfSL) is an innovative group therapy intervention created by the ASR program for those with multiple suicide attempts.

Knowledge translation and patient engagement initiatives include:

- Storybook Project: a published collection of personal stories related to suicide is under development to spread awareness of suicide and mental health issues, decrease the stigma associated with suicide and encourage personal healing through creativity;
- CHOICE-D Project: the CHOICE-D Guide is a zero-cost resource for patients and families about depression treatment options available in Canada. The guide empowers individuals to understand evidence-based depression treatment options, encourages a patient-centred approach to treatment selection and promotes equitable access to information about depression care. Strategic dissemination of the CHOICE-D Guide will be evaluated to assess the impact of this guide on the quality of care, including in the domains of effectiveness, safety, efficiency, timeliness, and equitability.

6. Research Metrics

In order to understand the growth and quality of research at St. Michael’s Hospital it is important to look at how various measures of growth and activity have changed over time. This section will give an overview of the number of people involved in the research enterprise at St. Michael’s, the research funding and awards that have been received, the number of publications resulting from our scientists and the amount of commercialization we have been able to accomplish.

A. Faculty, Staff and Students

There are 244 Principal Investigators (PIs) in research; 191 are also clinicians. There are 3 categories of PIs (as per the appointments policy, which was formally implemented in September 2008). These PIs are individuals who lead independent research programs and are appointed as either a Project Investigator (<25% protected time for research), Associate Scientist (25-70% protected time for research) or Scientist (>70% protected time for research) (Figure 4).

In 2017, Research at St. Michael’s Hospital employed 977 staff members and supported the studies of 235 graduate students and post-doctoral research fellows. Table 1 lists the number of trainees across the institute over the past 5 years. The number of staff has more than doubled over the past decade, growing from 453 in 2007 (Figure 5).
Figure 4: Research faculty, staff, and students of St. Michael’s Hospital

Table 1: Number of students and postdoctoral fellows

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>Graduate Students and Postdoctoral Fellows</th>
<th>Research Summer Students</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-12</td>
<td>136</td>
<td>264</td>
<td>400</td>
</tr>
<tr>
<td>2012-13</td>
<td>181</td>
<td>235</td>
<td>416</td>
</tr>
<tr>
<td>2013-14</td>
<td>186</td>
<td>225</td>
<td>411</td>
</tr>
<tr>
<td>2014-15</td>
<td>267</td>
<td>220</td>
<td>487</td>
</tr>
<tr>
<td>2015-16</td>
<td>250</td>
<td>260</td>
<td>510</td>
</tr>
<tr>
<td>2016-17</td>
<td>242</td>
<td>209</td>
<td>451</td>
</tr>
</tbody>
</table>

Figure 5: Number of research staff
Over the past decade the number of PIs who have at least 25% of their time protected for research, has increased by more than 38%, from 152 to 209 (Figure 6).

**Figure 6: Number of appointed researchers**

![Bar chart showing the number of appointed researchers from 2007 to 2017](image)

*Researchers are defined as those with Scientist or Associate Scientist appointments

**B. RESEARCH CHAIRS AT ST. MICHAEL’S HOSPITAL**

Our data on the number of Research Chairs supported by Donors/Foundation dates back to 1996 (Figure 7). The number of Chairs has more than tripled over the past decade with 24 currently appointed active research chairs, and four additional pending. Currently, 14 of these chairs are endowed and 11 are term chairs (full list in Appendix 4). This highlights the commitment of the St. Michael’s Foundation to support high quality researchers.

In addition to donor/Foundation sponsored Chairs, there are several competitive Chairs available through the federal granting councils. The Canada Research Chairs (CRC) Program stands at the centre of a national strategy to make Canada one of the world's top countries in research and development. In 2000, the Government of Canada created this program to establish 2,000 research professorships across the country to attract and retain some of the world's most accomplished and promising minds. The CRCs are prestigious chairs that are allocated to Universities across the country. Each university’s allocation is dependent on their success in attracting tri-council funding (funding from the three Federal agencies, CIHR, NSERC and SSHRC). There are two tiers of Chairs:

- **Tier 1 Chairs**, tenable for seven years and renewable once, are for outstanding researchers acknowledged by their peers as world leaders in their fields. For each Tier 1 Chair, the institution receives $200,000 annually for seven years.

- **Tier 2 Chairs**, tenable for five years and renewable once, are for exceptional emerging researchers, acknowledged by their peers as having the potential to lead in their field. For each Tier 2 Chair, the institution receives $100,000 annually for five years.
St. Michael’s Hospital (as with all other fully affiliated hospitals) receives its Chair allocation from the University which is tied to our tri-council funding. Figure 8 highlights the change in allocation to St. Michael’s and the larger affiliated hospitals, showing that over the last 10 years, the CRC allocation for St. Michael’s has increased by 126%, which is the largest growth of any of the GTA hospitals (See Figure 9). Table 2 describes our current CRC chair holders at St. Michael’s Hospital.

The Canadian Institutes of Health Research has several highly competitive Chair opportunities, which some of our Faculty have been awarded (Table 3).

Figure 8: Canada Research Chair allocations across the GTA hospitals
Figure 9: Canada Research Chair allocation growth over the past 10 years

<table>
<thead>
<tr>
<th>Type of Chair</th>
<th>Chairholder</th>
<th>Start Date</th>
<th>End Date</th>
<th>Name of Chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1</td>
<td>Straus, Sharon</td>
<td>May-10</td>
<td>Apr-24</td>
<td>Knowledge Translation and Quality of Care</td>
</tr>
<tr>
<td>Tier 1</td>
<td>Gilbert, Richard</td>
<td>May-10</td>
<td>Apr-24</td>
<td>Diabetes Complications</td>
</tr>
<tr>
<td>Tier 1</td>
<td>Jha, Prabhat</td>
<td>Apr-14</td>
<td>Mar-21</td>
<td>Global Heath</td>
</tr>
<tr>
<td>Tier 1</td>
<td>Laupacis, Andreas</td>
<td>Jan-12</td>
<td>Dec-18</td>
<td>Health Policy and Citizen Engagement</td>
</tr>
<tr>
<td>Tier 1</td>
<td>Juni, Peter</td>
<td>Oct-16</td>
<td>Sep-23</td>
<td>Clinical Epidemiology of Chronic Diseases</td>
</tr>
<tr>
<td>Tier 1</td>
<td>Verma, Subodh</td>
<td>Jan-18</td>
<td>Dec-25</td>
<td>Cardiovascular Surgery</td>
</tr>
<tr>
<td>Tier 2</td>
<td>Tricco, Andrea</td>
<td>Jul-16</td>
<td>Jun-21</td>
<td>Knowledge Synthesis</td>
</tr>
<tr>
<td>Tier 2</td>
<td>Lee, Warren</td>
<td>Oct-16</td>
<td>Sep-21</td>
<td>Mechanisms of Endothelial Permeability</td>
</tr>
<tr>
<td>Tier 2</td>
<td>TBA*</td>
<td>Apr-19</td>
<td>Mar-24</td>
<td>Drug Policy Research and Evaluation</td>
</tr>
<tr>
<td>Tier 2</td>
<td>TBA*</td>
<td>Apr-19</td>
<td>Mar-24</td>
<td>Health Equity</td>
</tr>
</tbody>
</table>

*Two Tier 2 CRCs have approved and will be announced in Spring 2019.

Table 2: Canada Research Chairs currently held by SMH researchers

<table>
<thead>
<tr>
<th>Year</th>
<th>Chair Name</th>
<th>Faculty</th>
<th>Award Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-2014</td>
<td>Applied Chair in Health Services and Policy Research</td>
<td>Ahmed Bayoumi</td>
<td>$925,000</td>
</tr>
<tr>
<td>2012-2018</td>
<td>Applied Chair in Reproductive, Child &amp; Youth Health Services &amp; Policy Research</td>
<td>Joel Ray</td>
<td>$775,000</td>
</tr>
<tr>
<td>2014-2019</td>
<td>Applied Public Health Chair</td>
<td>Janet Smylie</td>
<td>$925,000</td>
</tr>
</tbody>
</table>
D. Research Funding

Funding for research at the Hospital comes from a variety of sources including external grants/awards, industry contracts, indirect funding, as well as scientist salaries (from the University or clinical practice plan), Hospital and Foundation support, and miscellaneous income (commercialization, core facilities, ethics and investments). More than 2/3rd of the total research funding is sourced externally (grants/awards, contracts and indirect funding – see Figure 10).

**Figure 10: Overview of research funding sources**

Total Research Revenue: outlines the total revenue to research (from all sources) dating back 10 years (Figure 11). Data from 2007/08 to 2010/11 were derived from internal hospital reporting, while data from 2011/12 onwards is collected from the annual report to the Council of Academic Hospitals of Ontario (CAHO).

Tri-Council Funding (which includes CIHR, NSERC and SSHRC) provides a good indication of the overall “quality” of our research enterprise. Data from 2000/01 to 2011/12 were derived from internal Hospital reporting (Figure 12), while data from 2012/13 onwards is collected from CAHO. We have seen an 18-fold increase in tri-council funding over the years with nearly a doubling over the past 10 years.
While tri-council funding, particularly from the Canadian Institutes of Health Research, is the major source of research funding at SMH, our scientists are also successful at obtaining peer-reviewed funding from other sources, including the provincial government, international funding bodies, and national foundations such as societies (e.g. Heart and Stroke Foundation). Analysis of the total peer-reviewed funding revenue in 2016/2017 showed that our researchers were awarded more than $38 million to support the operational costs of their research.
The **Faculty of Medicine Tri-Council Funding**: The Faculty of Medicine at UofT collects all information from their faculty in an annual synopsis report, which includes information from all of the affiliated hospitals. Within the Faculty of Medicine, St. Michael's was ranked fourth in tri-council funding for the 2016/17 fiscal year with $12.9 million, which is lower than UHN, SickKids and Mount Sinai, and higher than Sunnybrook and CAMH. Analysis of data over the past 10 years (2007/2008 versus 2017/2018; **Figure 13**) shows that St. Michael's Hospital had the largest growth in tri-council funding (77% increase) amongst the 6 larger affiliated hospitals.

**Figure 13: Percent growth in tri-council funding within the Faculty of Medicine, UofT**

Peer-Reviewed Salary Awards: **Figure 14** provides salary award data and includes scientists salary awards, studentships and fellowships. This data is derived from the annual CAHO report.

**Figure 14: Peer-reviewed salary award revenue**
**CIHR Salary Awards:** Salary awards are an area where our hospital excels not just in comparison with other affiliated UofT hospitals but with institutions across Canada. These awards are quite competitive (peer-reviewed) and are not only valuable from a prestige perspective, but bring in salary support enabling research administration to reallocate funds for recruitment. Using the CIHR Funding Database we analyzed all Salary Awards across Canada from 2007/2008 to 2017/2018.

- **Number of CIHR Salary Awards:** St. Michael’s is ranked 8th for the number of CIHR Salary Awards and is the highest ranked research hospital in the Country (Figure 15).

*Figure 15: Number of CIHR salary awards by research institution across Canada*

**Early Researcher Awards (ERA):** ERAs are competitive grants from the Ministry of Research, Innovation and Science that fund salaries for staff and trainees. These awards enable early career scientists to build their research programs, especially important in the last few years given there has been a lack of external funding for this cohort. St. Michael’s scientists have been very successful in obtaining ERA awards as outlined in Figure 16.
**Figure 16: Number of Early Researcher Awards obtained each round**

ERA Comparison across the GTA: St. Michael’s Hospital does exceedingly well in these competitions. This data was obtained from the Ministry database, which shows that St. Michael’s is ranked 11th across the province and 2nd amongst the GTA Research Hospitals for the total number of ERA awards. (Figure 17)

**Figure 17: Early Researcher Awards granted across the GTA hospitals**
Industry Contracts: Figure 18 provides data on both industry-initiated and investigator-initiated contracts, as well as unrestricted grants from Industry. Data is derived from the CAHO report.

Figure 18: Industry contract revenue

D. PUBLICATIONS

Scientific publications are a good indication of productivity. Since 2008 our total number of publications has grown by 75% (Figure 19). These numbers are generated annually by the hospital’s Health Sciences Library.

Figure 19: Number of publications
High Impact Publications: Publications that have the highest impact are those that are published in highly prestigious journals or those that are most cited by other authors. Journal quality is often measured by the impact factor (IF), with the most influential journals having higher impact factors (e.g. Science has an IF of 37.21, The Lancet's is 44.00, and The New England Journal of Medicine’s is 72.41). Over the past decade, we have tracked our number of publications with IF greater than 13 and this has grown from 24 to 113 (Figure 20).

Figure 20: Number of high impact publications (IF≥13)

E. AWARDS AND HONOURS

Awards and honours are a way to recognize the outstanding work and contributions of our scientists and physicians. Starting in 2014, the office of the Vice President, Research began to actively support the nomination of appropriate individuals for various awards. Table 4 highlights some of the more prestigious awards that our researchers have received over the past decade. This list is not comprehensive in nature but highlights the high quality of researchers at St. Michael’s Hospital.

Table 4: Awards received by individuals at St. Michael’s Hospital

<table>
<thead>
<tr>
<th>Year</th>
<th>Award Name</th>
<th>Awardee</th>
<th>Dollar Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Top 40 under 40</td>
<td>Subodh Verma</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>Top 40 under 40</td>
<td>Muhammad Mamdani</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Queen Elizabeth II Diamond Jubilee Medal</td>
<td>Robert Howard</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Andreas Laupacis</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Arthur Slutsky</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Andrew Baker</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Ori Rotstein</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Anthony Graham</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Teodor Grantcharov</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>Award Name</td>
<td>Awardee</td>
<td>Dollar Value</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
<td>--------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>2013</td>
<td>Barer Flood Prize in Health Services &amp; Policy Research</td>
<td>Andreas Laupacis</td>
<td>$25,000</td>
</tr>
<tr>
<td></td>
<td>Canadian Academy of Health Sciences Fellowship</td>
<td>Paul Dorian</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Prabhat Jha</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Muhammad Mamdani</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Philip Marsden</td>
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<tr>
<td></td>
<td></td>
<td>John Marshall</td>
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<tr>
<td></td>
<td></td>
<td>Patricia O’Campo</td>
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<tr>
<td></td>
<td></td>
<td>Sean Rourke</td>
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<tr>
<td></td>
<td></td>
<td>Sharon Straus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Order of Canada</td>
<td>David Jenkins</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prabhat Jha</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>CIHR Researcher of the Year</td>
<td>Arthur Slutsky</td>
<td>$500,000</td>
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<tr>
<td></td>
<td>Canadian Academy of Health Sciences Fellowship</td>
<td>Richard Glazier</td>
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<td></td>
<td>Royal Society of Canada Fellowship</td>
<td>Philip Marsden</td>
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<tr>
<td>2015</td>
<td>Royal Society of Canada McNeil Medal</td>
<td>Mike Evans</td>
<td>$1,500</td>
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<td>Royal Society of Canada Fellowship</td>
<td>Arthur Slutsky</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Andreas Laupacis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bloomberg Manulife Prize</td>
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<td>RSC College of New Scholars, Artists, and Scientists</td>
<td>Subodh Verma</td>
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<tr>
<td></td>
<td>Order of Canada</td>
<td>Wendy Levinson</td>
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<td></td>
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<td>Norman Marcon</td>
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<tr>
<td>2016</td>
<td>CIHR-IPPH Trailblazer Award</td>
<td>Prabhat Jha</td>
<td>$15,000</td>
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<td></td>
<td>RSC College of New Scholars, Artists, and Scientists</td>
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<td></td>
<td>Sharon Straus</td>
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<td></td>
<td>Canadian Academy of Health Sciences Fellowship</td>
<td>Nancy Baxter</td>
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<tr>
<td></td>
<td></td>
<td>Sidney Kennedy</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Laurie Morrison</td>
<td></td>
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<tr>
<td></td>
<td>National Academy of Medicine, US</td>
<td>Prabhat Jha</td>
<td></td>
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<tr>
<td>2017</td>
<td>Partners in Research: Biomedical Science Ambassador Award</td>
<td>Michael Cusimano</td>
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<tr>
<td></td>
<td>Robert H. Herman Memorial Award</td>
<td>David Jenkins</td>
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<tr>
<td></td>
<td>CIHR Distinguished Lecturer in Respiratory Sciences Award</td>
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<td>John Charles Polanyi Prize</td>
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<td>CIHR-IPPH Trailblazer Award</td>
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<td>CIHR-IHSPR Article of the Year</td>
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<td>Canadian Academy of Health Sciences Fellowship</td>
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<td>Michael Cusimano</td>
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<tr>
<td>Year</td>
<td>Award Name</td>
<td>Awardee</td>
<td>Dollar Value</td>
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<tr>
<td>--------</td>
<td>------------------------------------------------</td>
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<tr>
<td></td>
<td>Year Award</td>
<td>Awardee</td>
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<td></td>
<td>Top 40 under 40</td>
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<td>2018</td>
<td>Canadian Medical Hall of Fame Laureate</td>
<td>Navindra Persaud</td>
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</tr>
<tr>
<td></td>
<td>F.N.G. Starr Award - Canadian Medical Association</td>
<td>Andreas Laupacis</td>
<td></td>
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<tr>
<td></td>
<td>CIHR-IPPH Trailblazer Award</td>
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<td>University of Toronto Research Impact Awards</td>
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<td></td>
<td>Faculty of Medicine Dean's Alumni Emerging Leader Award</td>
<td>Fahad Razak</td>
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<tr>
<td></td>
<td>Royal Society of Canada Fellowship</td>
<td>Patricia O’Campo</td>
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</tr>
<tr>
<td></td>
<td>Order of Canada</td>
<td>Arthur Slutsky</td>
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</table>

### F. COMMERCIALIZATION

The hospital’s intellectual property (IP) commercialization activity dates back about 10 years (data is unavailable before this time). In April 2013 we revised our Intellectual Property Policy to one where the Institution owns IP that has been developed at or uses resources from the Hospital. Over the past decade we have filed an average of 5.4 patents per year and since 2013 have secured $1.7 million in commercialization grants. Figure 21 lists our invention disclosures over time. Figure 22 provides data on the number of patents held by St. Michael’s Hospital.

*Figure 21: Number of disclosures*
Since 2000, 11 companies have been established based on intellectual property developed at the hospital (see Table 5). The Hospital has held or currently holds equity in all 11 companies.

Table 5: Spin-off companies that have been established

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Date Started</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trillium Therapeutics Inc.</td>
<td>1998</td>
</tr>
<tr>
<td>Angogen</td>
<td>2000</td>
</tr>
<tr>
<td>Matrizyme Pharma</td>
<td>2011</td>
</tr>
<tr>
<td>Bluedot (previously known as BioDiaspora)</td>
<td>2013</td>
</tr>
<tr>
<td>Translatum Medicus Inc.</td>
<td>2013</td>
</tr>
<tr>
<td>Tracery Ophthalmics Inc.</td>
<td>2017</td>
</tr>
<tr>
<td>Surgical Safety Technologies Inc (SST)</td>
<td>2017</td>
</tr>
<tr>
<td>CCOA Therapeutics Inc.</td>
<td>2016</td>
</tr>
<tr>
<td>MIMOSA Diagnostics Inc.</td>
<td>2016</td>
</tr>
<tr>
<td>Fibrocor Therapeutics</td>
<td>2018</td>
</tr>
<tr>
<td>Zebrapeutics</td>
<td>2018</td>
</tr>
</tbody>
</table>

Revenue from Commercialization: St. Michael’s Hospital currently has three active licenses that are generating revenue. Combined, the hospital receives approximately $220,000 in royalties from these licenses per year.
7. Research Infrastructure & Operations

A. Research Facilities and Infrastructure

Over the course of the last 10 years, the hospital has created a centralized facility to support the activities of the basic science community. Located on floors 4, 5, 6 and 7 of the Keenan Research Centre (KRC), the Research Core Facility (RCF) is a multi-user facility offering significant financial savings and operational efficiencies by pooling equipment into a centralized core, thereby reducing duplication, as well as prolonging equipment lifetime through a centralized training and maintenance program.

Managed by a team of trained scientists, the RCF Specialists provide training and project design advice with a focus on teaching people to run their own samples rather than running the samples for them. The RCF includes both common and specialized facilities such as: BioImaging, Flow Cytometry, Molecular Biology, Histology and Microfabrication. In addition to one-on-one training, the RCF provides bi-weekly and monthly educational series exposing researchers to the latest equipment, facilities and scientific techniques. The RCF also runs several methodology courses with both theoretical and “hands-on” components.

In addition, facilities include a 25,000 square-foot state-of-the-art animal research facility (the Research Vivarium). It is fully compliant with the Animals for Research Act (Ontario Ministry of Agriculture, Food and Rural Affairs) and is accredited through the Canadian Council on Animal Care (CCAC). The facility serves the in-vivo based research and teaching needs of the Hospital’s scientists, physicians, and surgeons. It is also the official animal facility of Ryerson University. The Vivarium operates on a fee-for-service basis.

Specialty Services also provide support to the basic science community. A specialty service is a resource that includes unique expertise and specialized equipment. The service is a fee-for-service-business, available to everyone in the institution and directed by a St. Michael’s Scientist. Our largest specialty service is the Zebrafish Centre for Advanced Drug Discovery.

Over the last 10 years, $15 million worth of specialized equipment has been added to the RCF, Vivarium and Specialty Services. Of this, $4 million was funded as part of the establishment of Keenan Research Centre and the LKSKI. The remaining infrastructure (~$11 million) was funded through competitive Canada Foundation for Innovation grants that were awarded to St. Michael’s Hospital, the University of Toronto and Ryerson (via our iBEST partnership).

B. Research Space

Research currently occupies close to ~200,000 sqft across the hospital and external sites. Approximately ~140,000 sqft of this is within the LKSKI with ~55,000 sqft offsite (at 250 Yonge St, 193 Yonge St, and 2 Queen St E). Research space has grown by 25% in the last ~6 years. Prior to 2012, our offsite rental space was located at 229 Yonge St. and 193 Yonge St. and we paid $1.6 million/year for these leases. With increased demands for research space, we looked to 250 Yonge St as an option for growth. Because of the efficiencies we gained with the floor plan of the 250 Yonge St space and the low rental rate of 193 Yonge St, our lease rate has not increased significantly since 2012.
Currently, the rental costs for offsite research space are approximately $1.5M - $1.6M. These costs are paid by Research. This rental rate, however, will change next year due to upcoming rental negotiations at 193 Yonge St. and additional space needs that have been identified. We expect the rental fees to increase to possibly nearly $2M annually.

If Research continues to grow at the same rate as it did after 2011, we would anticipate the need for 1 additional wet bench floor and 3 additional dry bench floors over the next 10 years.

C. RESEARCH OPERATIONS

i. Office of Research Administration & Research Ethics Board

The Office of Research Administration (ORA), with a staff of ~30 people, co-ordinates and manages all aspects of research operations at Unity Health Toronto. The ORA provides leadership and assistance with research finance, contracts, grant applications (including managing the internal peer review program) and human resources. All funding and expenditures related to research projects are monitored and controlled to ensure compliance with the Hospital's financial policies and funding agency requirements, including the submission of financial reports. Research contracts and agreements with external organizations/parties are drafted and reviewed by staff in the ORA. Research revenues have grown over the last ten years and research support services have grown to accommodate the increase. The table below highlights some of the growth in research and its associated administration over the last ten years.

### Table 6: Growth in Research and Associated Administration

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2018</th>
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</thead>
<tbody>
<tr>
<td>Active Cost Centres</td>
<td>1,047</td>
<td>1,543</td>
</tr>
<tr>
<td>Contracts Reviewed Annually</td>
<td>527</td>
<td>1,147</td>
</tr>
<tr>
<td>Grant Applications Submitted</td>
<td>286</td>
<td>462</td>
</tr>
</tbody>
</table>

The Research Ethics Board (REB) is responsible to ensure that research involving humans or human biological materials meets current scientific and ethical research standards for the protection of human research participants. It recently joined forces with the REBs at our other two hospital sites, to form one network-wide Unity Health Toronto REB. The REB has the mandate to independently approve, reject, propose modifications to, or terminate any proposed or ongoing research involving human participants or human biological materials, which is conducted within, or by members of Unity Health Toronto. The REB reports directly to the Research and Education sub-committee of the Board, and is supported by the Research Ethics Office (a Director and a staff of eight). The office receives approximately 400 REB submissions per year.

ii. Research Facilities

With a team of 20 full time employees, the department of Research Facilities (RF) supports the resources, infrastructure and facilities for research at St. Michael’s Hospital. Specifically, RF provides leadership and management for, construction and space allocation, a biosafety programme, basic science core facilities (Research Core Facilities – RCF) and the Research Vivarium.
The RF supports the Animal Care Committee (ACC) and the Research Biosafety Committee (RBC). The ACC is responsible for ensuring that the Hospital’s use of animals is ethical, responsible and lawful, and the RBC is charged with ensuring that the Hospital’s research activities involving biohazardous agents are conducted in a safe manner and in conformity with all applicable standards and guidelines.

Over the last 10 years, the department has added 4 positions, 3 RCF specialists and a biosafety officer. In recent years the department has actively been employing LEAN methodologies to its work processes resulting is considerable savings and the commercialization of some new technologies.

iii. Intellectual Property Management and Commercialization

The IP management and commercialization activity of the network is overseen by the VP Research Office. The Director, Strategy & Commercialization oversees the activity with support from a part-time Commercialization Manager as well as the Office of Research Administration contracts team and external IP/legal counsel (as needed).

While St. Michael’s Hospital started accepting invention disclosures and filing patents related to research as early as 2005, it was not until April 2013 that we revised our Intellectual Property Policy to one where the Institution owns IP that has been developed at or uses resources of the hospital. This policy was hospital-wide (including physicians, staff, trainees, volunteers etc.). Since 2013, the VP Research Office increased its commercialization support to the hospital community, including technology scouting, providing commercialization training and workshops, intellectual property protection and management, assistance in identifying and securing commercialization funding, industry partnerships and licensing opportunities, and spin-off company creation. Commercialization activity and metrics are reported annually to the Hospital’s Research & Education Subcommittee of the Board.

A Commercialization Committee was established in 2015 to monitor and make recommendations about the commercialization activities of the network. The Committee reports to the VP Research and all committee decisions that require a financial commitment from Research must be approved by the VP Research.

iv. Grants, Awards and Special Projects

Over the last five years, the Director of Strategy & Commercialization has been leading a small team responsible for identifying funding opportunities (from all sources) and supporting the research community with pre-award activities (i.e. all activities leading up to the submission of a grant/funding proposal). The team is also responsible for leading award nominations that are assigned by the Research Leadership. On average, the team is actively leading and/or supporting 50 to 60 grant submissions and ~30 award nominations per year (their work was recently profiled in the University’s Department of Medicine newsletter).

Since the establishment of this highly productive group, the funding from external peer-reviewed grants at St. Michael’s Hospital has continued to increase despite the record lows in national funding rates. In fact, our tri-council funding has increased more than any of the other large UofT affiliated hospitals and we hold an outstanding number of CIHR and provincial salary awards (as outlined in the metrics section of this report). This is a testament to the success of this office. Support for PIs has been essential for obtaining many of our Canada Foundation for Innovation (CFI) infrastructure grants, our Canadian Research Chair applications and several large operating grants (ie. HeLTI grant for $17 million, two Health Services Research Fund grants totaling $4 million, a CIHR Team Grant for $5 million, a Brain Canada grant for $3 million,
and 10 CIHR Foundation Grants totaling over $18 million, three CIHR iCT grants in 2018 totaling ~$3.8 million.

In terms of awards and honours this team has been integral in promoting our internationally renowned scientists and ensuring that they are recognized for their contributions. Successful award nominations put forward include (but is not limited to):

- Four inductions into the Royal Society of Canada (RSC)
- Three inductions into the RSC College of New Scholars, Artists, and Scientists
- 17 inductions into the Canadian Academy of Health Sciences
- The RSC McNeil Medal
- The CIHR Researcher of the Year
- Distinguished Lecturer in Respiratory Sciences Award
- Three CIHR-IPPH Trailblazer Awards
- The Bloomberg Manulife Prize
- F.N.G. Starr Award
- One induction into the Canadian Medical Hall of Fame

In addition to their work on grants and awards, this team also works on all special projects that fall within the VP Research portfolio including but not limited to research action plan development and progress reporting, coordination and planning of Research Month, managing strategic partnerships/alliances, and supporting the Foundation with fundraising for research.

v. The 2012 Operational and Administrative Review of Research

In 2012, in the face of a looming operational deficit challenge facing the Research Institute (largely due to increased research growth following LKS Foundation gift as well as increased lease payments), the Executive Vice-President and Chief Administrative Officer of the hospital, John King, commissioned Corpus Sanchez International (CSI) Consultancy Inc. to undertake an administrative and operational review of research. The objective of the external review was to analyze the present operation, delivery and cost efficiency of administrative and operational support provided to researchers and research staff at St. Michael’s and to make recommendations for improvements, within the corporate guidelines of the hospital and the granting/funding agencies, which constitute the revenue sources of research.

Key findings of the review were:

- Space: some research activity remains located in rental space outside of the St. Michael’s footprint, and the cost of rental is a significant drain on the research budget. There does not appear to be space available to repatriate all research activity in the near future
- The Hospital’s financial system is not well suited to managing research accounts, making financial management a cumbersome process that needs a large staff (a new financial system was being planned at the time of the review and was subsequently implemented in 2014)
- Approximately 50 new clinical trial contracts are executed each year by a staff of 3 analysts. Recognizing that each organization has their specific needs, another Canadian academic health care organization has one person executing approximately 85 clinical trial contracts each year. There may be opportunities to streamline this work at St. Michael’s Hospital
- Irrespective of cost-recovery processes, it is the case in research institutes throughout Canada that the total cost of research cannot be covered exclusively from research income derived from grants and contracts.
Recommendation 1: In the near term, with no potential sources of new revenue possible from the operations of the Research Institute, the hospital and the Hospital Foundation will be required to find the resources to cover the deficit. In the longer term, the Hospital, the Foundation and the Research Institute need to collaborate on the establishment of a model that will sustain the operations of the institute.

Recommendation 2: It is recommended that the ORA undertake a thorough internal review of all its process and procedures, with a view to achieving cost savings where possible, when the new financial system is implemented.

Recommendation 3: The last research review of the institute was carried out in 2006. With the significant growth of the institute since then, it is recommended that a review of the Research Institute be undertaken within the next 12-18 months. This will support the long term planning required for the sustainability of the Institute.

**Actions taken in response to the recommendations:**

The new financial system was launched in October of 2014, though the grant management module was not launched. The system provided some better capabilities to manage research expenditures but did not meet the expectations for reporting and other efficiencies required in order alleviate headcount. There is no plan to upgrade the system and future considerations for the business system will include the network partners as a whole.

The ORA consistently reviews its workflow processes against volumes and required turnaround times. The rapid increase in contracts and cost centres has made it difficult to find human resource savings since that would have severe implications on control and compliance. The administration of grants and contracts has become more complex over the last decade due to increased reporting requirements for both financial and scientific progress. The Foundation and the hospital have collaborated on the creation of the Research Advancement Fund (RAF) to help address the ongoing sustainability of research.

### 8. Research Training

The Research Training Centre (RTC) aims to build an outstanding, internationally-recognized training environment and in so doing provide graduate students, postdoctoral fellows (PDFs) and other research trainees with a stimulating, high-quality training experience. Currently assisting more than 200 graduate students and PDFs and their supervising principal investigators from KRCBS, LKSKI and iBEST, the RTC is committed to providing strong mentorship, financial support, and advice/guidance on career development.

The RTC has grown extensively over the past 10 years under the leadership of the inaugural director Dr. Andras Kapus. Currently the RTC is led by two co-directors, Dr. Katalin Szaszi and Dr. Janet Parsons, representing the wide range of research interests of KRCBS and LKSKI, respectively.

The RTC provides funding and organizational support to assist the St. Michael’s Hospital Student Research Association (SRSA). The SRSA engages in important community building with graduate students at St. Michael’s, advocates for students’ interests and organizes student-led events, such as social events, fundraising campaigns, outreach activities and career seminars.
RTC services and activities:

(i) Financial Support
The RTC offers internal funding opportunities. The SMH-LKSKI Scholarship competition runs annually, and is awarded to a few top-tier MSc and PhD students to support their studies. We also offer up to 12 Travel Awards of up to a maximum of $1,000 granted annually to trainees to off-set the costs associated with presenting their research at national/international conferences. In 2017, eight Postdoctoral Awards were given to help PDFs and their supervisors bridge the funding gap associated with the fellows’ mandated transition to employee status.

(ii) Educational Activities
a) Student Seminar Series: These bi-weekly seminars permit trainees to share their research with the broader research community, and provide opportunities to enhance presentation skills.
b) Special Events, Courses and Workshops: In addition to organizing special events and workshops, the RTC keeps trainees apprised of additional opportunities offered in-house (e.g. Core Facilities’ hands-on technical courses, HUB sessions) and training programs at the University of Toronto and Ryerson University.
c) Annual Research Day: The annual trainee research day organized for the past 5 years has showcased trainee research in the form of oral and poster presentations. This full day event affords trainees opportunities to present their work and hear from guest speakers/leading scholars, and includes awards for the best presentations.

(iii) Communication, Collaboration and Community Building
We are starting new community engagement initiatives this year. In order to better tailor our offerings to the diverse needs of our trainees and PIs across the institution, in-person meetings, surveys and other events are planned over the next 6 to 8 months. Additional activities include:

a) New website: The RTC has a new website which includes a comprehensive set of resources to serve the RTC community’s needs (e.g. funding opportunities, job postings, upcoming events, registration info).

b) Great Toronto Area (GTA) RTC Network: The RTC has joined the recently-established GTA RTC network, bringing together representatives from RTCs across the Toronto Academic Health Science Network (TAHSN) hospitals. The RTC participates in this Network which provides access to shared events and other resources/opportunities available to Unity Health Toronto trainees.

c) Annual Career Development Day: In collaboration with SRSA, the RTC will be co-hosting its first Annual Career Development Day, bringing together experts who cross a range of career paths in diverse disciplines and fields to provide real world insights to trainees. This event will facilitate trainee learning about career opportunities across a range of health-related sectors and roles.

9. Internal Collaboration
Research has strong internal collaborations with many Hospital departments; some of which are outlined in this section.
A. CLINICAL DEPARTMENTS

The hospital’s clinical departments work closely with Research on the conduct of clinical trials, recruitment of high quality clinician scientists, providing matching funds for various grant applications, and general promotion of research as a priority.

Many clinical trials have been conducted at St. Michael’s Hospital each year, and each requires the full collaboration and support of the clinical department in which the trial is being run. Clinical departments recognize the importance of clinical trials, since studies have shown that patients enrolled in trials do better than patients who are not enrolled, and hospitals that participate in clinical trials have better outcomes and lower mortality that hospitals that do not participate.

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<td>Number of Studies</td>
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<td>1613</td>
<td>1803</td>
<td>1996</td>
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</table>

** This indicates a 60% increase since 2007

Clinical departments also work intimately with Research for the recruitment of high-quality clinicians who are drawn to our innovative research environment. For example in the Department of Medicine, of the 158 full-time physicians, 70 of them are researchers; and Dr. Tom Parker, former Physician-in-Chief and currently the Hospital’s Chief Medical Officer, has said that, “There’s no doubt that the high quality of clinical candidates I have been able to recruit is directly related to St. Michael’s being a research-focused hospital.” Similarly in the Department of Surgery, of the 33 surgeons recruited over the past five years, 25 of them (or 76%) have been researchers. For these recruitments, the clinical department works with Research Leadership and the Office of Research Administration to ensure that incoming clinician-scientists have research appointments and access to research support.

Clinical departments also support their clinician-scientists by regularly providing matching funds, allowing them to apply for grant funding. For example clinical departments and research have often split the matching funds required for Early Researcher Awards. This monetary support has been extremely important for many of our clinical researchers.

B. ST. MICHAEL’S HOSPITAL FOUNDATION

St. Michael’s Hospital Foundation, through its philanthropic activities, supports the Hospital in attracting the resources required to fulfill and enhance its mission of caring, research and education, as inspired and fostered by the Sisters of St. Joseph. The Foundation has a long-standing relationship of supporting the high quality research that is conducted at St. Michael’s Hospital, including fundraising for term and endowed research chairs, capital campaigns to finance the construction of the Keenan Research Centre and the LKSKI, and infrastructure and direct operational support for identified research priorities. In 2016, the Foundation hired a member of the Major Gifts team with a specific mandate to support fundraising for research. The sustainability of the research enterprise at St. Michael’s would not be possible without the spectacular support of the Foundation and its volunteers.

The Keenan Research Centre and Li Ka Shing Knowledge Institute
From 2006 to 2009 the St. Michael’s Hospital Foundation ran a capital campaign “Advancing Care. Every Day.” to build the Keenan Research Institute and Li Ka Shing Knowledge Institute.
This was made possible by philanthropists Patrick and Barbara Keenan who provided support to build the KRC, and four endowed chairs, including the first-ever endowed chair in Research at St. Michael’s. St. Michael’s Hospital also received a very generous donation from the Li Ka Shing (Canada) Foundation. This campaign raised a total of $140 million to build the 240,000 sqft building which opened in 2011.

Krembil Cell Facility
In 2008 the Foundation secured a donation from the Krembil Foundation to establish the Krembil Cell Facility. This is one of a handful of facilities across North America that is certified for the processing and manufacturing of Good Manufacturing Practice (GMP) -grade cell products intended for preclinical research, investigator-initiated cell therapy trials, and eventual therapeutic use. The facility includes a fully equipped clean room suite designed and established under ISO designation 7/ Class 10,000 classification, ensuring orderly flow of raw materials, processes and personnel.

Translational Innovation Fund and Angels Den
In a further attempt to grow the relationship between the Foundation and Research, in 2014/2015 there was a join collaboration to establish the Translational Innovation Fund and Angels Den. The Translational Innovation Fund was initiated by an endowment that would support 20 research projects over 2 years at $50,000 each. In collaboration with Research, the Foundation supported 20 research project that were led by joint teams of researchers and clinician – 10 teams in 2015 and 10 teams in 2016. Each year the 10 teams that were selected were invited to participate in the Angels Den to compete for additional prizes. This was a pitch competition to a jury of donors, based loosely on the popular TV series Dragon's Den®. Previous Angels Den winners can be found in Appendix 5.

Due to the high success of the first two years, the Foundation agreed to continue fundraising for an Annual Angels Den Competition. In 2017, the event outgrew the LKSKI, and was held offsite at Koerner Hall, where over 500 people were in attendance. That year the competition was divided into two streams: Biomedical Innovation and Social Innovation. There were eight teams selected to present in the Angels Den, with the winner in each category receiving $50,000 toward their research, while the other teams were given $10,000 each for competing. The Foundation was able to secure celebrity judges; Joe Mimran, Michele Romanow and Michael Wekerle. The Foundation also had Maureen Holloway be the Masters of Ceremony for the evening. This event did an outstanding job of making the science of St. Michael’s researchers fun and accessible to the general public (Appendix 6 – 2017 Angels Den Program).

The 2018 Angels Den competition was also held at Koerner Hall on November 6th, 2018, and was an amazing success with ~800 people in attendance. Grand prizes were increased to $100,000 in each stream, and a total of $400,000 was given out in support of the superb research projects. (Appendix 7 - 2018 Angels Den Program)

Research Innovation Council (RIC) and Circle
In January 2017, the Foundation launched the Research Innovation Council to support Research at St. Michael’s Hospital. The Council is a group of donors who have made a 5 year commitment to fund research. The council members interact with research several times throughout the year, so that they develop a vested interested specifically in the Research. They have an opportunity to select between a series of possible projects. The first cohort has 12 committed members.
Fundraising for Research Priorities
The St. Michael’s Foundation has worked very closely with the Research Leadership Committee to identify specific priority areas, including the Centre for Urban Health Solutions, the Barlo Centre for Multiple Sclerosis and the International Centre for Surgical Safety. In 2015, the Foundation and Research jointly released an open “call for proposals” for projects that would be considered for fundraising, which yielded several mini-campaigns specifically for research.

Urban Angel and “The Insider”
The St. Michael’s Foundation has also been very active in promoting research achievements and impact to the public. This is through various outlets including the Urban Angel Newsletter, which each month provided updates to over 26,000 readers. This publication highlights exciting news about our advances in research, innovation in patient care and inspiring stories, and details opportunities of how to get involved, attend events and support the Hospital. The Foundation has also started providing a quarterly communication to the Research Innovation Council and research donors call “The Insider”, which provides research specific information about the progress of various donor-supported research projects and information regarding breakthroughs/advances our scientists have had over the past few months.

C. COMMUNICATIONS AND PUBLIC AFFAIRS
The Communications and Public Affairs Department (formerly known as Corporate Communications) leads the external and internal promotion, branding and communications of scientists and their work. Communications meets regularly with Research Leadership to support key priorities, works with researchers in advance of publication dates to profile their work, and promotes the celebration of Research successes, awards and grants. This collaboration has resulted in numerous research stories garnering national and international media coverage, two successful Research Months, and more awareness within the enterprise and the Hospital of ongoing work and achievements. Currently, Communications is in the process executing a strategic Research communications strategy that lines up with the Research Action Plan one-year extension and is supported by Research Leadership.

Media Highlights: 2009 – 2017
Please note: Over the course of this time period, newsroom sizes decreased significantly and less reporters focused solely on health, medicine and science. According to this 2017 report from the Public Policy Forum, there has been a 30% reduction in journalism jobs since 2010, with 225 weekly and 27 daily newspapers lost to closure or merger. In this shifting media landscape, St. Michael’s Communications and Public Affairs department continues to leverage innovative opportunities to tell impactful stories to targeted audiences, such as social media. Meanwhile, our mainstream media coverage has remained strong. The snapshot below (Table 8) is by no means a comprehensive analysis of the media coverage in the past eight years but rather meant to showcase the diversity and reach of some key coverage over the years. Infographics summarizing media coverage and impact for 2015/16, 2016/17 and 2017/18 can be found in Appendix 13.

<table>
<thead>
<tr>
<th>Year</th>
<th>Subject</th>
<th>Researcher Highlighted</th>
<th>Reach of Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>The BIO.DIASPORA Project and a report, entitled “An Analysis of</td>
<td>Dr. Kamran Khan</td>
<td>International coverage, including media stories in The Washington Post, BBC,</td>
</tr>
<tr>
<td>Year</td>
<td>Subject</td>
<td>Researcher Highlighted</td>
<td>Reach of Coverage</td>
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<tr>
<td>2010</td>
<td>Research Study by Dr. Irfan Dhalla on Opioid Use in Ontario</td>
<td>Dr. Irfan Dhalla</td>
<td>International coverage, including media stories in the National Post, Toronto Star, Globe and Mail, Irish Sun, Zimbabwe Star and Japan Herald.</td>
</tr>
<tr>
<td>2011</td>
<td>Foods that lower cholesterol</td>
<td>Dr. David Jenkins</td>
<td>International coverage, including: Time Magazine, the Wall Street Journal, Reuters, The Globe and Mail, CNN Health, ABC News, USA Today</td>
</tr>
<tr>
<td></td>
<td>Concussion research about impact of full-contact hockey on younger children</td>
<td>Dr. Michael Cusimano</td>
<td>National coverage, including: The Globe and Mail, Toronto Star, CBC, CTY - Online, The Toronto Sun, The National Post - Online</td>
</tr>
<tr>
<td></td>
<td>Diabetes in Toronto: immigrants in ‘less walkable’ areas at high risk</td>
<td>Dr. Gillian Booth</td>
<td>International coverage including: REUTERS Health, Toronto Star, CBC Radio, Chicago Tribune, Yahoo! News.</td>
</tr>
<tr>
<td>2013</td>
<td>Snake venom may help treat blood clots</td>
<td>Dr. Heyu Ni</td>
<td>International coverage, including: Canadian Press, Huffington Post, Reuters, Toronto Star, Globe and Mail, CTV, City News, and Yahoo!</td>
</tr>
<tr>
<td>2014</td>
<td>Cigarette taxation can reduce smoking</td>
<td>Dr. Prabhat Jha</td>
<td>International coverage, including: ABC News radio, CBC, Globe and Mail, Toronto Star, MSN, Yahoo! Health and Canadian Press</td>
</tr>
<tr>
<td></td>
<td>Underweight or overweight, study looks at which is deadlier</td>
<td>Dr. Joel Ray</td>
<td>International coverage, including CBS News, ABC Radio, Huffington Post, MSN, World Health, National Post</td>
</tr>
<tr>
<td></td>
<td>Milk choice may affect vitamin D levels</td>
<td>Dr. Jonathan Maguire</td>
<td>Featured in The New York Times</td>
</tr>
<tr>
<td>2015</td>
<td>Opiate withdrawal in Ontario newborns jumps 15—fold</td>
<td>Dr. Suzanne Turner</td>
<td>National coverage, including Canadian Press, Toronto Star and 258 other outlets</td>
</tr>
<tr>
<td></td>
<td>Research on &quot;Housing first&quot;, approach works for homeless populations</td>
<td>Dr. Vicky Stergiopoulos</td>
<td>International coverage, including a feature in The Washington Post, and coverage in 68 other outlets</td>
</tr>
<tr>
<td>2016</td>
<td>Cardiac arrests and high-rises a deadly combination</td>
<td>Ian Drennan and Dr. Laurie Morrison</td>
<td>International coverage, including the New York Times, the BBC and Reuters.</td>
</tr>
<tr>
<td></td>
<td>Playing card games aids stroke recovery</td>
<td>Dr. Gustavo Saposnik</td>
<td>International coverage, including the BBC and 370 other outlets</td>
</tr>
<tr>
<td>2017</td>
<td>Study shows universal drug coverage could save Canadians billions</td>
<td>Dr. Nav Persaud</td>
<td>National coverage, including CTV, CBC, Toronto Star, The Globe and Mail and Canadian Press</td>
</tr>
<tr>
<td></td>
<td>St. Michael’s takes steps to address gender gap found at its research</td>
<td>Dr. Sharon Straus</td>
<td>Far-reaching local coverage, including the CBC, CTV News, and 26 other</td>
</tr>
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</table>
Research Month

Research awareness is a powerful tool to increase collaborations, public engagement, workplace satisfaction, and the overall profile of the institution. Starting in 2016, Research and Corporate Communications started working closely together to proactively increase research awareness through the establishment of Research Month each November. The goals of Research Month are to:

1) Highlight current research programs in order to increase awareness, communication and synergy between various research groups, the various departments of the hospital and the public;
2) Recognize the efforts and impact our research has had through awards, social media, and appreciation gifts, and;
3) Support the development/growth of our scientists, staff and trainees through workshops, training sessions and international lectureships.

In 2016 the Month was entirely planned and executed by Research and Corporate Communications and was considered a pilot project. Due to overwhelming positive feedback, the Month was expanded in 2017 to involve a Research Month Planning Committee that helped to execute at least one event on every working day of the Month. In 2017 we introduced the Research Month Passport (see Appendix 8) that helped to communicate all of the event times, locations and descriptions, and prizes were given to encourage attendance.

The 2017 Research Month also instituted more awards and recognitions with Unsung Heroes (outstanding staff) and Rising Stars (outstanding trainees) being recognized throughout the month, and the St. Michael’s Research Awards being extended to include a Legacy Award (Scientist), Culture of Discovery Award (Staff), and Excellence Award (trainee) for both the KRCBS and the LKSKI. These awardees are displayed annually on plaques placed in the stairwell on the 2nd Floor of the LKSKI.

One of the objectives of Research Month is to engage people in the hospital in learning about research. Some events that were particularly successful in doing this were:

- The KRCBS Open House: the KRCBS held a guided open house of the basic science laboratories for people to gain a better understand of the translational research happening at St. Michael’s Hospital. Over 200 people attended this event both in 2016 and 2017;
- Randomized Coffee Talks (RCTs): one-on-one matching of individuals from Research and the Hospital for individual coffee meet-ups, to discuss their respective roles at St. Michael’s. Approximately 70 people signed up to be matched with a random “coffee partner”. There was also one group RCT where people discuss their roles, experience and interest in Research;
- IPBR Event: the Interprofessional Practice-Based Research group led an event where nursing and health discipline teams shared their experiences, results and successes in research;
• Screening of "A Dark Room": the Institute for Biomedical Engineering, Science and Technology (iBEST) sponsored a screening of "A Dark Room"; a documentary about concussion and mental health;

• How Research can contribute to public health in Toronto: the Centre for Urban Health Solutions hosted Dr. Eileen de Villa, Toronto's Chief Medical Office, who hosted a seminar outlining the priorities of the Toronto Public Health and how our research can collaborate;

• Lunches with Leadership: members of Research Leadership each hosted a lunch to facilitate open dialogue regarding all issues related to Research and the Hospital. These lunches were very popular and led to great discussions and new ideas.

Research Month in 2018 was an event bigger success with 62 outstanding events throughout the month of November. The theme for 2018 was TOgether and attempted to showcase research across Unity Health Toronto. Events were held at both St. Michael’s and St. Joseph’s, and several workshops were offered remotely through Zoom.us, which surpassed expectations. Some highlights of the month include:

• The opening event provided an overview of research at St. Michael’s, St. Joseph’s and Providence with talks from Tim Rutledge and Pat O’Campo.
• Some research that was highlighted symposiums include Multiple Sclerosis and HIV
• Both the KRCBS and AERO Simulation Centre held open houses
• Two movie screenings were held: The Valedictorian and To Err is Human
• Randomized Coffee Talks were held individually through random matching and in groups at both St. Michael’s and St. Joseph’s

D. EDUCATION

Research and Education have a strong collaborative relationship. Education at St. Michael’s Hospital is located on the 4th Floor of the Li Ka Shing International Healthcare Education Centre and supports the growth of our education programs through the Allan Waters Family Simulation Centre, Centre for Faculty Development, Health Sciences Library and Student Centre. Our overall education vision is "Excellent patient outcomes through leadership in health professional education". With innovation as one of our priorities, our approach focuses on three core themes:

1) Interprofessional education across all of our disciplines
2) Leadership through Partnerships (with academic and health institutions locally and globally)
3) Research/Scholarship in Education

Specifically regarding Research in Education, academic research is considered an important outcome, which enhances health disciplines student educational activities and the ability to share results and successes across the broader academic community. In addition, Education Research through publication enhances our local and international reputation as a leader in education and also increases our attractiveness as a learning destination of choice for students and health care professionals. To this end Education has recruited four Scientists (two of which hold Term Research Chairs) who conduct education research. These Scientists report to the Executive Director of the Li Ka Shing Knowledge Institute and hold full Scientist privileges and support from Research.

Research and Education also work closely in reporting to the Hospital’s Research & Education Subcommittee on a quarterly basis.
10. External Partnerships

Outside of the numerous local, national and international partnerships that exist at the program or individual scientist level, the VP Research Office has established several key strategic partnerships focused on research, training and commercialization. A brief description of each of these partnerships is included below.

Shantou University

The hospital’s partnership with Shantou University began in 2008 and was fueled by the donation from the Li Ka Shing Foundation. The partnership is centered on two key areas: 1) The Li Ka Shing summer student program and 2) Li Ka Shing Centre for Healthcare Analytics Research and Training.

The Shantou Summer Student Program is a partnership between Shantou University Medical College (SUMC) and St. Michael’s Hospital. Since 2008, this initiative provides visiting SUMC medical students with an opportunity to participate in scientific research while they are still exploring their future specialties. Over six weeks, each summer, St. Michael’s research teams supervise four SUMC 2nd year medical students. The students also participate in weekly roundtables with Research leaders on a wide range of themes including healthcare governance, innovation, medical models - west and east. To date, 40 students have participated in this program. The total budget for the program is ~$22,000 per year (with St. Michael's Hospital providing $6,500 and SUMC providing $15,500).

Shantou University is interested in establishing a data warehouse, similar in structure to the data warehouse that is being established at St. Michael’s Hospital. Over the past two years, Dr. Muhammad Mamdani (Director of the Li Ka Shing Centre for Healthcare Analytics Research & Training, or LKS-CHART) and his team have held several meetings with representatives at Shantou with the following aims:

1. Conceptualize a data warehouse within Shantou University's environment
2. Share documentation and experiences at St. Michael’s Hospital in building an enterprise data warehouse (e.g. sharing our RFP documentation for data warehouse as well as business intelligence tools and vendor selection criteria)
3. Review of Shantou's preliminary plans for RFP and vendor selection

As of April 2018, a vendor has been secured and development of the electronic data warehouse in Shantou should begin shortly. Shantou plans on using the same business intelligence and core statistical tools as St. Michael’s Hospital. It is expected that once the data warehouse has been established, it will enable collaboration between Shantou and LKS-CHART in data management and analytics through shared practices, analytical tools and approaches.

MaRS Innovation

MaRS Innovation (MI) is a non-profit organization that provides commercialization services, early-stage funding resources and brokers deals with industry and private investors on behalf of its 15 members. MI was started in 2008 with a federal grant from the Network of Centres of Excellence in Commercialization and Research (CECR) program, a provincial grant from the Ministry of Research & Innovation and with matching funding support from its member institutions. St. Michael’s Hospital is one of the founding members of MI and the hospital CEO is
currently a Board member. The hospital (via VP Research Office) submits all invention disclosures (with unencumbered intellectual property) to MI for review and due diligence. If the project has commercial potential and is aligned with MI’s priorities, the hospital and MI enter into an Agency Agreement, whereby MI becomes our official commercialization agent for the project. Since its inception, federal funding to MI has been renewed once via the CECR program and has since ended in 2017. The organization currently relies on revenues generated from successful commercialization “exits” as well as annual membership fees for its operations.

**RYERSON UNIVERSITY**

In 2013, St. Michael’s Hospital and Ryerson University entered into a 20 year co-operation agreement to establish a joint centre for biomedical research called the Institute for Biomedical Engineering, Science and Technology (iBEST) as well as a biomedical incubator, called the Biomedical Zone. Under this agreement, the Hospital leased approximately 14,000 sqft of research space to Ryerson. The Institute and the Zone each have their own governance and the operating budget of both is shared between the host institutions.

**iBEST:** The Institute for Biomedical Engineering, Science and Technology (iBEST) brings together Ryerson’s engineering and science strengths with St. Michael’s biomedical research and clinical expertise to translate research concepts into testable healthcare solutions. Located within the Keenan Research Centre for Biomedical Science, iBEST’s access to biomedical, technological and clinical expertise allows its members and partners to identify challenges and rapidly pilot, modify and introduce biomedical discoveries and inventions to improve health. The overall goals of the Institute are to:

- Advance collaborative health research and development, and drive innovation through the widespread dissemination of research discoveries and findings and the creation of publications, patents, products and companies;
- Deliver results for Ontario’s economy through the development of spin-off companies and the advancement of patient-centered solutions that reduce healthcare spending;
- Provide world-class training to graduate students and research trainees and develop the next generation of innovators and multi-disciplinary talent.

The Institute has two co-Directors representing each institution. The hospital Co-Director is the Director of the KRCBS and the Ryerson Co-Director rotates annually between the Associate Dean, Faculty of Science and the Associate Dean, Faculty of Engineering & Architectural Science. The iBEST is organized into four research themes (Biomaterials Tissue Injury & Repair, Biomedical Delivery Systems, Biomedical Imaging & Therapy, and Healthcare Analytics & Applications), with a Theme Lead for each. The 50 scientists appointed to the Institute collaborate on research projects (and grants), co-supervise students and participate in networking and scientific events including Visiting Lecture series and an annual Symposium. The iBEST also offers multiple research training resources and initiatives for Ryerson and hospital students and staff (some training initiatives are delivered in collaboration with the Biomedical Zone).

**Governance:** The iBEST Executive is responsible for the overall governance of the Institute. The membership includes VP Research (St. Michael’s), VP Research & Innovation (Ryerson) and Provost and VP Academic (Ryerson). The iBEST Executive drives the strategic objective of the partnership and approves strategic planning activity and the Institute’s operational budget. The Executive has also established a joint Scientific and Operations Committee (SOC) which is
responsible for strategic planning, objective setting, budget development, fostering collaboration, assisting in identifying fundraising opportunities, and representing the members of iBEST and championing their needs and priorities to both institutions. The SOC includes membership from both institutions, with an annually rotating Chair position. The SOC develops objectives every year (as part of an action planning process) and provides annual progress reports to the iBEST Executive Committee. Appendix 10 contains the iBEST At a Glance report from 2017.

The Biomedical Zone: Officially founded in 2015, the Zone is an incubator and innovation centre that helps early-stage health technology companies to validate their need-based solutions directly in a hospital setting. Part of Ryerson’s Zone Learning program, the Biomedical Zone offers students unique experiential learning opportunities. The Zone currently has ~2000 sqft of space on the 7th floor of the Keenan Research Centre and includes shared space for 10-12 individual start-ups, collaboration/meeting space, as well as a micro-fabrication/3D printing facility. Appendix 11 contains the 2017-2018 BMZ Annual Report. The Zone runs many innovative programs including but not limited to:

- HealthBound: the Hospital identifies an opportunity for process improvement and selected start-ups work on the solution (HealthBound is now in its second year);
- The Co-Development Lab: clinicians and Ryerson students have the opportunity to co-develop solutions to real world problems in the hospital. There have been 15 projects submitted from St. Michael’s clinicians and researchers;
- Clinical Validation: allow start-ups in the Biomedical Zone to design and execute focused analysis and validation of their technology. To date, zone start-ups have engaged with over 110 clinicians at hospitals across North America, and the majority of these within St. Michael’s Hospital and some GTA hospitals.

Governance: The Director of the Biomedical Zone reports to the Biomedical Zone Executive which is responsible for the overall governance of the zone (including approving strategic directions and budgets). The membership includes the VP Research of St. Michael’s Hospital and the Provost & VP Academic of Ryerson.

11. Impact of Research

Highlighting the impact or our research (beyond just publications) is critical in order to fully demonstrate that our goal is to ultimately improve patient care, strengthen our communities and improve our healthcare system. Over the years, the Research Leadership has had opportunities to present the impact of our research to various audiences (both internal and external – See Knowledge Translation: From Evidence to Impact in Appendix 12). We do this to support our fundraising efforts (public and private), but also to better engage the communities we serve and to showcase our researchers and their incredible achievements. This section of the report provides a sample of the impact of some of our research studies (more examples are provided in Appendix 13).

Providing high quality data for health and social policy

Working with a number of partners, Dr. Rick Glazier has helped to create an open access website to improve the health care system’s access to high quality, area-level data related to health equity. The Ontario Community Health Profiles (OCHP) provides relevant and timely
information at no cost online and in a user-friendly format so that communities in Ontario can identify issues related to health equity and respond. Recently, the Toronto Central Local Health Integration Network used OCHP to identify neighbourhoods in need of additional primary care resources.

Dr. Patricia O’Campo brought together a wide range of organizations and generated Urban HEART @ Toronto, providing detailed information about Toronto neighbourhoods (e.g., walkability, availability of healthy food). This tool has been used to examine neighbourhoods and diagnose key problems in specific areas that affect the health and wellbeing of the local population (CBC news). Toronto City Council approved use of Urban HEART @ Toronto to help select Toronto’s Neighbourhood Improvement Areas for 2014-2020.

Improving services and policies related to homelessness

In collaboration with Toronto Public Health, Dr. Stephen Hwang demonstrated that people dealing with homelessness sustain cold weather injuries in weather too mild to trigger cold weather alerts. This research informed new municipal policy in Toronto: now, cold weather drop-ins open earlier in the season, and remain open continuously over the coldest winter months.

Drs. Vicky Stergiopoulos, Stephen Hwang, and Pat O’Campo worked with the Mental Health Commission of Canada and a range of local partners to run the Toronto site of a five-city randomized controlled trial of The At Home/Chez Soi (Washington Post article). The trial offered 240 people experiencing homelessness and mental health problems access to housing and supports without preconditions. Citing evidence of the cost-effectiveness of the trial in improving housing stability and wellbeing for clients, the Ontario Ministry of Health and Long-Term Care committed to invest long-term funding to sustain housing and support to At Home participants in Toronto and the Government of Canada made a long-term commitment to Housing First. In addition, the At Home/Chez Soi helped to influence the province to set a goal to end chronic homelessness in Ontario within the next 10 years.

Dr. Flora Matheson is working with service providers to develop a range of responses to gambling for people experiencing homelessness. Dr. Matheson’s research has led directly to the implementation of an unique Gambling Addiction Program offered with a shelter setting, Good Shepherd Ministries which includes case management (counseling), cognitive behavioural therapy and life-skills groups focusing on issues related to gambling. Dr. Matheson and her team have also partnered with the Problem Gambling Institute of Ontario at the Centre for Addiction and Mental Health (CAMH) and Good Shepherd Ministries to develop a manual for service providers to enhance care for their clients with gambling problems.

Improving services and responses related to opioids

Research from Dr. Ahmed Bayoumi at C-UHS and Dr. Carol Strike at U of T exploring the utility and feasibility of supervised injection facilities (SIFs) was instrumental in bringing supervised injection sites to Toronto. Their findings provided policy-makers with a solid evidence base for discussions about introducing SIFs. The Toronto Board of Health relied on these findings to appeal to the Federal Government to relax criminal restrictions on SIFs.

Dr. Stephen Hwang and post-doctoral fellow Dr. Fiona Kouyoumdjian collaborated with partners on study exploring mortality rates for people released from provincial custody and published a paper exploring mortality rates for people released from provincial prisons. The study
demonstrated that the chance of dying by overdose spikes dramatically during the two weeks after release.

Furthermore, Dr. Navindra Persaud led a study linking opioid-related death records with correctional services data that found that 10% of deaths are associated with release from incarceration and that the highest risk period is the first few days following release – before most people can see a healthcare provider (CBC news report). These studies from C-UHS helped inform advocacy efforts leading to the Ontario Ministry of Health and Long-term Care’s decision to start distributing the opioid antidote naloxone to inmates just prior to their release; this change should save dozens of lives each year.

**Improving accessibility and responsiveness of health care system**

Dr. Darrell Tan is exploring ways to make pre-exposure prophylaxis (PrEP) more widely available in Toronto to men who have sex with men (MSM) and who are also considered to be at high risk of contracting HIV by: disseminating information about PrEP to MSM and providing training and making PrEP available through family physicians and sexual health clinics run by Toronto Public Health (more information).

Dr. Ann Burchell is working with four Ontario clinics to see syphilis screening incorporated whenever men in HIV care undergo HIV viral load testing (more information), which typically occurs every three to six months. This intervention means that greater numbers of HIV-positive men may be screened for syphilis and more often, and that early treatment may be initiated in a greater number of cases.

Dr. Aisha Lofters and others have worked with range of community partners to increase understanding of barriers to breast, cervical and colorectal cancer screening for South Asian communities in Peel Region (more information), and propose solutions.

Dr. Navindra Persaud is leading the ‘CLEAN Med’ study to increase access to essential prescription medications at two Family Health Teams in Toronto and two in Northern Ontario. This study will compare the health outcomes and health care use of people who receive free medications to those who are under usual care, and use this information to advocate for better access to prescription medication for all.

**Improving Indigenous health**

Knowledge sharing and application by Well Living House (WLH) led by Dr. Janet Smylie and community partners (for example, Our Health Counts) contributed to:

- Successful proposal to see Seventh Generation Midwives (SGMT) act as the lead midwifery group for the Toronto Birth Centre. SGMT provides high quality maternity care to women and their families from Toronto, particularly those from the downtown area, and from Indigenous communities;
- 300% increase in funding for De dwa da dehs nye>s Aboriginal Health Access Centre (locations in Hamilton and Brantford);
- $11.6 million dollars of additional funding for Indigenous child programming in the City of Toronto by the Government of Ontario.

**Improving mobility of hospitalized seniors**

Dr. Sharon Straus, Dr. Julia Moore, and Dr. Barbara Liu from Sunnybrook Health Sciences Centre developed a tailored intervention to promote early mobilisation of hospitalised older
adults (MOVE ON). The MOVE ON study showed improved mobility and decreased length of stay; initially this initiative targeted 14 hospitals in Ontario and it has now spread to 63 Ontario hospitals as well as those in Alberta, Saskatchewan, the US, UK and Australia.

Informing national and international drug policy

The Ontario Drug Policy Research Network (ODPRN) led by Drs. Tara Gomes and Muhammad Mamdani has informed national and international drug policy over the past decade. Examples include:

- Research on the safe and effective prescribing of opioids established the prevalence and risks of high dose opioid prescribing and the potential impacts of formulary changes for long-acting oxycodone. This research influenced the development of Ontario’s Narcotics Safety and Awareness Act (2011), U.S. Food and Drug Administration (FDA) opioid labeling policies (2013), and Ontario’s Opioid Strategy (2017); and delisting of high strength opioids from the provincial formulary (2017).
- Research describing the clinical risks of thiazolidinediones played a major role in the delisting of these products in Ontario (2009/2010).
- An ODPRN Drug Class Review on hepatitis B medications led to recommendations for formulary modernization for this drug class. These proposed recommendations directly led to expanded coverage of these products on the Ontario public drug formulary (2018).
- Research published in 2009 and 2014 was directly used to drive a change to the listing status of blood glucose test strips in Ontario (2013) and BC (2014). Since this time, 6 additional provinces have implemented quantity limits, which are estimated to save over $50 million annually across Canada. Following this, the ODPRN published a statement confirming that this change led to no major changes in major clinical outcomes in this population.

Informing global health through innovation

- **BlueDot**

In 2013 Dr. Kamran Khan founded the social enterprise, BlueDot, a certified B corporation, with the mission of empowering government decision-makers and public health officials to prepare for inevitable future outbreaks of dangerous infectious diseases such as SARS, Ebola, and Zika. After just one year of incorporation BlueDot received a Series A investment from Horizons Ventures. Over the span of a few years, BlueDot quickly grew from three to 50 employees.

Its flagship innovation, *BioDiaspora*, is a first-of-its-kind web-based application that utilizes geographic information systems (GIS) technology to integrate, analyze, and visualize high-value, diverse data to help countries better prepare for and respond to dangerous global infectious disease threats.

Currently, *BioDiaspora* is in use in 12 countries and has supported time-sensitive risk assessments by the U.S. Centers for Disease Control and Prevention, the White House, and the World Health Organization. Moreover, *BioDiaspora* is in the process of being integrated with the government of Canada’s internal global epidemic intelligence system known as the Global Public Health Intelligence Network (GPHIN). This synergy between *BioDiaspora* and GPHIN will help to further strengthen Canada’s readiness against inevitable future global epidemic threats such as SARS.
For the unique insights generated during real-world outbreaks such as Ebola and Zika, Dr. Khan’s research has been covered by news organizations such as The New York Times (2013, 2016), BBC World, and The Economist.

- **The Million Death Study**

  The Million Death Study (MDS) led by Dr. Prabhat Jha has provided for the first time reasonably reliable age-specific, cause-specific death rates up to age 70 for the whole of India (the BBC, Slate Magazine, the Globe & Mail, The New York Times articles). It has also facilitated assessment of the effects of risk factors such as tobacco far more reliably than before. MDS will cover 23 million Indians by 2023 and will expand the MDS model to other countries, starting with Ethiopia and Mozambique.

  Dr. Prabhat Jha’s quantification of mortality from smoking in many countries has raised political support for tobacco control. He has developed new concepts of “smart taxes” which increase their impact by preventing downward substitution and tax and poverty analyses that established higher taxes as a powerful tool to reduce poverty from tobacco-attributable diseases. Dr. Jha worked closely with the Indian Minister of Health to ensure that the release of his 2008 NEJM paper was timed to support the Minister’s efforts to introduce prominent warning labels and to ban smoking in public places. Dr. Jha has worked with three Indian Ministers of Finance and four Ministers of Health to help raise cigarette taxes in the last few budgets, resulting in the difference between most and least expensive cigarette has narrowed from 4.1 to 1.6 fold, and that cigarette prices rose substantially from 2013 to 2017. Moreover, Dr. Jha has advised Bill Gates and several heads of state directly on tobacco and mortality measurement. Dr. Jha personally briefed the Prime Minister of Trinidad and Tobago in 2008 which led to prompt tobacco tax increases; actions that became an example to other governments in the region.

**Informing CIHR’s equity strategy**

The Knowledge Translation Program led by Dr. Sharon Straus has been leading gender equity initiatives at St. Michael’s Hospital and the University of Toronto. Their work has informed the development of an unconscious bias training module. This module is now part of required training for all CIHR and Canada Research Chair Program peer reviewers.

**Improving surgical safety and education through innovation**

Borrowing the concept of the black boxes in the airline industry, Dr. Grantcharov and his team developed a black box for the operating room (OR) that records nearly everything that happens in the OR, including video, audio, patient, device and environmental data. It’s currently used in minimally invasive surgery where video cameras are inserted through small incisions in the body, allowing the surgeon to see what’s going on inside the patient.

By analyzing the data, Dr. Grantcharov’s team can identify what errors occurred during surgery, why they occurred, and find ways to improve surgical safety and education. The team is also applying artificial intelligence to analyze the data from the black box and provide feedback to surgical teams. Dr. Grantcharov’s research program is leading several international studies to evaluate the impact of this platform on patient safety and clinical costs. They demonstrated that by using this approach surgical trainees can reduce errors in the operating room by 50%. The black box received significant media attention from both national and international outlets such
as CNN, Forbes, Washington Post, the Globe and Mail, CBC and CTV news, and the Toronto Star.

Increasing awareness of concussion and informing policies for injury prevention

Dr. Michael Cusimano, a neurosurgeon and clinical researcher, leads the Injury Prevention Research Office, a multidisciplinary team of highly qualified researchers who conduct research in areas including skull base surgery, hydrocephalus, quality of life and traumatic brain injury. For more than a decade, Dr. Cusimano’s research on traumatic brain injury has directed significant policy changes and contributed to raising the awareness of the causes and implications of concussion. For example, Dr. Cusimano’s findings have been implemented by policy makers to change sport practices, including new rules for bodychecking in youth ice hockey and a ban on hits to player’s heads in the professional and elite levels, as well as changes in school-level concussion management, including the Ontario Ministry of Education’s mandate to all school boards in Ontario to develop and implement by January 30, 2015. He has also developed collaborations with the Toronto Catholic District School Board and the Toronto District School Board and has presented injury prevention and concussion-related presentations at their respective schools. These school boards are now adopting standard guidelines to respond to students who have sustained brain injuries, which stems in part from Dr. Cusimano’s CIHR-funded research results. Moreover, his work is often cited by Toronto Public Health and has led to important policy decisions and recommendations to increase awareness and cycling safety.

Dr. Cusimano hosts an annual “Heads Up” Conference as a means to generate discussion amongst parents, athletes, teachers, coaches, healthcare providers, public health workers, and researchers about the prevention, diagnosis, and treatment of head injuries. His work has been covered in numerous newspaper, radio and TV interviews with outlets such as the Globe and Mail, Toronto Star, the New York Times, Sports Illustrated, all national Canadian TV channels, CBS sports, BBC and many others.

Innovating life support ventilators to help the patient recover better with minimal discomfort

Drs. Jennifer Beck and Christer Sinderby at Critical Illness and Injury Research Centre (CIIRC) have developed a ventilation approach that uses the brain’s signal to the diaphragm to determine how much air is needed each breath and how frequently to deliver air to the patient. With this approach, timing and assist delivered by the ventilator is synchronized with the patient’s own respiratory drive (measured by the electrical activity of the patient’s diaphragm), so it increases patient comfort and reduces sedation while promoting lung protective spontaneous breathing, and helps the critically ill patient wean off the ventilator earlier. Drs. Beck and Sinderby named the approach Neurally Adjusted Ventilatory Assist, or NAVA and are co-inventors on 26 patents thus far, addressing the needs of patients of all ages ranging from premature babies to adults. This technology has been licensed to Maquet, a Swedish company that manufactures and markets ventilators using NAVA. The NAVA approach has been proven effective in numerous peer reviewed studies and is used around the world.

Spin-off companies

Trillium Therapeutics Inc.
Trillium Therapeutics is an immuno-oncology company publicly listed in NASDAQ/TSX (TRIL) in 2013 and dedicated to the discovery and development of novel and innovative cancer therapies.
**Matrizyme Pharma**
Matrizyme Pharma is developing innovative therapeutics in the area of interventional cardiology, enabling patients to treat their coronary chronic total occlusions (CTOs). The company has successfully completed Phase I trial in 2011 and Phase II in 2016.

**Bluedot**
Stemmed from Dr. Kamran Khan’s scientific research program, BioDiaspora was incorporated as a Certified B Corporation in 2013 with support from MaRS Innovation and St. Michael's Hospital. The company received investment from Horizons Ventures and was renamed to BlueDot in 2014. It analyzes big data to study how infectious diseases can spread worldwide.

**Translatum Medicus Inc.**
Translatum Medicus Inc. (TMI) founded by Dr. Shelley Boyd, an ophthalmologist and clinician-scientist, provides therapeutics for Age-Related Macular Degeneration (AMD) which is the leading cause of irreversible blindness in the developed world. TMI is dedicated to saving eyesight with a first-in-class immunomodulator therapy for patients with dry AMD that currently has no treatment.

**CCOA Therapeutics Inc.**
Dr. Heyu Ni founded a spinoff company CCOA Therapeutics in 2016, which is dedicated to antibody engineering and antibody-based drug development targeting thrombotic diseases, bleeding disorders and potentially cancers.

**MIMOSA Diagnostics Inc.**
The company co-founded in 2016 by Dr. Karen Cross, a surgeon-scientist, and Dr. General Leung, a physicist, is currently developing a novel handheld optical technology called the MIMOSA (Multispectral Mobile Tissue Assessment Device) for early detection of diabetic foot ulcer which is a leading cause of non-traumatic lower limb amputation. Attached to a smartphone, the device allows a user to photograph the skin with near-infrared light and detects poor blood circulation in the feet, which can lead to diabetic foot ulcers.

**Tracery Ophthalmics Inc.**
Tracery, another company founded by Dr. Shelley Boyd, is a clinical stage ophthalmic imaging & health data analytics company specializing in Precision Medicine and Customized Clinical Trial design, currently focused on Age-Related Macular Degeneration (AMD). Tracery offers new image-based biomarkers (IBB) using their own novel technology, and incorporating patients’ personal health data (from health records, genetic analysis and more), it enables personalized drug development and design based on a patient’s IBBs.

**Surgical Safety Technologies Inc. (SST)**
SST was founded in 2017 by Dr. Teodor Grantcharov who developed the Operating Room Black Box® (see page 33). Its mission is to improve clinical outcomes by the development of technology and processes for rigorous analysis of perioperative factors. Based on a better understanding of human, technological and system performance, SST wants to create a base for better medical education, instrument design and process improvement to enhance patient safety.
Fibrocor Therapeutics LP
Fibrocor co-founded by Drs. Richard Gilbert and Darren Yuen, clinician-scientists at St. Michael's and Dr. Jeff Wrana at Sinai Health System, is focused on developing first-in-class therapeutics targeting fibrotic diseases. The company was launched in 2017 with CDN $2.8 million financing, including funds from MaRS Innovation. Evotec will provide all drug discovery activities. Fibrocor uses a state of the art genomics platform and a 20 year biobank repository to identify new fibrotic targets that are linked to specific clinical populations that suffer from fibrosis.

ZebraPeutics Inc.
ZebraPeutics is a spin-off company from the Zebrafish Centre for Advanced Drug Discovery (ZCADD) founded by Dr. Xiao-Yan Wen for preclinical drug development and services in generating transgenic and mutant zebrafish lines. It has recently secured seed funding from an angel investor to support early drug discovery initiatives.

12. Challenges & Mitigation Strategies

In the near term, the Research enterprise will face some challenges (both internal and external). We have mitigation strategies for many of these, while others will need additional consideration and planning.

Sustainability: The Internal and External Funding Environment
There are two major challenges with respect to funding. The first is the funding to run the research enterprise. Currently, the research operation’s budget is ~$13 million. This money supports scientist salaries/stipends, core research facilities, maintenance/replacement of equipment, research administration (contracts, financial accounting, legal, HR, insurance, research training centre etc.) and leases on properties required to house research personnel outside of SMH/LKSFI. The network receives funding from various sources to support research operations. These sources include funds from hospital’s core budget of approx. $5M (which has not grown over last 5 years), overhead received from grants and industry contracts, and interest income.

A major contributor to the deficit is the ongoing need to lease space (see below). We currently lease about 55,000 sqft of office space (193 Yonge Street and 250 Yonge Street) which costs about $1.6M per year. This represents the annual cash flow deficit of Research, on a budget of about $13M. To date the shortfall has been taken from Research reserves, but this cannot continue indefinitely.

This problem is in part a consequence of the research funding model in Canada. For example, the level of “indirect” funding from the federal (and provincial) grants is far below that available in other countries (e.g. the NIH provides from 55-90% indirect funding while CIHR only provides 17%) and our ability to adequately support research operations with minimal indirect funds has proven to be a major challenge. Our researchers have been very successful at garnering CIHR awards and funding but the eligibility of expenses on these grants, which does not include provision for scientists’ salaries, presents the institute (and indeed all Canadian research institutes) with significant funding challenges. Some of the other GTA research hospitals have overcome this deficit through sizeable funds raised through parking lot or lottery revenues. Research sustainability poses several risks to the hospital:
- Lack of support for Research could lead to the loss of world class talent to other research intensive hospitals. This applies not only to pure researchers but also to clinicians who have major research interests.
- Many of our clinician-leaders (e.g., Sharon Straus, Andrew Baker, Ori Rotstein, Laurent Brochard) are scientists and work at St. Michael's Hospital because it is a research-intense institution.
- A major contraction in Research will make it more difficult to attract talent at all levels to St. Michael's Hospital.
- Abandoning research projects due to lack of support and the potential for closing out clinical studies would have severe implications on existing research subjects

Over the last few years, a number of initiatives have been undertaken aimed at addressing our sustainability issues:

i) Dedicated pre-award grant support: the VP Research office established this function in 2013, supporting researchers in identifying funding opportunities and putting together competitive grant applications; data analyzed to date, shows that our overall success rates in programs like the CIHR Foundation, Early Researcher Awards, etc. have been well above average, which is almost certainly due to the work by the superb Pre-Award team (Dr. Erica Conte, Dr. Yunjo Lee and Samar Saneinejad)

ii) Cost recovery strategies: we have increased clinical trial overhead to 35%, core facility recovery charges were increased by 1%, our Research Ethics Board fees have been increased and we have developed, and are continuing to develop, commercial opportunities (e.g. spin-offs, and ancillary revenues such as MRI and the eye tissue bank). As stated above we now have equity in a number of companies. Realization of income from these sources will take time, and of course is not guaranteed.

iii) The Research Advancement Fund (RAF) was established in collaboration with the St. Michael's Foundation in 2016 to support research operations. This was based on common practice among Foundations of academic hospitals

iv) Research Innovation Council and Angels Den: as described in Section 8B, these initiatives in collaboration with the Foundation have provided significant directly support research programs and operations

v) Research holdings were moved to higher interest bearing accounts to provide greater returns to Research

vi) A broader institutional based approach to the use of Infrastructure Operating Funds (IOF) has helped alleviate operational costs.

vii) We have completed a number of LEAN projects in the Vivarium and are now starting to apply LEAN techniques in the Office of Research Administration.

The second challenge is the difficulty in obtaining external grants in the current funding environment which has impacted researchers across the country. An Advisory Panel led by Dr. David Naylor was commissioned by the Federal Government in 2017 to review the federal system of supports for extramural research (including all peer-reviewed funding programs). The panel found that federal granting council funding per researcher has been in steady decline since 2008-09. The years from 2006-07 to 2013-14 also saw a shift in funding away from independent research, be it basic or applied, that allows individuals or teams to define their topics and/or the structure of the research collaboration. The panel estimated that scientists wishing to pursue independent research work saw a decline of available real resources per researcher of about 35% during this period.
We have been fortunate that our tri-council funding has increased substantially over the last 10 years. Since fiscal 2006-2007 our CIHR funding within the Faculty of Medicine has increased 77%, the largest increase of the TAHSN hospital. Nonetheless, our researchers have felt a great deal of pressure and have had to carefully consider their programs’ growth due to increased competition and low success rates at agencies like CIHR and NSERC. It has not been uncommon to see competition success rates below 15% at CIHR over the last few years. The “funding reform” that took place a few years ago, created programs that are more targeted vs. open (e.g. the CIHR Foundation program). Several salary award programs (e.g. the CIHR New Investigator Award) have been disbanded, hence putting increased pressure on institutions.

Space
As discussed in Section 6B, research space has grown ~25% since 2012 and the demands for growth continue as research programs continue to be successful and obtain funding to grow and hire students and staff, and new programs and centres are established. Our Facilities team has analyzed our growth based on historical figures (last ~5 years) and projected our future needs. If we continue on our current growth trajectory, we anticipate needing one additional wet bench floor and three additional dry bench floors over 10 years – equaling an additional ~80,000 sqft (if we use 2018 rental costs, means an additional $2.8 million in rent annually). A detailed Research Growth and Master Plan study which was commissioned and was recently completed to provide more detailed insight into these space issues.

The inability to grow our programs poses several risks:

i) Potential loss of top talent: Researchers apply for grants in order to support and grow their programs; without the ability to house staff/students, we risk losing our top talent

ii) Inability to recruit: Several of our centres/programs are relatively new (e.g. International Centre for Surgical Safety) and as part of their strategic planning, have plans to recruit more scientists and staff; a lack of space will hinder their ability to recruit. Our established programs such as the Knowledge Translation Program have been successful in receiving funding via grants/contracts and they are looking to recruit more staff/students but are hindered due to lack of space onsite at the LKSKI.

It is interesting to note that the space challenges and the financial shortfall are interlinked. Without the addition of new owned space any growth must be accommodated in additional leased properties. Although it is possible that some programs could be relocated to unused space within the network (largely Providence), it is more likely that this unused space will be used to create new research opportunities that better fit the priorities and interests within those sites.

Retention and Recruitment of Talent

A critical component of our research enterprise is the cohort of superb individuals. We have very special technicians, administrative personnel, and scientists who largely have a very collaborative culture, and make the research environment such a success. To date we have been able to recruit world class scientists even though our pay scales and our start-up packages are not as high as other sister institutions in Toronto and our space constraints make it difficult to find adequate space for our research personnel. One major reason we have been able to attract such great people despite these challenges is the collaborative culture that exists in the LKSKI and KRC. This has largely been based on our recruitment strategy which has to been to recruit for the smartest researchers, but then to hire based on personality, from this
cohort. However, the ability of this “culture advantage” to attract superb individuals has its limits. There is a concern that if the sustainability and space issues discussed above are not adequately addressed, we will have trouble retaining and recruiting the best talent in the future.

13. Opportunities Going Forward

A. NETWORK-WIDE RESEARCH OPPORTUNITIES

In our first year as Unity Health Toronto, an integrated network with St. Joseph’s Health Centre and Providence Healthcare, we have begun to consolidate and streamline some of the processes and policies that impact research. For example, the Research Ethics Boards at the three sites have now been consolidated into one Board and the administrative functions are now coordinated by one centralized office. The Office of Research Administration is leading the work on streamlining other key processes (e.g., research contracts, research job descriptions, research policies etc.) and developing procedures and infrastructure for onboarding research volunteers and visitors at St. Joseph’s. In collaboration with the privacy department, the ORA are looking to provide registered research personnel controlled and appropriate access to Sunrise (electronic health records system at St. Joseph’s) for approved research studies.

While the bulk of research within the Network is done at St. Michael’s, a recent exercise to capture an inventory of research across all sites, showed that there is physician-led clinical research activity at St. Joseph’s (e.g., oncology, cardiology, critical care/ICU & family medicine) and health discipline led research activity with a patient-centered approach at Providence. Consultations with both sites have shown that there is significant interest from both to participate and engage in research. In fact, late last year (November 23, 2017), Dr. Arthur Slutsky visited St. Joseph’s Health Centre and presented an overview of research at St. Michael’s Hospital and later in April and June, representatives from the Applied Health Research Centre and the Funding & Awards and Commercialization Teams at St. Michael’s, visited St. Joseph’s and presented an overview of the resources/support available to researchers. Currently there are discussions taking place to introduce the research lead at Providence to the Director of Interprofessional Practice Based Research from St. Michael’s (a new program that has been under development for the last year). There are certainly opportunities in the near term, for further engagement with those interested in Research at both sites.

Our staff and researchers across Unity Health Toronto will learn and benefit from established best practices in research methods and access to internationally renowned scientists whose research focuses on our unique patient populations. At this early stage of our integration, the area where we see the biggest opportunity for network-wide research activities is clinical research. With two additional sites, our unique patient populations have increased and the potential for research to span the continuum of care as never been greater. For example the Chief of the ICU at St. Joseph’s is exploring new research opportunities with the critical care research group from St. Michael’s. Other discussions are taking place in Oncology and Pediatrics across the Network. The Director of the St. Michael’s Neuroscience Program has also started conversations with Providence to explore enrolling patients in clinical research. The Office of Research Administration is reviewing the research appointments policy to determine how researchers (both physicians and health disciplines) from across the network could be appointed to our research institute. These appointments and external profiles will lead to identifying further collaboration opportunities across the network.
B. Big Data Opportunities

**LKS-CHART:** The LKS-CHART has worked with IT, administration and clinical programs since 2016 to develop an enterprise data warehouse at St. Michael’s Hospital. It has also secured leading data analytical tools, and assembled a team of high quality data scientists to enable advanced analytics such as multivariable regression modeling, simulation modeling, optimization, cluster analysis, forecasting, and machine learning. The goals are to: 1) work with hospital administration at St. Michael’s on high-priority initiatives to inform decision-making, 2) work with clinical leadership at St. Michael’s to inform optimal clinical practice, 3) work with researchers to collaboratively conduct research that will contribute to the efficiency of hospital operations, advance patient care in a meaningful manner, and advance healthcare analytics research methodology, and 4) provide mentorship to trainees interested in healthcare analytics.

The Centre has seen tremendous growth in activity over the past year. The Centre’s team is engaged in more than a dozen ongoing projects and there is increasing interest from clinicians and administrators to collaborate on new projects. Projects include forecasting emergency department patient volumes to assist with staffing decisions and predicting patient deterioration in general internal medicine units using machine learning to prevent transfer to the ICU and mortality. The developed solutions are being implemented to enhance management and clinical decision-making. Evaluations of impact are part of this process. There is significant opportunity to grow LKS-CHART’s activities within the hospital but also to the entire Network and beyond. Discussions are currently under way to determine the best strategy to scale up LKS-CHART’s activities and explore ways in which the hospital could monetize some of the novel tools that are being developed in the Centre. There is already interest from external organizations in utilizing some of the tools to improve decision making within their organizations. LKS-CHART’s future path looks bright and it will be important to ensure its growth is sustainable and that the right partnerships and collaborations are established to enhance and further the Centre’s mission.

**The AHRC:** In collaboration with St. Michael’s CardioLink Program, the AHRC received a Canada Foundation for Innovation Infrastructure grant to procure a new state-of-the-art electronic data capture system. Now implemented at the AHRC, eSOCDAT™ will provide first-in-class infrastructure to support big data initiatives, including scientific registries and pragmatic trials. One key project that this infrastructure supports is TARGet Kids! (The Applied Research Group for Kids) - a collaboration between child health researchers and primary care doctors, which enrolls healthy children age 0-5 years from 14 sites in the General Toronto Area and Montreal (over 9000 patients to date). The AHRC is the data coordination centre for TARGet Kids!, providing data management and analytic support. The infrastructure is also supporting another project, a CIHR-funded pragmatic parallel group diabetes cluster trial that is being coordinated at the AHRC. The objective of the trial is to compare the multi-faceted intervention plus usual care with usual care alone for Type 1 diabetes.

Through the acquisition of the Resuscitation Repository & Research (R3) team, the AHRC has grown into the pre-hospital emergency service space and has started working with emergency responders to develop and evaluate processes of care and timely interventions. Our goal is to improve outcomes for patients suffering life threatening trauma and cardiac emergencies in the out-of-hospital setting. By providing feedback to emergency responders, the AHRC aims to provide the tools required to improve patient care. Our R3 team will be key in developing the next generation of a quality assurance and research registry in out-of-hospital resuscitation, and initiate major registry-based clinical trials.
**GEMINI:** The General Medicine Inpatient Initiative (GEMINI) study is a retrospective cohort study involving 7 large hospital sites at 5 University of Toronto affiliated health care organizations. GEMINI has developed infrastructure and methods to extract and standardize electronic clinical data from hospital IT systems (laboratory, imaging, pharmacy, etc.) at St. Michael’s, Toronto General, Toronto Western, Sinai Health System, Credit Valley and Mississauga Trillium Hospitals, and Sunnybrook Health Sciences Centre. The first functional dataset from this work was operational in 2017 and contains data on 270,000 hospitalizations between 2010 and 2017. GEMINI data has become a rich research resource, with 4 published papers in the year since the data became available, with many additional papers under review or nearing submission. GEMINI has been supported by more than 20 sources (grants, non-profit foundations and in-kind donations), ~$1 million and has supported the work of 30 co-investigators and more than 25 research trainees. The dataset contains more than 500 million data-points with sufficient sample size and depth to fully harness AI based analytics. Data-sharing agreements with each institution include ongoing updates of data, and linkage of GEMINI to the Institute of Clinical and Evaluative Sciences (ICES) to allow study of out of hospital outcomes and resource utilization are underway.

**General Medicine Quality Improvement Network (GeMQIN) – a Collaboration with Health Quality Ontario:** Through support from Health Quality Ontario, GEMINI data extraction methods are being extended to the 30 largest hospitals in Ontario to create a data backbone for a provincial quality improvement network called GeMQIN. The planned budget for this expansion is approximately $4 million and when completed will form one of the largest data-driven quality improvement networks in the world.

C. **Promoting Innovation across Unity Health Toronto**

In addition to network-wide research opportunities, we have also begun to explore ways to promote overall innovation across the Network. For example, the work of the Biomedical Zone in incubating and supporting start-up companies and promoting innovation within the healthcare setting, could be expanded. Early discussions are taking place to determine whether there is interest in expanding the Zone’s activities across the other sites. This would enable clinicians and staff at St. Joseph’s and Providence, to participate in the zone’s numerous initiatives, thereby encouraging and promoting innovation across the entire network. Initial site visits have taken place but further discussions are needed to determine next steps.

D. **Establishment of an Institutional Biobank**

In 2016 a biobanking committee and an internal scan of the current biobanking activities across the institution was initiated. The scan revealed that there are 10 different groups actively biobanking or in the process of setting up an individual biobank. Some of these groups have secured funding, such as the Neuroscience Biobank that was supported through the Labatt Foundation, others have obtained infrastructure, such as the Kidney Biobank that had successfully obtained a John Evans Leadership Fund award through Canada Foundation for Innovation. The Eye Biobank led by Drs. Yeni Yucel and Neeru Gupta is well established and independent, while the Hematology Biobank led by Dr. Michelle Sholzberg is at the early stages of development.

Through committee discussions, it became clear that there is a general interest to combine efforts and create a centralized, institutional biobank that could benefit all parties. This
institutional biobank would provide additional infrastructure, standard operating procedures, and centralized coordination of activities. In early 2018 it was confirmed that the coordination of the biobank should be done in collaboration with the Department of Laboratory Medicine and that the Biobank Manager would report to the Chief of Lab Medicine, as well as the VP, Research. The position of Biobank Manager has been approved and will likely be filled in early 2019. This Manager will have a three year mandate to establish an institutional biobank with the hope of synergizing efforts and providing more effective and efficient support for our translational scientists.

E. EQUITY, DIVERSITY AND INCLUSION

Over the last 2 years, Research has established guidelines around gender equity within the research enterprise. The need for these guidelines came about as a result of a study done by Dr. Sharon Straus, looking at gender disparity within the Department of Medicine at the University of Toronto, as well as within Research specifically at St. Michael’s Hospital (the latter commissioned by the Research Leadership at St. Michael’s). The study found that there is gender inequity within Research (at the Scientist level – Appendix 14). Since then, there have been specific guidelines implemented to ensure that search committees have appropriate gender representation, and that specific procedures are followed to minimize unconscious bias when recruiting Scientists. There are also specific guidelines to encourage equal committee representation, visiting speaker invites, leadership opportunities etc.

There is also a major initiative within the federal (and to some degree provincial) funding agencies to ensure there is equity, diversity and inclusion (beyond simply gender) in all activities that fall within their mandate (including disbursement of funding and awards). All research organizations must comply with new policies and procedures set forth by these agencies (see for example, the Canada Research Chairs Equity, Diversity, and Inclusion Action Plan). It is important for our hospital and network to ensure we are compliant in order to remain competitive within already tough funding environment.

Across Unity Health Toronto, we have an opportunity to expand our gender equity initiatives to include and address any possible inequities within other underrepresented groups including visible minorities, racialized persons/persons of colour, indigenous people and members of sexual minority groups. We have begun discussions at the Hospital and Network levels, to determine next steps, specifically in how we can collect existing data across our sites. Without data, it will be challenging to design appropriate initiatives to tackle potential inequities. Research is fully committed to developing an equity, diversity and inclusion action plan and is eager to participate as a partner in a potential network-wide initiative.
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