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Dear Colleagues,

The shared vision for Health Services Research (HSR) in the SingHealth Duke-NUS Academic Medical Centre is to improve the health of Singapore, and the region, through HSR driving excellence in population health.

The SingHealth Health Services Research Centre contributes to this vision by providing expertise in various areas of HSR and analytics support for SingHealth institutions, working closely with colleagues in Duke-NUS through the joint Health Services Research Institute. In 2016, these contributions have included our inaugural Analytics and Research Technologies (ARTs) grant call, as well as ongoing work with the Health Engagement and Action Labs (HEALs). We have also embarked on a number of collaborations, working closely with both our internal and external partners.

This report summarizes the work which has been done by HSRC in 2016, and provides readers with an overview of the breadth of work in HSR in SingHealth. I hope it would also serve as a springboard for interaction and possible collaborations in HSR in SingHealth and Duke-NUS.

As we move forward into 2017, there are many opportunities for progress and challenges to be overcome to develop these opportunities. In this regard, I would like to thank my colleagues in HSRC and our partners from SingHealth, Duke-NUS and elsewhere for their hard work, passion and contributions to improving the health of Singapore and the region through HSR in 2016 and in the years ahead!

Prof Julian Thumboo
Director, SingHealth HSRC

“The SingHealth Health Services Research Centre contributes to this vision by providing expertise in various areas of HSR and analytics support for SingHealth institutions.”

SingHealth Health Services Research Centre

Health Services Research (HSR) is a multi-disciplinary field of scientific investigation, consisting of both basic and applied sciences, that aims to identify the most effective ways to organize, manage, finance, and deliver high quality care in order to optimize population health, service costs, and satisfaction of patients and providers. This field draws from many disciplines to address the breadth of research, including biostatistics, epidemiology, decision sciences, health economics, medicine, nursing, operations research, psychology and medical sociology.

The SingHealth Duke-NUS Academic Medical Centre (AMC) has built significant capabilities in HSR in the last decade. In 2008, Duke-NUS Medical School established its Signature Research Program in Health Services and Systems Research (HSSR). Several HSR initiatives have also been developed in SingHealth institutions, examples of which are Health Services Research Unit in SERI and the Health Services Research and Biostatistics Unit in the Singapore General Hospital.

In 2015, SingHealth established the SingHealth HSRC to coordinate and synergize existing HSR capabilities across various SingHealth institutions. The Health Services Research Institute (HSRI) was also set up as a functional bridge between HSR researchers at SingHealth and Duke-NUS Medical School. The goal of HSRI is to maximize the quality, efficiency, and utility of HSR across the AMC through a shared vision, mission, and guiding principles. Operationally, these initiatives will help to simplify and promote collaborations across the AMC towards the achievement of scientific, clinical and operational excellence for the improvement of patient outcomes.
Our Team

The current HSRC team is led by the Director, and two Heads (Analytics and Resource Cores). It currently comprises of a team of Data Scientists, Analysts and Project Managers supported by an administrative team.

HSRC Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
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<tbody>
<tr>
<td>Prof Julian Thumboo</td>
<td>Director, HSRC</td>
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<tr>
<td>Prof Ecosse Lamoureux</td>
<td>Head, Resource Core</td>
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<tr>
<td>A/Prof Marcus Ong Eng Hock</td>
<td>Head, Data Analytics Core</td>
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<tr>
<td>Dr Sean Lam</td>
<td>Senior Manager, Analytics</td>
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<tr>
<td>Dr Liu Nan</td>
<td>Principal Research Scientist</td>
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<tr>
<td>Dr Jing Xuan</td>
<td>Data Specialist</td>
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<tr>
<td>Brendon Lyn</td>
<td>HSR Project Manager</td>
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<tr>
<td>Francis Nguyen</td>
<td>Analyst</td>
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<tr>
<td>Wu Jun Tian</td>
<td>Analyst</td>
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<tr>
<td>Ang Boon Yew</td>
<td>Executive</td>
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<tr>
<td>Ms Eileen Aw Kah Chin</td>
<td>Admin Associate</td>
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<td>Ms Nurfaezah Binte Ramli</td>
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Our Milestones & Achievements

Analytics and Research Technology for SingHealth (ARTS) Call-for-proposals *

10 projects selected under the ARTS Call were successfully initiated and are expected to be completed in 2017.

Health Engagement and Action Labs (HEALs) *

5 HEALs projects were successfully initiated and are currently under active development.

HSRI 5-Year Strategic Plan *

A HSR Retreat was held in May 2016 and a Strategic 5-Year Plan was developed.

HSRC Internship Symposium

The HSRC Internship Symposium was successfully held in August 2016. It showcased the work done by the 11 interns in 2016.

DEDUCES Pilot *

A successful demonstration of the DEDUCES pilot system in the SingHealth HSRC was completed.

25 Publications and Proceedings

More than 25 journal articles and conference proceedings in various international and local conferences.

3 Research Awards

SingHealth Duke-NUS Research Appreciation Awards; SingHealth Publish! Award, Medical Research; INFORMS Healthcare Conference, First Prize (USA)

5 Grants Awarded

5 grants for various collaborations (e.g., SingHealth Foundation, SCRI and MOH Healthpass)

* In collaboration with Duke-NUS
Analytics & Research Technologies Call

The Analytics and Research Technologies (ARTS) Call is a yearly call for projects which require analytical support. This is a joint SingHealth Duke-NUS initiative fronted by the HSRC Analytics team. The Call supports collaborative research projects with emphasis on analytics, data mining, data management, and data exploration to improve patient care and cost-efficiency of the healthcare system.

In April 2016, the inaugural Analytics and Research Technologies for SingHealth (ARTS) call-for-proposal was launched to promote the useful application of data and analytics to solve health services challenges. The ARTS call for proposal will be held every year. Selected projects would receive data science and analytics support from the team, as well as support in the use of advanced analytics software, health services research methodologies and the deployment of electronic data capture systems.

The project selection is based on 3 major criteria:

- **Health/Economic Impact**
  - Clinical Significance (benefit to patient/clinical outcomes)
  - Aligned with organisational priority by senior leadership
  - Potential for wider practical impact

- **Scientific Impact**
  - Scientific merit and significance
  - Quality of Methodology
  - Likelihood of project getting competitive grant

- **Project Feasibility and Sustainability**
  - Capability of team to complete the project
  - Robustness/completeness of Time/Budget estimates
  - Feasibility of actual implementation within 2 years
  - Collaboration opportunities and funding sources

**ARTS Grant Call Process**

In the last call, more than 30 project submissions across all SingHealth Institutions were received and 10 projects were shortlisted. Another ARTS Call for Proposals will be launched in Feb/Mar 2017. Once this has been announced, PIs from the various institutions will have the opportunity to submit their proposals for analytical support. The proposals will then be reviewed based on the evaluation criteria. Successful applicants will be notified and these projects will be initiated.

<table>
<thead>
<tr>
<th>Institution / Department</th>
<th>Project Title</th>
<th>PI</th>
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<tbody>
<tr>
<td>NCCS Medical Oncology</td>
<td>Circulating Markers in Colorectal Cancer [A Subproject Within the POLARIS Program]</td>
<td>Dr Iain Tan</td>
</tr>
<tr>
<td>Duke-NUS Precision Medicine</td>
<td>Real-time Flagging of PRISM Study Participants in the SingHealth Clinical Environment via eHintS</td>
<td>Prof Patrick Tan</td>
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<tr>
<td>KKH Anaesthesia</td>
<td>Integrated Drug Delivery Systems and Smart Patient Analytics to Improve Patient Healthcare Outcomes and Patient Safety by Developing Cost-Effective Healthcare Clinical Pathways</td>
<td>Dr Sng Ban Leong</td>
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<tr>
<td>HEAL/SHP Pasir Ris Polyclinic</td>
<td>Determinants of the Prevalence and Treatment of Chronic Kidney Disease in the SingHealth Polyclinics</td>
<td>Dr Jasmine Lew</td>
</tr>
<tr>
<td>KKH O&amp;G/ OBGYN ACP</td>
<td>Transforming Gestational Diabetes Mellitus (GDM) Postnatal Management with Data Analytics</td>
<td>Prof Tan Kok Hian</td>
</tr>
<tr>
<td>SGH Rheumatology &amp; Immunology</td>
<td>Using Electronic Health Records and Multi-dimensional Patient Similarity Analytics to Select Optimal Therapy for Patients with Rheumatoid Arthritis</td>
<td>Dr Ng Chin Teck</td>
</tr>
<tr>
<td>SGH Emergency Medicine</td>
<td>To Forecast Short-term Bed Occupancy in SGH and Have an Interactive Dashboard of Current Bed Situation</td>
<td>A/Prof Marcus Ong</td>
</tr>
<tr>
<td>HEAL/SGH Family Medicine</td>
<td>Derivation and Validation of a Real-time Risk Predictive Model for Elderly Frequent Admitters Using Advanced Machine Learning Techniques</td>
<td>Dr Low Lian Leng</td>
</tr>
<tr>
<td>SGH/KKH General Surgery</td>
<td>Improvement of OT Listing and Scheduling System Using Retrospective Data</td>
<td>Dr Wong Ting Hway</td>
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The project “Determinants of the Prevalence and Treatment of Chronic Kidney Disease in the SingHealth Polyclinics” is a retrospective study. It aims to evaluate the determinants of prevalence and treatment of chronic kidney disease (CKD) in SingHealth Polyclinics cluster of patients. It’s hypothesised that amongst patients who have sought care at SingHealth polyclinics over the 4-year study period, the prevalence of CKD, failure by physicians to detect CKD, appropriate management of CKD and referral to nephrologist are independent of (not associated with) known socio-demographic and clinical factors.

Another project “Developing a Simple Segmentation Tool to Understand Elderly Health Status and Needs in Singapore” is a prospective cohort study. The aim for this project is to assess a novel Simple Segmenting Tool (SST) as a method of patient population segmentation in terms of its inter-rater reliability, as well as convergent and predictive validity. This study will provide evidence supporting the use of a standardized tool for evaluating the medical and social needs of patients at various sites. Following which, tailored packages of healthcare services can then be delivered in order to meet these needs.

200 participants were recruited as of 14 June 2016. These participants have completed the third and sixth month follow-up assessments in December 2016. Initial results from this study support the validity of the SST.
HSR 5-Year Strategic Plan

The inaugural SingHealth Duke-NUS Health Services Research Retreat on “Building Partnerships in Health Services Research to Improve Outcomes” was held on 10 May 2016 at The Academia. More than 70 participants comprising of senior leaders, members of the Health Services Research Institute and SingHealth HSRC Joint Steering Committee, ACP chairs and vice-chairs of research, researchers, research support, administrative, clinical and operational staff from SingHealth and Duke-NUS attended this retreat. Following the retreat, the HSR 5-Year Strategic Plan was successfully developed.

The HSR 5-Year Strategic Plan highlights the following areas:

• Where do we want to be in 5 years?
• How do we get there?
• What are potential enablers and obstacles?

The key areas of focus identified in the Strategic Plan are:

• Developing, retaining and mentoring a pool of interdisciplinary and high caliber researchers and leaders in HSU
• Communicating clearly on the structure of coordination and support for HSR activities in the AMC
• Fostering a research culture within the AMC
• Developing a sustainable funding model for HSR
• Establishing collaborations and partnerships
• Providing opportunities for interaction between HSR Researchers and other researchers
• Development of a strong research analytics infrastructure to support HSR

For detailed information regarding the 5-year plan, please email Ms Eileen Aw (eileen.aw.k.c@singhealth.com.sg)

Internship Symposium

In 2016, 11 full-time interns from various institutions such as the National University of Singapore (NUS), Nanyang Technological University (NTU) and Singapore Management University (SMU) joined HSRC and embarked on several analytics projects, providing invaluable support, insights and learning opportunities for everyone.

“Before coming for this internship I felt daunted as I did not have any experience in data analytics. However, this internship has made me learnt that work is not simply about having technical skills but also soft skills such as communication and building good relationships with others in the workplace.”

Hans Chan, Year 3 NUS Industrial and Systems Engineering

“I was able to make use of my knowledge and apply it in a real organisation. I was able to see the fruits of my efforts as a result of the work I put into my calculations. This has ignited my interest in data analytics and I hope to work in relevant fields in the future.”

Ms Donna Goh, Year 3 NTU Mathematical Sciences, Statistics

“Over the past few months I have gained lots of hands-on experience on developing predictive models to support clinicians in improving patient outcomes. I believe that the HSRC internship was really successful in furthering my knowledge of a career in the field of healthcare analytics. I really appreciate this internship opportunity from HSRC.”

Dr Jing Xuan, NUS MSc in Business Analytics
* Dr Jing joined HSRC after graduation
Selected Collaborations

NHCS-Holmusk Collaboration-HSRC  holmusk

This longitudinal data analytics project aims to examine the long-term cost of care and outcomes of patients presenting with coronary artery disease (CAD) (including stable angina, acute coronary syndromes, and myocardial infarctions), congestive heart failure (CHF) or atrial fibrillation (AF).

This collaboration aims to provide insights into research questions, as well as tools to interpret or explain these findings. Predictive models in order to estimate the risks of important clinical and quality outcomes in patients with CAD/CHF, as well as future cost of care for a particular patient will be developed.

BMU Performance Monitoring System

The Bed Management Unit (BMU) in the Singapore General Hospital (SGH) manages the daily inpatient flows through the hospital. In recent years, bed occupancy rates (BOR) has been fluctuating between 80% to the high 90%. Apart from the BOR, waiting time of patients and the number of bed transfers are also important to monitor. Due to the mission-critical nature of the processes, many other important indicators are required for routine reporting.

In this project, a predictive model for the BOR was developed and incorporated into a comprehensive Tableau dashboard which contains all pertinent operational indicators. This dashboard has been implemented in actual operations by the BMU.

Duke Enterprise Data Unified Content Explorer for SingHealth Pilot (DEDUCES)

DEDUCES is a flagship HSR Analytics collaboration between SingHealth, Duke University (Durham) and Duke–NUS. It is envisioned to be a cluster wide system, which allows researchers to query SingHealth databases. It is a data discovery tool that is web-based, and can be deployed through the intranet for the querying of databases to identify patient cohorts suitable for research studies.

HSRC invited the Duke University DEDUCE team to set up the pilot implementation of DEDUCES in the Access Restricted Cluster (ARC) sandbox. Together, we successfully demonstrated the capability of DEDUCES to execute data queries on the data from the SingHealth data warehouse (eHinTs).

Frequent Attenders to the Emergency Department

The Singapore General Hospital has seen an increase in emergency department (ED) attendances over the years, resulting in an increased strain on ED resources. In addition, the prevalence of an aging population may have contributed to this increase. Some of these patients may be frequent users of the ED and may also have certain common characteristics that can be identified and studied. As a result of these increased attendances, these patients may also tend to require a higher level of healthcare resources. A predictive model was developed in this project for frequent attenders to the ED. This study is currently in progress.

REDCap Reporting System

REDCap is a free, secure, web-based application designed to support data capture for research studies. The system was developed by a multi-institutional consortium initiated at Vanderbilt University. The SGH HSRU manages REDCap projects initiated by study investigators who wish to use the platform’s research data management facilities. However, due to the overwhelming number of projects initiated in SGH, it has become increasingly difficult to keep track of the statistics and status of these projects. A business intelligence dashboard was developed in order to track and manage these projects. This dashboard has been successfully implemented in SGH.

OT Schedule Optimisation and Visualisation System

Operating theatre (OT) scheduling is an important process that assigns hospital surgeries to specific operating theatres, dates and times. This process allows planned surgeries to be carried out smoothly and ultimately, providing optimal patient care. Some of the important process measures which support OT scheduling include OT utilization, patient’s waiting time to surgery and OT cancellation rates.

A business intelligence visualisation system has been developed and successfully implemented for SGH, KKH, NHCS and SingHealth through the OT Optimisation Task Force.

In order to test out the effects of certain policy changes and scheduling methods on these measures, a discrete-event simulation model is currently being developed. HSRC together with the Office of Service Transformation (OST) aims to develop a comprehensive decision support system making use of the detailed discrete-event simulation model and business intelligence system for situational awareness as well as scenario analysis to support planning.

Hip Fracture Bundled Payment

The Hip Fracture Bundled Payment Analytics Project is a collaboration between HSRC, the Office of Strategic Management (OSM) and the Regional Health System (RHS) Office to develop an integrated electronic data collection and business intelligence visualization system for the tracking of hip fracture patients under the bundled payment pilot programme initiated by the Ministry of Health (MOH). This system is envisioned to be a comprehensive system that allows for the implementation of a complete electronic journey for data on hip fracture patients under the bundled payment framework.
SingHealth Access Restricted Cluster

The SingHealth Access Restricted Cluster (ARC) was set up in 2016 in order to facilitate projects and collaborations while ensuring the privacy and security with regards to the use of clinical and operational data for the improvement of health services. The purpose of the SingHealth ARC are as follows:

(1) To develop insights for the improvement of patient care from data obtained from public healthcare institutions through targeted collaborative projects with academic and industry partners who are leaders in the field of healthcare analytics;

(2) To ensure the confidentiality and security of the personal, clinical and operational data which are used for research purposes, and;

(3) To facilitate collaborations with external industry and academic partners in leveraging healthcare analytics for the improvement of patient care.

The ARC houses High Performance Computers (HPCs) which have been secured and customized to achieve these goals. The use of these HPCs are governed by a set of policies for data transfer and access.

The ARC is housed in the HSRC offices in Academia Level 6 and maintained jointly by the HSRC Analytics Core and IHIS. Core characteristics of the SingHealth ARC are listed in the diagram below.

For more information regarding the ARC, please contact Dr Sean Lam (lam.shao.wei@singhealth.com.sg)