NMRC National Medical Research Council
Singapore

TRANSLATING RESEARCH INTO BETTER HEALTH

ANNUAL REPORT FY2016

Contents

Message from Chairman

Building Next-Generation Research, Innovation & Enterprises

This year, we embark on RIE2020 and strive towards the vision for Singapore to be a leading centre that advances human health and wellness, and create economic value for Singapore and Singaporeans through the pursuit of excellence in research and its applications.

Public investment in research and innovation has grown over the last 25 years. The Science & Technology (S&T) 2010 Plan aimed to sustain innovation-driven growth over five years; through the support and strengthening of research and development (R&D) capabilities by 2010. From 2011 to 2015, the Research, Innovation and Enterprise (RIE) 2015 Plan aimed to establish Singapore as a global research and development hub. Under the RIE2020 (2016 – 2020) Plan, we build on the progress made to date and continue to grow industry R&D capabilities and nurture innovative enterprises to meet our national needs.

The Health and Biomedical Sciences (HBMS) domain, along with three other domains, was set up under the RIE2020 framework to allow focused efforts, optimised manpower and maximised impact in the area of health and wellness, coupled with potential economic outcomes. Under RIE2020, the allocation of $4 billion to HBMS highlights the shift towards the closer integration of research thrusts, stronger dynamic towards developing the best teams and ideas and sharper focus on value creation. The integrated strategy is evident of Singapore's emphasis on the articulation of pathways to health and economic outcomes, while enhancing central coordination of major thrusts to increase synergy among the various domains.

Our healthcare research landscape has evolved dramatically over the years, evident of Singapore's development driven by the directives and support provided. From building and enhancing research capabilities, to encouraging innovations from bench to bedside, our focus is now on transformative research with potential healthcare advances and improvements to public health.

The pathway from bench to bedside has not been easy, despite its potential to generate tangible healthcare outcomes. Efforts are ongoing to address gaps and build transformative capabilities; from reviewing and stock-taking health and economic returns from previous research investments, to identifying existing and future potential needs to better direct translations in areas of most relevance to the local population.

Technology accelerates integration efforts and is the key to augmenting potential health and economic outcomes and moving beyond quality to value. One of NMRC's key initiatives include spearheading the development of the framework for research data governance and sharing, to encourage the sharing of research data with the rest via the National Electronic Health Record (NEHR) system. NMRC will also be working with IHis to develop a centralised research data repository on the Business Research Analytic Insight Network (BRAIN), to marry intelligent and cost effective technologies with process and people.

Under RIE2020, NMRC will continue to engage its various stakeholders actively to facilitate the translation of excellent research into impactful outcomes and promote value capture that aligns with national initiatives.

Prof Ranga Krishnan
Chairman

"Our healthcare research landscape has evolved dramatically over the years, evident of Singapore's development driven by the directives and support provided."

Ms Tricia Huang
Executive Director

"NMRC, together with MOH, has identified five therapeutic areas of focus for translational research … We are encouraged that the community has responded positively to these themes."

Message from Executive Director

A Good Start for RIE2020

2016 marked the start of Singapore's Research, Innovation and Enterprise (RIE) 2020 Plan. NMRC received a total allocation of about $1.35 billion to continue our research grants, human capital and talent development, as well as infrastructure programmes for the medical schools and public healthcare institutions. We also manage the $546 million Health & Biomedical Sciences Open Fund, which comprises the Open Fund-Large Collaborative Grant, Open Fund-Individual Research Grant and Young Individual Research Grant which are available to the entire biomedical research community.

In FY2016, we supported the research community with $257mil in project grants and $102mil in human capital and talent awards.

Putting Priority on Translation to Health Outcomes

NMRC, together with MOH, has identified five therapeutic areas of focus for translational research: cancers, cardiovascular diseases, diabetes, infectious diseases, and neurological and sense disorders. These have been emphasised in our grant funding. We awarded the first $25 million Open Fund-Large Collaborative Grant to a multi-institutional team led by Prof Thomas Coffman, Dean Duke-NUS Medical School, who is conducting a Diabetes studY on Nephropathy And Other Microvascular cOmplications, or DYNAMO for short. The 5-year programme supports MOH's War on Diabetes and will work towards reducing diabetic kidney disease in Singapore by 30% over the next 5 years. In our Health Services Research Grant, we have similarly emphasised specific themes such as Diabetes, Health Promotion, End-of-Life Care, Community Mental Health and Optimisation of Care which reflect the needs of the healthcare system. We are encouraged that the community has responded positively to these themes. To facilitate the adoption of research findings into healthcare policy and practice, we set up the MOH Research Translation Subcommittee, led by the Director of Medical Services, to review high-potential findings arising from NMRC-funded projects or those supported by the National Health Innovation Centre and the Singapore Clinical Research Institute. With further evaluation and support, we expect that the outcomes of health research can positively impact clinical practice, and help us to transform the healthcare system for the benefit of patients.

Shaping the Future of Health

Looking ahead, we expect that Precision Medicine will play a greater role in healthcare and will work with the medical research community, MOH and stakeholders to develop the strategy and implementation plan. The aim is to use Precision Medicine in clinically- and cost-effective ways, and to optimise disease treatment and prevention.

Lastly, we have awarded the Centre Grant for FY17-20 to 12 centres and 13 collaborative centres among the public healthcare institutions. This is to continue to support the research infrastructure that has been built up, and to enhance capabilities for translational and clinical research through collaboration.

NMRC's work is key in supporting the Health and Biomedical Sciences community in Singapore. Our work would not be possible without strong support from the leadership and colleagues in MOH, the NMRC Board, the healthcare community, and our partner agencies and stakeholders. We look forward to working with all of you in the year ahead.

About NMRC

About NMRC

Established in 1994, the National Medical Research Council (NMRC) oversees the development and advancement of Translational and Clinical Research (TCR) in Singapore. It provides competitive research funds to publicly funded healthcare institutions, awards competitive research funds for programmes and projects, supports the development of core clinical research infrastructure, is responsible for the development of clinician scientists through awards and fellowships, and fosters interactions and knowledge exchange among researchers.

In 2006, the Ministry of Health (MOH) established a new mandate to support TCR in areas where Singapore has great potential. With this in mind, NMRC's role is ever more important in leading, promoting, coordinating, and funding TCR in Singapore. NMRC-funded research has led to interdisciplinary partnerships and international collaborations, helping to boost the role played by Singapore's biomedical sector on the global stage.

The Research, Innovation and Enterprise 2015 (RIE2015) plan aimed for greater integration of activities across the entire Biomedical Sciences (BMS) community, including private and private sector performers, hospitals and government agencies. NMRC spearheaded these investments to realise long-term health and wealth outcomes.

Under the RIE2020 Plan[1], Singapore saw continued support for research, with an increase in investment from $16 billion in the previous tranche to the current $19 billion. Funding was prioritised in four strategic technology domains where Singapore had competitive advantages and/or important national needs, including Health and Biomedical Sciences (HBMS). NMRC is one of the beneficiaries of this boost in funding, reinforcing the Council's mandate as the champion for translational and clinical research in Singapore.

NMRC spearheads MOH's vision for healthcare research to deliver better health and wealth outcomes for Singaporeans. Five therapeutic areas of focus have been identified by MOH, in which NMRC will complement the top-down directed strategic research by funding research proposals received by the various competitive grants and awards administered. In 2013, the National Health Innovation Centre (NHIC) was established to coordinate across the industry cluster to support a vibrant ecosystem comprising local enterprises, start-ups and multinational corporations.

Human Capital plays a key role in the success of Singapore's TCR industry. Having a critical mass of clinician scientists is crucial for improving human health by providing through leadership and driving the translation of bench discoveries to bedside applications. As such, NMRC actively supports clinician scientists with funding through research grants, human capital awards and talent development programmes. NMRC has stepped up its efforts to boost the number of clinician scientists in Singapore.

[1] RIE2020 Info from NRF Website: http://www.nrf.gov.sg/research/rie2020

NMRC Board

Board Members

The NMRC Board advises the Council on the formulation of strategies and priorities to promote excellence in translational and clinical research in Singapore, with the objective of improving human health. By overseeing the implementation of the research programmes approved by MOH and the HBMS Executive Committee, the Board ensures that the Council is being effectively managed to meet its mission and key performance targets. The Board also ensures that governance frameworks are in place, such that NMRC's budget is appropriately managed and optimally utilised.

In FY16, the NMRC Board consists of 18 members.

Prof Ranga Krishnan
Chairman
National Medical Research Council

Ms Tricia Huang
Executive Director
National Medical Research Council

Prof Edward Holmes
Advisor
National Research Foundation

Prof Ivy Ng
Group Chief Executive Officer
SingHealth

A/Prof Benjamin Ong
Director of Medical Services
Ministry of Health

Dr Anand Tharmaratnam
President (Asia Pacific)
IQVIA™

Prof John Wong
Chief Executive
National University Health System

Prof James Best
Dean
Lee Kong Chian School of Medicine, Nanyang Technological University

Dr Cheong Wei Yang
Deputy Chief Executive Officer
National Research Foundation

A/Prof Chong Siow Ann
Vice Chairman of Medical Board (Research)
Institute of Mental Health

A/Prof Chong Yap Seng
Executive Director
Singapore Institute for Clinical Sciences

Prof Thomas Coffman
Dean
Duke-NUS Medical School

Prof Ian D. Graham
Professor
School of Epidemiology, Public Health and Preventive Medicine, School of Nursing University of Ottawa

Prof Lim Tock Han
Deputy Group CEO (Education & Research)
National Healthcare Group

Prof Peter Piot
Director & Handa Professor of Global Health
London School of Hygiene & Tropical Medicine

Dr Benjamin Seet
Executive Director
*Biomedical Research Council A*STAR*

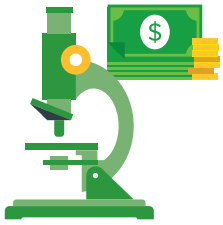
Prof Wong Tien Yin
Medical Director
Singapore National Eye Centre

A/Prof Yeoh Khay Guan
Dean
Yong Loo Lin School of Medicine, National University of Singapore

NMRC RIE2020 Funding Portfolio

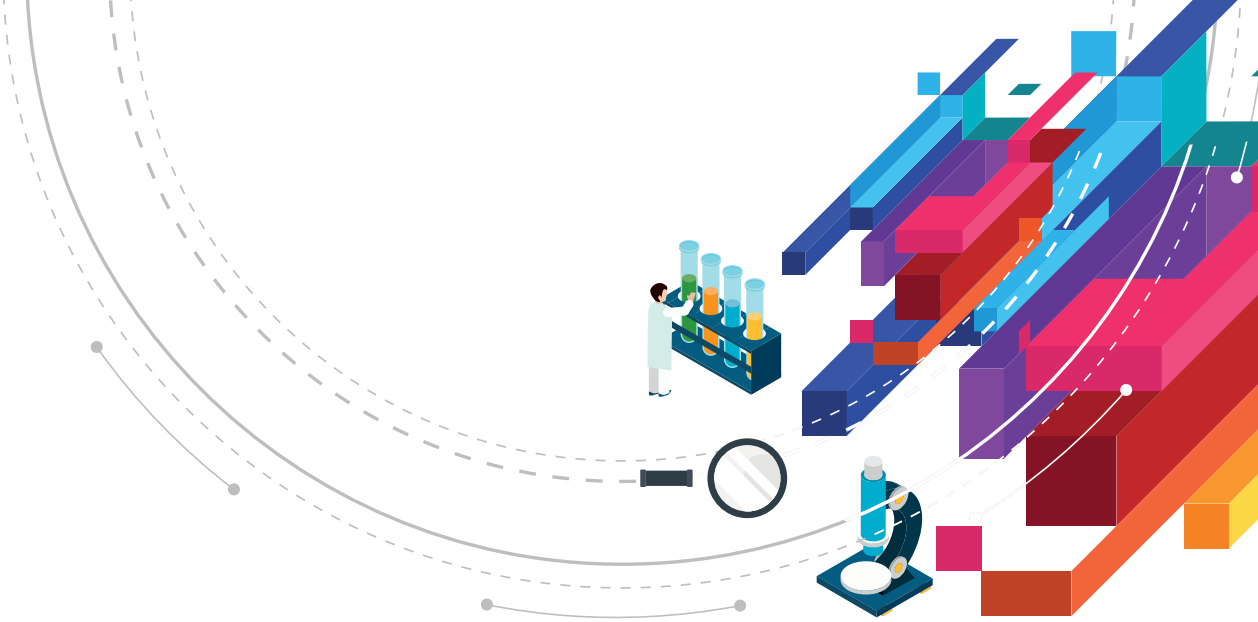
NMRC RIE2020 Funding Portfolio

Under the RIE2020's HBMS Domain, NMRC will continue to drive translational and clinical research through sustained and strategic investment in three key areas: human capital and talent development programmes, research grants, and enablers and infrastructure.



Human Capital & Talent Development Programmmes	Research Grants		Enablers & Infrastructure
	NMRC-Funded/ Managed	Open Fund	
• Singapore Translational Research (STaR Investigator Award) • Clinician Scientist Award (CSA) • Transition Award (TA) • Clinician Scientist/ Clincian Investigator Salary Support Programme (CS/CISSP) • NMRC Research Training Fellowship • MOH Healthcare Research Scholarship – Master of Clinical Investigation (MCI)	• Centre Grant (CG) • Clinical Trial Grant (CTG) • CS-Individual Research Grant (CS-IRG) • Health Services Research Grant (HSRG)	• Large Collaborative Grant (LCG) • Individual Research Grant (IRG) • Young Individual Research Grant (YIRG)	• Bioethics Advisory Council (BAC) & Centre for Biomedical Ethics (CBmE) • Clinical Research Coordinators (CRC) • HSA Cell Therapy Facility • Institutional Review Boards (IRBs) • Integrated Grants Management System (IGMS) • Investigational Medicine Units (IMUs) • National Health Innovation Centre (NHIC) Singapore • National Large Animal Research Facility (NLARF) • Research Space Funding (RSF) • Singapore Clinical Research Institute (SCRI) Pte Ltd • Duke-NUS Research Budget • Saw Swee Hock School of Public Health

Human Capital & Talent Development Programmes



Nurturing a Vibrant Community of Clinician Scientists

Manpower is one of the three cross-cutting programmes under the RIE2020 framework. Singapore aims to nurture a sustainable pipeline of skilled clinician scientists who will advance its strategic goals in RIE2020's health and biomedical sciences domain.

Clinician scientists play a critical role in translational and clinical research: their first-hand interaction with patients enables them to identify gaps in the detection, diagnosis and treatment of diseases, while their scientific experience and expertise allows them to frame these clinical insights as pertinent research hypotheses.

NMRC recognises the need to train and develop clinician scientists who are able to plug these knowledge gaps and, over time, develop breakthrough research that will translate into impactful health outcomes.

To help Singapore nurture a vibrant community of clinician scientists, NMRC has put in place various human capital awards and talent development programmes aimed at supporting individuals in their research and career progression.

These awards and programmes include:

Human Capital Awards

- Singapore Translational Research (STaR) Investigator Award
- Clinician Scientist Award (CSA)
- Transition Award (TA)
- Clinician Scientist/Clinician Investigator Salary Support Programme (CS/CISSP)

Talent Development Programmes

- NMRC Research Training Fellowship
- MOH Healthcare Research Scholarship - Master of Clinical Investigation (MCI)

Human Capital Awards

Singapore Translational Research (STaR) Investigator Award

The prestigious STaR Investigator Award is the highest level of NMRC's Human Capital Awards. Designed to recruit and nurture world-class clinician scientists to undertake cutting-edge translational and clinical research in Singapore, the STaR Investigator Award includes five-year funding for the researcher's salary, an annual budget for research support and a one-time start-up grant.

Clinician Scientist Award (CSA)

The CSA is structured to develop local research talent and give clinician scientists valuable protected time to focus on their research. The Senior Investigator (SI) level of the CSA offers funding for up to five years, catering to senior doctors who are already actively involved in highly productive research. The Investigator (INV) level offers funding for three years and targets younger doctors with the potential to become independent investigators. The CSA provides funding for salary support, together with a competitive research grant.

Transition Award (TA)

The Transition Award is designed to help budding clinician scientists who have just completed formal research training. This award provides research funding and salary support to help recipients build up their research capabilities by facilitating their transition to a stable, independent research position, which in turn will enhance their ability to successfully obtain independent research support later on. The Transition Award is non-renewable, as awardees are encouraged to apply for national-level independent research grants after they have completed this award.

Clinician Scientist/Clinician Investigator Salary Support Programme (CS/CISSP)

The CS/CISSP supports clinical research by providing funding for clinicians' research time in the form of salary support or full-time-equivalent (FTE). In recognition of the support from clinical departments for their clinicians' time and participation in clinical research, the awarded funding is channelled to the respective departments, which are given flexibility in using the funds to support clinical research.

Singapore Translational Research Investigator Award Recipients

Translating 'Omics' into a Stratified Approach for Prevention of Type 2 Diabetes: TOAST-T2D

Diabetes is a major public health problem that affects ~400 million people worldwide. I have recently shown that methylation of DNA, a key regulator of how cells behave, is a powerful predictor for developing future diabetes. In this project I will test whether DNA methylation and other molecular biomarkers can be used to help identify people at risk of diabetes, so that they can be offered treatment to help avoid the disease. I will first confirm that methylation can be used to predict diabetes in Singapore Chinese people, and identify the methylation markers that best predict diabetes. I will use the results to develop risk scores that use methylation, and other blood markers, to predict diabetes. I will use these scores as part of a clinical trial to test whether drug treatment or lifestyle modification can be used to prevent the development of diabetes in people whose blood methylation levels suggest they are at high risk of the disease. The results of this research will determine whether DNA methylation and other newly discovered blood markers can be used to promote health, and help reduce the burden of diabetes in Singapore and elsewhere in the world.

Prof John Campbell Chambers
Professor
Lee Kong Chian School of Medicine,
Nanyang Technological University

Understanding and Targeting High-Risk Myeloma

Multiple myeloma is the second most common cancer of the blood system and the number of new patients affected is rising in Singapore. Much improvement has been made in the treatment of myeloma over the last decades with an improvement in average survival of patients from 4 years to about 10 years now. However there still remains a group of about 20% of patients who have high-risk disease that still have poor outcomes despite the improvement in treatment. We can identify these high-risk patients with the use of genetics but the reason why they have such poor outcomes is not understood. Our strategy is to first understand why these high-risk tumours are more prone to relapse and becoming resistant to treatment and by doing so, we can then test and study ways to treat these high-risk patients. This will be a key next step to improve the outcomes of myeloma patients.

Prof Chng Wee Joo
Director
National University Cancer Institute, Singapore
Senior Consultant
Department of Haematology-Oncology,
National University Hospital
Professor
Yong Loo Lin School of Medicine,
National University of Singapore
Deputy Director
Cancer Science Institute of Singapore
National University Health System

Molecular Dissection and Therapeutic Targeting of Cardiac Fibrosis

Fibrosis is important for wound healing and tissue repair. However, excessive and damaging fibrosis is common in many diseases that include diseases such as heart and kidney failure, lung diseases, skin diseases and liver disease. With excessive fibrosis, tissues become stiffened, and enzymes released from fibroblasts, the cells that cause fibrosis, can degrade the normal healthy tissue. In the heart, fibrosis limits the amount of blood entering the heart, resulting in back-pressure on the lungs, causing difficulty in breathing, and also causing dangerous heart rhythms. We have been studying the factors causing heart fibrosis and recently identified a soluble factor in blood that when released from activated fibroblasts causes a fibrotic reaction in cells in a dish. In this study we will begin to explore the role of this secreted factor, called a cytokine, in heart fibrosis using mouse and rat models of human heart disease. We will try to understand how the cytokine activates fibrosis and will test if we can inhibit the cytokine with antibodies and whether this can limit fibrosis in tissues in the body. These studies will help us better understand fibrosis and we will explore whether this secreted factor can be developed as a drug target for inhibiting fibrosis in patients.

Prof Stuart Cook
Director
National Heart Research Institute Singapore
Director
Clinical Cardiac MRI,
National Heart Centre Singapore
Senior Consultant
Department of Cardiology,
National Heart Centre Singapore
Director and Professor
Programme in Cardiovascular and Metabolic Diseases,
Duke-NUS Medical School

Clinician Scientist Award (Senior Investigator) Recipients

A/Prof Jerry Chan
Senior Consultant
Department of Reproductive Medicine,
KK Women's and Children's Hospital
Associate Professor
Duke-NUS Medical School

A Non-Human Primate Model for Intrauterine Haemopoietic Stem Cell Transplantation for Beta-Globinopathies

Inherited genetic diseases such as thalassaemia, collectively affects 1 percent of all births, many of which cause irreversible damage even before birth. Thus intervening before birth may alleviate or cure the disease before damage occurs. In addition, the developing immune system is immature and the delivery of stem cells from another donor may be possible without the toxic effects of treatment necessary for postnatal treatment. Here we propose a pre-clinical model for the treatment of thalassaemia in a clinically relevant animal model. By giving the affected baby some bone marrow stem cells from its mother, we may be able to correct the anaemia associated with this disease, and effect a cure even before the baby is born. The successful completion of this proposal will set the stage for the foetal therapy of thalassaemia.

A/Prof Christopher Chen Li Hsian
Visiting Senior Consultant &
Associate Professor
Department of Psychological Medicine,
Yong Loo Lin School of Medicine,
National University of Singapore
Director
Memory Aging & Cognition Centre
National University Health System

Translational Research in Vascular Biomarkers of Dementia: Discovery, Validation and Assessment of Clinical Utility

Due to both genetic and lifestyle factors, some people have high risks of developing heart disease and ischemic stroke. At their core, both heart disease and ischemic stroke are due to damage and disease in the small vessels of the heart and brain, respectively. We believe that the same kind of chemical signals are released into the bloodstream when vessels of the heart and brain are damaged, or when the body attempts to repair them. Furthermore, disease in the brain vessels (called cerebrovascular disease, or CeVD) will also lead to higher risk of developing vascular dementia or Alzheimer's Disease (AD) later in life. This realisation has prompted us to propose to study chemical signals that become detectable when the brain has CeVD. Besides signals which are known to be released in heart disease, we will also study a wide range of other signals, such as those for inflammation and nerve function. We will then compare these chemical changes with changes in CeVD measured with neuroimaging and thinking abilities in a group of patients to see whether these signals can be useful in predicting brain vessel disease. Ultimately, we hope to develop accurate blood tests for vascular dementia and AD.

A/Prof Cheng Ching-Yu
Head & Principal Clinician Scientist
Ocular Epidemiology Research Group
& Statistic Platform,
Singapore Eye Research Institute
Associate Professor
Duke-NUS Medical School

Deep Phenotyping and Genetic Landscaping of Primary Open Angle Glaucoma

Glaucoma is one of the major blinding diseases in Singapore and worldwide, and thus a major public health issue. However, its pathogenesis is not fully known and effective treatment options remain limited. Together with experts from leading institutes across Singapore and in the world, we envision a research program that encompasses state-of-the-art clinical imaging and measurements, next-generation sequencing and integrative genomic analysis, for novel genetic discovery of glaucoma. We will recruit a cohort of 800 patients with primary open angle glaucoma, a major form of glaucoma, and perform detailed clinical examination and ocular imaging on them to build up a large genetic biobank, linking to their rich glaucoma-related clinical profiles. We will also use the latest sequencing technologies and innovative analytical approaches to identify new genes contributing to glaucoma diseases. In the future, results from this research program will allow more effective individualised medicine and may open new avenues for drug targets.

Prof Derek John Hausenloy
Professor
Cardiovascular & Metabolic Disorders Programme, Duke-NUS Medical School

OPA1 as a Novel Therapeutic Target for Reducing Myocardial Infarct Size and Preventing Heart Failure

Heart attacks are a leading cause of death and disability in Singapore and worldwide. Therefore, new treatments are needed to reduce damage to the heart muscle during a heart attack in order to prevent the onset of heart failure and improve health outcomes. Whether heart muscle is able to recover following a heart attack is crucially dependent on the function of its mitochondria, the powerhouse of the cells, generating the energy required for normal heart function. In this research proposal we will investigate the role of OPA1, a mitochondrial protein, as a new target for protecting the heart muscle during a heart attack. By showing that activating OPA1 in the heart can protect the heart muscle against damage during a heart attack, we hope that new treatments will be discovered to improve health outcomes in heart attack patients in Singapore.

A/Prof Mikael Hartman
Senior Consultant
Department of Surgery, National University Hospital
Associate Professor
Saw Swee Hock School of Public Health, National University of Singapore
National University Health System

Genetic Origin of Adverse Drug Reactions in Singaporean Breast Cancer Patients

More than 90% of breast cancer patients will receive systemic therapy, which includes chemotherapy, hormonal therapy, and targeted therapy. One major issue of systemic therapy is adverse drug reactions (ADRs), which can lead to dose reduction and impair quality of life. The occurrence and severity of ADRs differs significantly between individuals and it is well-established that inherited gene variations contribute to the observed variability. We aim to discover genetic variants that influence susceptibility to taxane-induced febrile neutropenia and aromatase inhibitor-induced bone density loss. Breast cancer patients treated with taxane or aromatase-inhibitor will be identified in a large cohort of 10,000 breast cancer patients from the Singapore Breast Cancer Cohort Project. Information on sociodemographics, lifestyle and reproductive risk factors, and clinical data such as tumour characteristics and treatment will be collected from questionnaires and medical records. DNA samples (from blood or saliva) will be obtained to allow researchers to determine the genetic variants an individual possesses (genotyping) and the exact sequence of certain parts of the genome (exome sequencing). We will compare genetic profiles between patients who suffer extremely severe ADRs and patients who are virtually unaffected and try to predict which patients are at increased risk of ADRs based on their genetic makeup.

Prof Lim Seng Gee
Senior Consultant
Department of Medicine, National University Hospital
Professor
Yong Loo Lin School of Medicine, National University of Singapore
National University Health System

Characterisation of B Cells during Hepatitis B Seroclearance

Chronic hepatitis B (CHB) affects 300 million globally and commonly causes liver disease. Medicines can control but not eradicate the virus. Eradication of CHB is potentially achievable, and is the objective of a recently awarded NMRC TCR (TCR13dec008). However, the grant does not examine the role of B cells, which produce antibodies that protect against Hepatitis B Virus (HBV) infection after vaccination, and may also play a role in HBV clearance in patients. We hypothesise that B cells begin to recognise mutations in HBV over time and this leads to development of antibodies against the virus during two events in the natural history of CHB, HBeAg and HBsAg seroconversion that help to clear HBV. Consequently the grant seeks to identify the viral components recognised by antibodies that lead to viral clearance during HBeAg and HBsAg seroconversion using well established but sophisticated antibody techniques. We will also identify patients who achieve these two events from clinical studies, and determine if there is evidence of increased B cell activity over time, and and if they produce antibodies against the mutated viruses. Finally, we will test whether a dysfunctional interaction between T cells and B cells is the reason for impaired responses.

A/Prof Marcus Ong Eng Hock
Senior Consultant
Department of Emergency Medicine,
Singapore General Hospital
Associate Professor
Duke-NUS Medical School

Improving Outcomes for Out-of-Hospital Cardiac Arrest through a National, Living, Learning, Prehospital Emergency Care Laboratory

Singapore has more than 1800 out-of-hospital Cardiac Arrests (OHCA) each year. Changes implemented as a result of past research have increased OHCA survival from 2.5% (2001) to 11.0% currently, with potential for further improvements. The aim of the proposed study is to increase OHCA survival. We will establish a national, living and learning prehospital emergency care (PEC) laboratory, which can help improve clinical care as well as guide policy change for OHCA interventions. First, information from various sources in the chain of clinical care for OHCA, such as national ambulances, emergency departments, etc. will be consolidated. A simulation model will be developed to monitor performance, identify gaps and evaluate implementation of interventions. Second, the project will develop and evaluate the effectiveness of community programs such as mass, simplified cardio-pulmonary resuscitation (CPR) training, installation of automated external defibrillators in residential blocks, a mobile phone app which alerts users of OHCA nearby and a card that measures CPR quality. Lastly, the project aims to develop and evaluate the effectiveness of ambulance-based interventions such as high performance team CPR and new resuscitation drugs. The overall aim is to build a world-class PEC laboratory on a national scale that can increase the survival rate for OHCA.

A/Prof Toh Han Chong
Deputy Director
National Cancer Centre Singapore
Senior Consultant
Division of Medical Oncology,
National Cancer Centre Singapore
College Master and Associate Professor
Duke-NUS Medical School
Clinical Senior Lecturer
Yong Loo Lin School of Medicine,
National University of Singapore

Novel Therapeutic Interventions to Target GATA4-Related Pathways in Hepatocellular Carcinoma

Liver cancer is an endemic cancer across Asia. Risk factors include alcohol abuse, non-alcoholic fatty liver disease (NAFLD), Hepatitis virus infection, fibrosis, cirrhosis, etc. It will continue to prevail given the rise of the epidemic of non-alcoholic steatohepatitis, and the inability of childhood Hepatitis B vaccination to fully protect people, communities and countries from Hepatitis B transmission. However, there are no effective chemotherapeutic options for liver cancer. Aggressive care starts with surgical resection and transplantation, and chemotherapy is reserved for palliative approaches to delay cancer progression. The only FDA-approved targeted therapy is modest in terms of clinical outcome. Therefore, our proposal is to develop potentially novel treatment strategies that are different and distinct from existing treatment options, but focusing on tumour-immune system interaction and combination immunotherapy as areas of intervention. Our preliminary work has identified a key gene in liver cancer, which could be the key modulator of the tumour-immune interaction in liver cancer. Therefore, this award will support further translational research using different experimental models and two first-in-human clinical trials to target the impaired tumour-immune interaction in liver cancer.

Prof Yong Eu Leong
Head and Senior Consultant
Department of Obstetrics & Gynaecology,
National University Hospital
Professor
Yong Loo Lin School of Medicine,
National University of Singapore
National University Health System

Role of Chemokine Ligand-Receptor (CXCL12-CXCR4) Signaling in Osteoblast/Osteoclast Function, and its Modulation by Icaritin and Estrogens in Bone Remodeling and Osteoporosis

Osteoporotic fractures are increasing among women who have hit menopause, leading to greater health burdens in society if left unmanaged. In response, we aim to improve clinical management of osteoporosis through identifying protein sites that drugs can exercise their effects on. Preliminary findings and literature suggest that CXCR4, a protein receptor in humans, is able to regulate bone health by varying the concentration of bone-forming and bone-breaking cells. When CXCR4 binds to its exclusive molecule called CXCL12, it activates more bone-forming cells. Interestingly, we have identified a compound from the herb *Epimedium* called icaritin which appears to increase the rate of binding, thereby stimulating more bone-forming cells. Our study will involve using icaritin as a catalyst to evaluate the efficacy of CXCR4 in the regeneration of bone tissue. This will be tested in cellular and animal models to identify if bone development by the binding of CXCR4 and CXCL12 is independent of other biochemical reactions. The findings will help us understand if the combination is suitable to enhance bone health and open up new options for the management of osteoporosis and identification of new drugs.

Clinician Scientist Award (Investigator) Recipients

A/Prof Christopher Ang Beng Ti
Head & Senior Consultant
Department of Neurosurgery (SGH Campus),
National Neuroscience Institute
Associate Professor
Duke-NUS Medical School

Preclinical Evidence for STAT3 Inhibition Therapy in Recurrent Malignant Glioma (MG) Patients: Use of Ruxolitinib

Malignant brain tumours (gliomas) have a dismal outlook despite surgical removal, chemotherapy and radiotherapy. A new paradigm of treatment involves targeting of specific activated cellular signaling pathways unique to each patient's tumour - precision medicine. We defined how such an activated pathway, STAT3, contributed to drug resistance and tumour recurrence. Importantly, we showed that the STAT3 gene signature predicted for drug response. As such, we were able to identify STAT3-stratified subgroups. At present, there is little uniformity in the selection of drug treatment at recurrence, hence clinical trials are carried out commonly at this stage. To provide pre-clinical evidence that STAT3-stratified patients can respond favourably to STAT3 inhibitor therapy, this project aims to demonstrate the response of mice bearing tumours derived from recurrent gliomas, to ruxolitinib, a STAT3 pathway inhibitor which is currently used in clinical studies for other conditions. In essence, we will collate glioma tissue material from patients with recurrent glioblastoma (the most aggressive form of glioma) for the creation of the mouse model, test the response to ruxolitinib using this model and establish biomarkers to help identify the STAT3-responsive patient cohort. This will facilitate the next step, namely clinical trials using ruxolitinib in recurrent glioblastoma.

A/Prof Chan Ling Ling
Senior Consultant
Department of Diagnostic Radiology,
Singapore General Hospital
Adjunct Associate Professor
SingHealth Duke-NUS Radiological Sciences
Academic Clinical Programme,
Duke-NUS Medical School

Case Control Nigrosome-1 and Connectivity MRI Study in Parkinson's-Linked Asian LRRK2 Gene Carriers

Nigrosome-1 imaging has potential as a surrogate non-invasive quantitative biomarker in Parkinson's Disease (PD) and preclinical genetic carriers. Its quantitative grading and correlation with functional connectivity are novel. Classical motor features of PD are attributed to profound neuronal loss in the substantia nigra of the midbrain, worst in nigrosome-1. Recent radiological advances allowed depiction of a healthy hyperintense nigrosome-1 with nearly identical neuropathological correlation. Nigrosome-1 imaging revealed excellent diagnostic accuracy in differentiating PD from healthy controls (HC). Abnormal connectivity has also been found in preclinical PD-at risk subjects on functional studies (rsfMRI). Asian-specific leucine-rich repeat kinase 2 (LRRK2) gene risk variants are common in Chinese PD patients, with accelerated motor progression compared to non-carriers. We will study LRRK2 gene risk carrier status through genotyping and nigrosome-1 and functional connectivity on brain MRI in 100 PD patients and 100 HC. We will establish clinical usefulness of nigrosome-1 imaging in differentiating PD from HC based on visual inspection, quantitatively grade nigrosome-1 hyperintensity and evaluate its correlates with clinical motor scores. We will also evaluate for differences in quantitative nigrosome-1 hyperintensity between gene carriers and non-carriers within each PD and HC groups, and finally correlate these with rsfMRI findings.

A/Prof Chan Shiao Yng
Consultant
Department of Obstetrics & Gynaecology,
National University Hospital
Associate Professor
Yong Loo Lin School of Medicine,
National University of Singapore
National University Health System

Placental Lipid Flux in Gestational Diabetes and the Effects of Myoinositol

In Singapore, 25% of pregnancies are complicated by new onset diabetes, called gestational diabetes (GDM). This condition is linked with bigger babies, poor pregnancy outcomes and increased risk of the child developing obesity and type 2 diabetes in future. Changes in the way fatty nutrients are transferred across the placenta from the mother to the baby is a major reason why babies of GDM pregnancies are fatter. Myoinositol is a nutritional supplement that could potentially prevent the development of GDM and big babies, but how it works is not understood. This proposal will investigate how myoinositol affects placental fatty nutrient transfer in GDM pregnancies and whether myoinositol can control the baby's size. If myoinositol can do this then hopefully it will also reduce complications at birth and improve the baby's future health. The project will use placental and blood samples as well as the extensive clinical data collected from three different research studies conducted on Singaporean pregnant women and their babies. The results will provide important scientific information, which gives credibility to ongoing clinical trials of myoinositol in pregnancy. This work could lead to myoinositol being given routinely to pregnant women to prevent GDM, leading to substantial health benefits worldwide.

A/Prof Narayanan Gopalakrishna Iyer
Senior Consultant
Division of Surgical Oncology,
National Cancer Centre Singapore
Head and Senior Consultant
SingHealth Duke-NUS Head and Neck Centre
Associate Professor
Duke-NUS Medical School

The Role of Tumour Heterogeneity in Lymph Node Metastasis in Oral Squamous Cell Carcinoma (OSCC): a Precision Medicine Approach

Oral cancer is a common lethal cancer and patients who develop cancer-spread (metastasis) to lymph nodes are at higher risk of dying. Within tumours, there are numerous groups of cells with differing properties, and we aim to understand how these go on to metastasise. One theory suggests that each layer acts like a sieve to purify the more potent cells, which then go on to the next level. The opposing theory is that there are different populations in the tumour; each of these can then go on to a separate deposit, independently. We believe that in each patient, only one of these processes is happening, and understanding this has important implications on how treatment could be tailored. In this project, we will use tumour tissue from patients and look at individual cells in the primary tumour and metastasis, to confirm our theory, and if so, which one predominates. We also intend to grow the same cells in culture or mice, so that we can use these to screen for new ways to block these pathways. Through these experiments, we hope to further understand the process of metastasis and plan for treatment in an individualised manner, specific to each individual tumour in each individual patient.

A/Prof Lim Su Chi
Clinical Director
Clinical Research Unit,
Khoo Teck Puat Hospital
Senior Consultant
Diabetes Centre,
Admiralty Medical Centre
Research Associate Professor
Saw Swee Hock School of Public Health,
National University of Singapore

Metabolomics of Progressive Diabetic Kidney Disease in Young-Onset Type 2 Diabetes – a Prospective Study

People with type 2 diabetes since young (YT2D) are increasingly common in Singapore due to increasing childhood and adolescent obesity. YT2D are prone to diabetic complications e.g. diabetic kidney disease (DKD), resulting in the need for long-term dialysis during early adulthood. This poses a major health burden to the person, family and society. Measurement of multiple metabolic-substances (metabolomics) is a very useful technique to study DKD in older-onset diabetes. This has not been attempted in YT2D to better understand their susceptibility to DKD. Therefore, we will compare the blood and urine metabolomic-profiles of a large group of ~660 YT2D at baseline. Subsequently, we will follow them up for the occurrence of DKD. Differences in metabolomics (at baseline) of those with and without progressive DKD will be identified. To ensure that the signals are valid, they will be tested in a second independent group of ~420 YT2D to evaluate their ability to correctly identify YT2D with and without progressive DKD. The study will help to improve our ability to predict the risk of DKD among people with YT2D. It may also shed light on the mechanisms underlying their susceptibility for DKD thereby revealing possible new and effective treatments.

A/Prof Jenny Low Guek Hong
Senior Consultant
Department of Infectious Diseases, Singapore General Hospital
Associate Professor
Duke-NUS Medical School

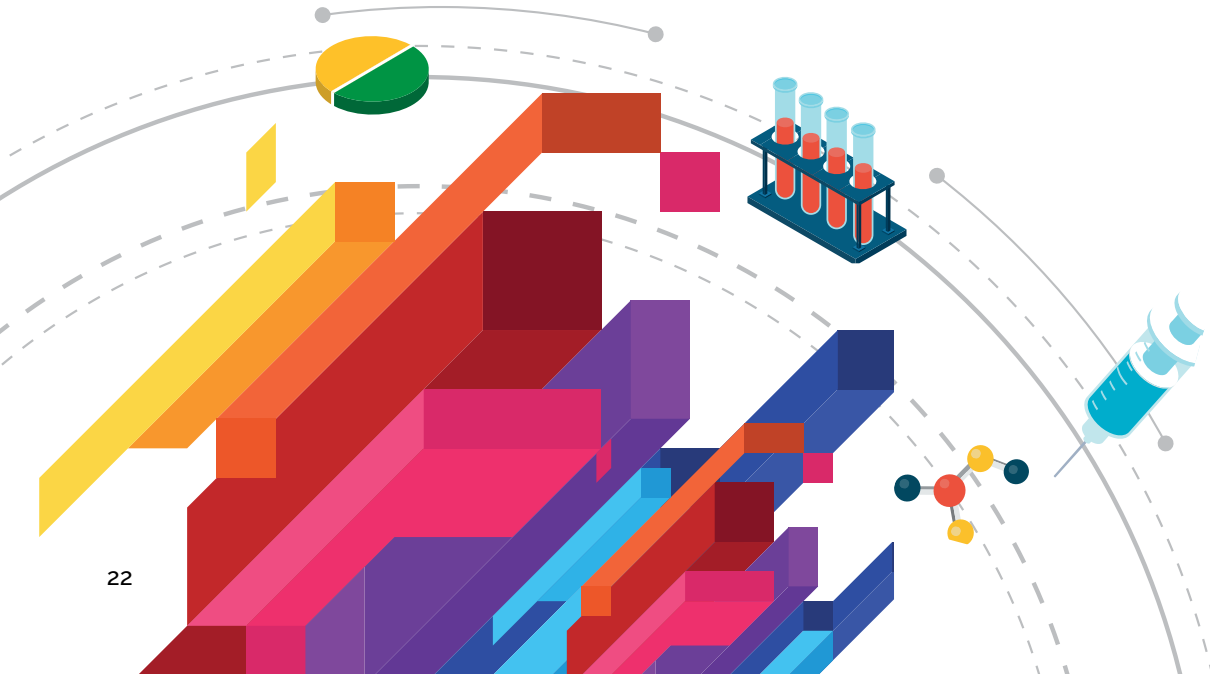
Using Systems Vaccinology to Elucidate the Effects of Anti-Inflammatory Therapy on Immune Response after Vaccination with a Live Attenuated Vaccine

Vaccination is the administration of antigenic material (a vaccine) to stimulate an individual's immune system to develop immunity to a specific pathogen. Live attenuated vaccines (LAV) are known to be the most successful forms of vaccines. It remains the most cost-effective public health tool available to prevent or stop infections. Rapid mass vaccination of healthy at-risk populations to establish herd immunity has been successful in controlling yellow fever outbreaks in Africa and South America. Recent clinical trials showed that vaccinating and monitoring a ring of people around each infected individual (ring vaccination) in contact with Ebola patients completely eradicates secondary virus spread. During a worldwide outbreak, vaccination must include different demographics of adults in order to rapidly raise herd immunity to stop further transmission. With improved nutrition, an estimate of 1 billion people is overweight globally. In Singapore one in 10 adults are obese with high fats in the blood. Statin, a cholesterol-lowering drug, with anti-inflammatory properties, may reduce the optimal effect of a vaccine. This study will test the hypothesis that statin reduces vaccine immune responses. This would provide evidence for public health response to outbreaks in order to estimate the population that should be vaccinated.

Dr Ng Kar Hui
Senior Consultant
Department of Paediatrics, National University Hospital
Assistant Professor
Yong Loo Lin School of Medicine, National University of Singapore
National University Health System

Next-Generation Sequencing and Mechanistic Understanding for the Diagnosis and Management of Primary Glomerular Disease in Asia

Glomerular disease is a kidney disease which may be due to gene changes and can result in renal failure. It is usually treated speculatively using immunosuppressive drugs with potential serious side effects. Therapeutic options are few. With a genetic diagnosis, doctors can better tailor treatment for the patient. However, most children in Singapore and Asia do not have genetic testing, and hence may not be receiving the best treatment. Unlike Europe and USA, there are no large-scale studies on genetics of glomerular disease in Asia. We have now set up "Deciphering Diversities: Renal Asian Genetics Network (DRAGoN)". New techniques of genetic testing will be used. We expect 650 patients over 3 years. We have also identified a change in the gene angiomotin (AMOT) in a family with hereditary kidney disease. We introduced this gene change into rats and noted these rats also developed kidney disease. When the function of AMOT was totally knocked out in rats, the kidney disease was worse. This study aims to further decipher the process by which AMOT causes glomerular disease via experiments on the rats. The ultimate aim is to identify molecules which drugs can potentially target and hence may lead to a new therapy.



Dr Joanne Ngeow Yuen Yie
Senior Consultant
Division of Medical Oncology,
National Cancer Centre Singapore
Assistant Professor
Duke-NUS Medical School

Molecular Mechanisms Underlying Soft Tissue Sarcoma Predisposition

A common question faced by cancer patients is: why me? Environmental causes, like smoking, sunlight, and radiation, have long been known to modify cancer risk. Although exposure to environmental factors gives tumours a head start, multiple additional events are still required for a cancer to establish itself. One possible answer for why there appear to be enormous differences between individuals in cancer risk, may be the genes we each inherit from our parents. The actual risk will vary according to the gene involved, and the effect of the mutation. Mapping each mutation and change to its consequence is not a trivial task, let alone testing ways to protect people. Recent data suggests that like breast, colon and ovarian cancer, a high proportion of soft tissue sarcomas (STS) is associated with an individual's genetic risk. This provides an exciting opportunity for us to understand how this can be used to guide screening and treatment. This is particularly important in STS as there is otherwise very limited treatment options for advanced disease. Our study will help us understand if this affects a large number of patients with STS in Singapore and how we can target these genetic changes for treatment.

A/Prof Sng Ban Leong
Head and Senior Consultant
Department of Women's Anaesthesia,
KK Women's and Children's Hospital
Research Director
KK Research Centre
Associate Professor
Duke-NUS Medical School

Comparison of the Role of Epidural Analgesia versus Non-Epidural Analgesia in Postnatal Depression and Persistent Pain Development: a Randomised Controlled Trial CODEPAD (Collaborative Outcomes of DEpression and Pain Associated with Delivery)

Depression after childbirth affects 15% of women which results in severe socioeconomic burden, suicide risk and affects the child's development. Depression after childbirth was present in 12.7% at our centre and epidural pain relief was a protective factor that reduced the risk by nearly half compared to other forms of pain relief during labour. Persistent pain affects 10% of women resulting in poor recovery and disability. Severe labour pain may be associated with abnormal brain signaling mechanisms that can contribute to depression and persistent pain. We aim to determine whether epidural pain relief compared to other forms of pain relief will reduce the risk of depression. We will use measures of pain vulnerability and severity, psychological vulnerability and pain relief choice to construct a model for these conditions. Genetic pathways related to depression and persistent pain development will also be explored. We will investigate 1326 term women randomly assigned to have epidural or non-epidural pain relief methods before delivery and conduct phone surveys 6 to 10 weeks after delivery to determine the outcomes. This trial will lead to change in clinical practice and recommendation of pain relief choice during labour. The knowledge will guide us in future research to discover new risk management strategies and identify modifiable treatment options.

Dr David Tan Shao Peng
Consultant
Department of Haematology-Oncology,
National University Cancer Institute, Singapore
Assistant Professor
Yong Loo Lin School of Medicine,
National University of Singapore
National University Health System

Integrated Molecular Analysis of Cancers in Gynaecologic Oncology (IMAC-GO)

Gynaecological (ovarian, womb and cervix) cancers represent a diverse spectrum of diseases. Many patients with these cancers present with advanced stage disease, or develop recurrent disease after initial treatment for early stage disease, and current therapeutic approaches are often ineffective in these situations. Recent studies have shown that these cancers harbour a wide array of molecular abnormalities that may potentially be targeted using novel therapeutic approaches. For this project, we intend to build a platform, known as the integrated molecular analysis of cancer in gynaecologic oncology (IMAC-GO), that will enable gynaecological cancer physicians in Singapore to characterise the abnormal molecular features of each tumour in order to identify potential personalised treatment strategies for each patient. Furthermore, this platform will serve as a tool to analyse tumour samples obtained from clinical trials of new therapies being conducted in Singapore in order to understand why these treatments succeed or fail in individual cases. It is anticipated that the ability to identify specific molecular aberrations and decipher the causes of good and poor responses to treatment in these cancers will provide key biological insights that will enable the design of more effective treatments in the future and improve survival outcomes for women with gynaecological cancer.

A/Prof Tan Shao Weng Daniel
Senior Consultant
Division of Medical Oncology,
National Cancer Centre Singapore
Principal Investigator
Cancer Therapeutics Research Laboratory,
National Cancer Centre Singapore
Adjunct Associate Professor
Duke-NUS Medical School
Senior Clinician Scientist
Cancer Stem Cell Biology,
Genome Institute of Singapore

Elucidating the Determinants and Therapeutic Vulnerabilities of Primary Tyrosine Kinase Inhibitor-Resistant EGFR Mutation-Positive NSCLC

Lung cancer remains the highest cause of cancer related mortality in Singapore. With advances in understanding lung cancer biology, we have discovered that up to 60% of patients in Singapore harbour a genetic abnormality in the EGFR gene, that results in vulnerability to targeted therapy in the majority of patients. However, despite the initial success of targeted therapies in lung cancer, tumours eventually develop resistance to therapy after initial response (known as secondary resistance), and about 20-30% of patients do not exhibit any tumour shrinkage at the outset – known as primary resistance. Unlike secondary resistance, where new genetic alterations have been found to account for treatment failure, the reasons underlying primary resistance are poorly understood. In this study, I plan to use cutting-edge genomics approaches and preclinical disease modeling of patient-derived cell lines to firstly understand the basis of this phenomenon, and subsequently identify new treatment opportunities for this group of patients. With the expanding number of new therapies available, there are also tangible opportunities to develop rational combinations to overcome primary resistance.

A/Prof Yeo Tsin Wen
Associate Professor
Lee Kong Chian School of Medicine,
Nanyang Technological University

The Role of the Endothelial Glycocalyx, Mast Cells and Vascular Nitric Oxide in the Pathogenesis of Dengue

Dengue is a common viral infection in Singapore and is spreading globally. Dengue infection can result in an acute fever for 5-7 days, and in some cases can cause death. The main cause of death is leaky blood vessels resulting in low blood volume and blood pressure, however the cause of the leaky blood vessels is still unknown. We aim to study the cause of leaky blood vessels in dengue patients by measuring the thickness of the endothelial glycocalyx. This is a gel-like layer lining the blood vessels, which if damaged or becomes thinner allow leakage of fluid from inside the blood vessel to outside. Mast cells are immune cells that release substances that can damage the glycocalyx. Mast cells have been found in animal models to make dengue worse and we will measure mast cell substances in patients with dengue. We think that the glycocalyx damage resulting in a thinner layer may be a result of mast cell substances released during dengue infection and may be the cause of blood vessel leakage. Treatments to make the glycocalyx thicker or block the mast cell substances may reduce the blood vessel leak in dengue.

Transition Award Recipients

Dr Clarinda Chua Wei Ling
Consultant
Division of Medical Oncology,
National Cancer Centre Singapore
Adjunct Instructor
Duke-NUS Medical School

Using Patient-Derived Colorectal Cancer Models for Personalised Prediction of Drug Response, Study of Drug Resistance Mechanisms and Identification of Treatments to Mitigate Resistance

Colorectal cancer (CRC) is the commonest cancer in Singapore. Many different drugs can be used to treat CRC but not all drugs are effective for each patient as each patient's cancer is unique. Using the patient's cancer tissue, we are able to set up cell and mice models unique to that individual. We will apply the same drugs that the patient receives in the clinic to their cell models to test if these models can accurately mimic real-life treatment. Using these models, we will also study why certain drugs may not work or stop being effective in some patients ie. drug resistance. Automated screening of large numbers of drugs can be carried out using these models. In this way, we aim to use these models to study drug resistance as well as identify new drugs that can prevent or overcome this problem of drug resistance. We hope this work will lead to better outcomes subsequently for patients with advanced CRC.

Dr Sanjay Haresh Chotirmall
Assistant Professor
Lee Kong Chian School of Medicine,
Nanyang Technological University

The Pulmonary Mycobiome in Health and Disease

The human 'microbiome' is a collection of bacterial microorganisms sharing our body space, with roles in health and disease. The analogous fungal 'mycobiome' despite ubiquitous presence has been ignored. We will determine the frequency and clinical role of *Aspergillus fumigatus* in bronchiectasis, the commonest fungi within a classic model of lung damage of high prevalence in Singapore, as a proof-of-concept study. Abnormal airways are at risk of fungal acquisition, colonisation and disease. Human fungal exposure occurs daily with >50,000 fungal spores/m3 in inhaled air. While spore exposure is universal, clinical disease is not. Aspergillus lung disease is difficult to identify necessitating improved diagnostics. To study this, we will employ culture, molecular biology and translational immunology to detect its presence and clinical manifestations in bronchiectasis. Next-generation pyrosequencing will be applied to define the lung 'mycobiome' and, through metabolomics uncover Aspergillus-derived small molecules with the potential to lead to novel diagnostic biomarkers. Of significance, this body of work will improve our understanding of the 'mycobiome' while promoting the development of novel diagnostics for this field.

Dr Feng Lei
Assistant Professor
Yong Loo Lin School of Medicine,
National University of Singapore
National University Health System

Diet and Cognitive Health in Ageing: a Community-Based Prospective Cohort Study

In this research study, we will examine the role of diet and nutrition in promoting cognitive health among community-living elderly Singaporeans. The study will be conducted based on the Diet and Healthy Ageing Study in which detailed information on diet and baseline cognitive function has been collected from a group of community-living elderly in Singapore. In the new study, we plan to conduct follow-up assessments of 900 participants aged 60+ at baseline using standard cognitive tests and clinical tools to determine their cognitive status. Blood and urine samples will be collected to measure biological markers that will provide scientific explanations for the expected benefits of certain foods, beverages, and dietary patterns. We also will test the interaction between diet and APOE, a gene that affects the risk of Alzheimer's Disease and other ageing-related conditions. This research study will be the first study that focuses on Asian diets and cognitive health in old age and may lead to the application of dietary approaches in preventing cognitive decline. Translations of the research findings into clinical and public health practices will potentially help to promote cognitive health at population level and reduce healthcare costs related to cognitive impairment.

Dr Anand Devaprasath Jeyasekharan
Associate Consultant
Department of Haematology-Oncology, National University Hospital
Assistant Professor
Yong Loo Lin School of Medicine, National University of Singapore
National University Health System

Oncogenic Determinants of Homologous Recombination (HR) DNA Repair Deficiency in Tumours

Advanced ovarian cancers remain a clinical challenge, with common early relapses and a high risk of mortality despite advances in chemotherapy/cancer surgery. Preliminary data suggests that a molecularly defined subset of these cancers may respond to a novel class of oral anti-cancer drugs termed PARP inhibitors, as well as to specific platinum-based chemotherapy. In this proposal we hope to refine the method of selecting such a patient group who may benefit from these specific anti-cancer therapies, and highlight our capacities for precision medicine, in the Asia Pacific region, and also worldwide. We will do this by accurately measuring a group of proteins termed mitotic kinases, in samples of ovarian cancer, and correlating these readings with the responses of the patients to platinum-based chemotherapy. We will also set up an in-vitro system to artificially generate high levels of oncogenes in cells growing in culture, to identify markers that can be assessed in patient samples to identify appropriate candidates for PARP inhibitor or platinum therapy. These approaches are expected to allow us to match the right drug to the right patient, to maximise survival and minimise toxicity in advanced ovarian cancer, and potentially in other incurable cancers as well.

Dr Catherine Dong Yanhong
Clinical Neuropsychologist
Department of Psychological Medicine, National University Hospital
Registered Nurse
Alice Lee Center of Nursing Studies
Research Assistant Professor
Yong Loo Lin School of Medicine, National University of Singapore
National University Health System

Heart-Brain Connection: Cognitive Impairment in Patients with Heart Failure

Memory loss is increasingly recognised in patients with heart failure and stroke. This study aims to better understand how common memory loss is in patients with heart failure and how this affects adherence to medications and self-care. We will assess 300 patients with heart failure for possible memory loss and invite 60 patients with memory loss for a group-based program that centers on lifestyle and memory coaching. The outcome of this study will provide an effective way of screening patients for memory loss and to test whether a group-based memory program can help reduce the growing tide of memory loss among patients with heart failure. This study builds on advances in MRI scans and biomarker technologies to help us better understand why memory loss takes place and how we can devise newer methods to overcome this problem.

Dr Lim Tze Peng
Senior Principal Pharmacist Researcher
Department of Pharmacy, Singapore General Hospital
Assistant Professor
Duke-NUS Medical School

Fighting the Superbugs: Development & Use of a Rapid Identification Pathway for Antibiotic Combination Therapy against Extensively Drug-Resistant Gram-Negative Bacteria (XDR-GNB) Infections

Antibiotic resistance is a major global medical challenge. Without new antibiotics, polymyxins, a potent but toxic alternative, may be the only effective remaining option. However, increasing resistance to polymyxins has been observed over the last few years. In essence, resistance to polymyxins implies a total lack of antibiotics for treatment of life threatening infections caused by the gram-negative 'superbugs' like *Pseudomonas aeruginosa, Acinetobacter baumannii & Enterobacteriaceae*. The goal of the study is to study the feasibility of implementing a novel method to identify effective antibiotic combinations in patients infected with these 'superbugs' to translate the laboratory findings to clinical application. We plan to accomplish the objectives by leveraging on an existing novel adenosine triphosphate (energy molecule)-based test developed by our research group recently. The antibiotics tested will be drugs that have been approved for use in humans but rendered ineffective, when used alone against the 'superbugs'. This proposal is unique and of high significance and may be the first to use integrative technologies and a multi-disciplinary approach to develop 'precision medicine' to treat a large variety of 'superbugs'. The potential findings may open a new paradigm in treatment approaches against the 'superbugs' until new potent antibiotics are developed against them.

Dr Liu Yu Chi
Clinician Scientist
Singapore Eye Research Institute,
Singapore National Eye Centre
Instructor
Eye Academic Clinical Programme,
Duke-NUS Medical School

The Applications of Terahertz Scan

Appropriate hydration of the cornea (the front part of the eye) is important in maintaining corneal transparency, which is essential for good vision. Cloudy cornea is a priority eye disease as stated by WHO, and it is caused by corneal edema (swelling) or corneal scars. However, currently there are no tools to directly and objectively evaluate the severity of corneal edema and corneal scars. Our preliminary work in porcine eyes has shown that the Terahertz scanning system, an emerging technology, has great potential to differentiate the severity of corneal edema and scars. The Terahertz scanning system also has the capacity to provide real-time measurements of water content in corneas, which may be beneficial in refractive surgery. In this study, we aim to investigate the accuracy of using the Terahertz scanning system to evaluate different severity of corneal edema and corneal scars, using animal models. The study has great potential to open a new avenue for early detection and decision-making in the management of corneal edema and corneal scars. It may also be useful in tear analysis in dry eye patients and in the adjustment of laser ablation parameters during refractive surgery.

Dr Sharon Cohan Sung
Assistant Professor
Office of Clinical Sciences,
Duke-NUS Medical School

A Randomised Controlled Trial of a Stepped-Care Intervention for Patients with Panic Attacks and Panic Disorder in the Largest Tertiary Emergency Department in Singapore

Panic disorder is a severe anxiety-related condition characterised by attacks that include symptoms like chest pain and difficulty breathing. Results from our previous studies show that up to 50% of Accident and Emergency (A&E) patients with chest pain meet the criteria for panic-related anxiety, but fewer than 1% are evaluated for panic symptoms or treated for anxiety in the A&E. It is important to identify and treat these patients when they first come to the A&E to prevent poor long-term outcomes, unnecessary return visits, and hospitalisations for panic symptoms. A new treatment model called stepped-care has been proposed to efficiently treat patients with panic symptoms, but has not been tested in an A&E. This study will examine the impact of stepped-care treatment on panic symptoms, quality of life, daily functioning, mental health, medical service use, and costs to the healthcare system. We will compare stepped-care to screening alone for 212 patients with panic symptoms recruited from the Singapore General Hospital A&E over a three-year period. We will use the results of this study to recommend an effective strategy to treat panic patients in the A&E, which is likely to reduce healthcare costs and improve long-term outcomes for patients with panic symptoms.

Dr Tan Siew Wei Gavin
Consultant
Department of Surgical Retina,
Singapore National Eye Centre
Assistant Professor
Duke-NUS Medical School

Novel Multimodal Imaging in Moderate Diabetic Retinopathy to Predict Vision-Threatening Stages of Retinopathy

Fueled by globalisation of diabetes and increasing lifespan among people with diabetes, diabetic retinopathy (DR) has remained the leading cause of preventable vision loss among working-aged people worldwide. Of 380 million worldwide with diabetes mellitus (DM), one in ten has vision-threatening DR (VTDR). Early identification of VTDR is a key starting point for patients in receiving sight-saving treatment. The major limitations of current DR management is the inability to accurately identify patients at a higher risk of development of VTDR, as traditional risk factors account for only a limited amount of this risk. Therefore, there is a need to improve risk stratification for VTDR. Novel imaging modalities have been developed to improve our assessment of diabetic retinopathy and vascular changes in the retina. Imaging features identified on these modalities may be able to predict progression of DR. In our current proposal, we aim to assess the use of multimodal imaging to stratify the risk of progression to VTDR in persons with pre-existing non-proliferative DR. This study will develop the use of multimodal imaging to improve the management of persons with diabetic retinopathy and enrich our understanding of the longitudinal vascular changes and pathophysiology in the progression of diabetic retinopathy.

Dr Teo Wan-Yee
Clinician-Scientist
National Cancer Centre Singapore &
KK Women's and Children's Hospital
Assistant Professor
Duke-NUS Medical School

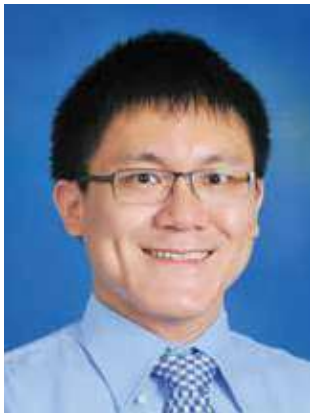
Development of Preclinical Drug Screening Strategies to Target Unmet Therapeutic Needs in a Treatment-Resistant Aggressive Model of Paediatric Germinoma

Paediatric brain cancer is the leading cause of death in childhood cancer. Germinoma is a brain cancer which occurs more frequently in Asia/East-Asian regions than Western countries. Although most children with germinomas are long-term survivors with chemo-radiotherapy, we observed that there is a group of aggressive germinomas which are universally lethal, and these tumours occur in infants and very young children. Moreover, 10-15% of all germinomas fail all standard therapy. Cancer cell lines are cancer cells derived from patient tumour samples, grown in plastic dishes. Brain cancer mouse models can be created by injecting patient tumour cells into a mouse brain to mimic the original patient tumour location. These cell lines and mouse models are commonly used in laboratory research to test the effectiveness of new drugs on specific cancers. However, there are no germinoma cell lines nor mouse models, which impedes drug testing. We have developed the first germinoma cell line and mouse model from a patient with aggressive germinoma. In this study, we propose to use this cell line and mouse model as drug discovery platforms to test a panel of shortlisted FDA-approved drug candidates, which can be rapidly translated into bedside clinical trials directly relevant to Asia.

Dr Hemant Vijaykumar Unadkat
Clinician Scientist
National Dental Centre Singapore
Assistant Professor
Duke-NUS Medical School

A Biomaterials Approach for Endodontic (Dental Pulp) Regeneration

Excessive decay or damage to a tooth affects the innermost layer of the tooth which is called dental pulp. To prevent any further pain either the tooth has to be extracted or repaired. The process for repairing such teeth is called root canal treatment. This treatment consists of complete removal of the pulp and replacing it with an inert material called gutta-percha. This procedure makes the tooth dead, as dental pulp is a storehouse of cells that can repair the internal hard layer called dentin. The ideal solution could be, to remove the decayed part of the tooth, disinfect it, remove the pulp and regrow new pulp tissue. The studies to regrow the pulp have mostly made use of cells or chemicals; however using this technology in a clinic is difficult. In our study we propose to modify the surface of a biomaterial in such a way that this material can attract cells from tissues surrounding the tooth. The attracted cells can then enter the pulp cavity and differentiate themselves into pulp cells thereby growing the pulp tissue. Thus we shall be able to restore the natural dental pulp with its reparative capacity.



Dr Yeo Joo Guan
Consultant
Division of Medicine,
KK Women's and Children's Hospital
Assistant Professor
SingHealth Duke-NUS Paediatrics
Academic Clinical Programme,
Duke-NUS Medical School

Interrogation of Childhood Onset Systemic Lupus Erythematosus Immunome for the Elucidation of Disease Mechanisms

The pathogenesis of SLE involves multiple derangements that disturb the fine balance between immunity and regulation. Traditional approaches that focus on the role of one cell type or molecule at a time are inadequate for the study of a multi-factorial disease like SLE. The lack of a holistic understanding of the lupus immunome is a critical unmet need. We hypothesise that abnormalities in multiple components of the immune system contribute to lupus pathogenesis. To address this and other unmet needs, we will use a multi-dimensional approach, using a new technology, mass cytometry, to interrogate different parts of the lupus immunome simultaneously. This will characterise a large number of immune markers, which is not possible with traditional flow cytometry, followed by identifying the different cell populations responsible for the disease or worsening of the condition (flare). Subsequently, these cell populations will be prioritised, based on how strongly it is associated with the disease activity, for mechanistic characterisation to elucidate the pathogenic pathway. This approach has the immediate translational potential of identifying cell populations useful for the prediction of disease outcome, and the unraveling of the disease mechanisms will be important for the development of better therapy against SLE.

Talent Development Programmes

NMRC Research Training Fellowship

The NMRC Research Training Fellowship aims to provide doctors and health science professionals with the training necessary to become clinician scientists. Medical doctors registered with the Singapore Medical Council, dental surgeons registered with the Singapore Dental Board, health science professionals and biostatisticians are all eligible to apply. The fellowship covers both overseas research training and graduate research degree programmes at local or overseas institutions. Awardees of the fellowship receive funding for salary and tuition fees for local graduate degree programmes, or allowances and other benefits in line with the host institution's policies for overseas research attachments.

MOH Healthcare Research Scholarship – Master of Clinical Investigation (MCI)

This scholarship aims to encourage clinicians to pursue advanced clinical research training through the MCI programme at the Yong Loo Lin School of Medicine, National University of Singapore. The scholarship covers the tuition and research fees for the programme.

Talent Development Award Recipients

NMRC Research Training Fellowship

16 recipients were awarded the NMRC Research Training Fellowship.

Name	Institution and Type of Training	Project
Dr Chee Hoe Kit	NDCS Part-time overseas PhD	Periodontal Health and its Impact on Diabetes: Inter-Relationships between Diabetes Mellitus, Periodontitis & Cardiovascular Disease
Dr Lao Zhentang	SGH Part-time local PhD	Characterisation of GIGFY2 Function in Haematopoiesis and a Novel GIGYF2 Frameshift Mutation in Acute Myeloid Leukemia
Mr Li Ruijie	NHG Full-time overseas PhD	Statistical Methods for Process Evaluation in Randomised Clinical Trials
Dr Liew Tau Ming	IMH Part-time local PhD	Pre-Death Grief in Dementia Family Caregivers and its Effect on Nursing Home Admission of Dementia Patients
Dr Wan Yi Min	NTFGH Full-time overseas PhD	Neuropsychiatric Evaluation in Parkinson's Disease
Dr Leonard Yeo Leong Litt	NUHS Part-time overseas PhD	The Ischaemic Pneumbra – Using Carbon Dioxide to Sustain It and MicroRNA for Diagnosis
Dr Yeo Tianrong	NNI Full-time overseas PhD	Metabolomics in Central Nervous System Inflammatory Demyelinating Disorders Associated with Myelin Oligodendrocyte Glycoprotein Antibodies: Identifying Biomarkers and Exploring Pathogenic Pathways
Dr Barnaby Young	TTSH Part-time local PhD	A Randomised Controlled Trial of Annual versus Biannual Influenza Vaccination in the Elderly
Dr Chong Shu-Ling	KKH Full-time overseas Master's Degree	Childhood Injury Surveillance and Control – No Child's Play
Dr Victor Koh Teck Chang	NUHS Part-time overseas Master's Degree	Self-Tonometry Device for Monitoring of Intra-Ocular Pressure (STOP) for Glaucoma
Dr Grace Yang Meijuan	NCCS Full-time overseas Master's Degree	Integrated Palliative Oncology for Advanced Cancer Patients Who Have an Unplanned Hospital Admission
Dr Ng Kok Pin	NNI Overseas research attachment	Mild Behavioural Impairment in Pre-Clinical Alzheimer's Disease: Correlation of Neuropsychological Assessment and Resting State Affective Networks
Dr Lee Guek Eng	NCCS Overseas research attachment	Pregnancy after Breast Cancer: Attitudes of Young Women in the Local Context and Outcome of Interrupting Endocrine Therapy for Pregnancy
Dr Li Lingjun	SERI Overseas research attachment	Antenatal Risk Factors and Offspring Cardio-Metabolic Health in Mid-Childhood
Dr Elizabeth Tham Huiwen	NUHS Overseas research attachment	Wheat Flour Alternatives in Baked Egg and Milk Oral Challenges
Dr Than Hein	SGH Overseas research attachment	Correlation of Genomic Clonal Architecture and Clinical Outcomes in Chronic Myelomonocytic Leukaemia Treated with Hypomethylating Agents

MOH Healthcare Research Scholarship (MCI)

17 recipients were awarded the MOH Healthcare Research Scholarship - Master of Clinical Investigation (MCI).

Name	Institution and Department	Project
Dr Kenneth Chen	SGH Urology	Establishing a Genomic Correlation between Circulating Tumour Cells and Primary Tumours in High-Risk Localised Prostate Cancer – a Pilot Study
Dr Chen Yunxin	SGH Haematology	Genome-Wide Association Study to Identify Susceptibility Loci for Carfilzomib-Associated Thrombotic Microangiopathy in Multiple Myeloma Patients
Dr Huang Qingyao Daniel	NUHS Medicine	Predicting Hepatocellular Carcinoma Biological Behaviour via Circulating miRNA to Guide Management
Dr Huang Weiting	NHCS Cardiology	Exercise Stress Cardiac Magnetic Resonance and Exercise-Induced Change in Biomarkers: New Methods for Detecting Cardiac Dysfunction and Understanding Cardiac Maladaptation Physiology in Hypertension and Heart Failure with Preserved Ejection Fraction
Dr Koo Chieh Yang Christopher	NUHS Cardiology	Variation of Epigenetic Signature in the Myocardial Stress Response
Dr Lee Wai Kheong Ryan	KKH Obstetrics & Gynaecology	Immunological Changes after Local Endometrial Injury in Women with Recurrent Implantation Failure Undergoing In-Vitro Fertilisation
Dr Liew Huiling	TTSH Endocrinology	The Impact of Continuous Glucose Monitoring System on Glycaemic Status in Poorly-Controlled Type 2 Diabetes Mellitus
Dr Liong Yee Vonne	NUHS Urology	Predictive Value of Exosomes in the Diagnosis of Prostate Cancer
Dr Ma Li	NUHS Obstetrics & Gynaecology	Comparative Serum Proteomic Study between Peritoneal Endometriosis, Endometrioma and Deep Infiltrating Endometriosis Using iTRAQ-Based Quantitative Proteomics Approach
Dr Mo Yin	NUHS Infectious Diseases	Developing Intervention Against the Transmission and Colonisation Of E. Coli Sequence Type 131 with Whole Genome Sequencing and Metagenomic Shotgun Sequencing
Dr Mark Dhinesh Muthiah	NUHS Gastroenterology & Hepatology	The Role of Macrophage Polarisation in Regression of Liver Cirrhosis
Dr Oh Choon Chiat	SGH Dermatology	Design of a Next Generation Sequencing (NGS) Platform for Human Papillomavirus (HPV) Typing in Cutaneous Squamous Cell Carcinoma (SCC) in Renal Transplant Patients
Dr Oh Lingzhi Bernice	NUHS Paediatrics	Optimising Use of Immunotherapy in Acute Lymphoblastic Leukemia (ALL): Studies of Effector Cell Function Throughout Intensive ALL Chemotherapy
Dr Puar Hai Kiat	CGH Endocrinology	Curing Patients of Hypertension by Enhancing Detection of Primary Aldosteronism (PA)
Dr Tan Chun Han Nigel	NUHS General Surgery	Identification of the Tumour–Parenchyma Junction with Peptide Signatures in Hepatitis B-Associated Hepatocellular Carcinoma Undergoing Curative Hepatectomy
Dr Tham Huiwen Elizabeth	NUHS Paediatric Medicine	Analysing Skin Microbiome Dysbiosis in Caregivers for the Development of Targeted Eradication Techniques in Families of Eczema Patients
Dr Wong Keng Lin Francis	NUHS Orthopaedic Surgery	Regenerating Bone and Cartilage in Osteoarthritis using Exosomes Derived from Human Mesenchymal Stem Cells (MSCs)

Clinician Scientists in the Spotlight

Sweet Dreams Are Made Of These

What if it is possible to precisely tell if someone is going to develop diabetes mellitus – and stage an intervention program 10 years before it happens, essentially preventing it from occurring at all?

Professor John Campbell Chambers, of Lee Kong Chian School of Medicine NTU, is pursuing a research study that hopes to make this possible, and translate the results from bench to bedside.

In March 2017, Prof Chambers, who is also Professor of Cardiovascular Epidemiology at the School of Public Health at Imperial's Faculty of Medicine, received a Singapore Translational Research Investigator Award (STaR), which comes with $8 million dollars to turn his dream into reality.

Said Prof Chambers, "Although the current tools we have identify some people as being at high risk (for developing diabetes), what those tools call high risk is actually a mixture of people, some of whom are actually completely normal. They miss people who are going to go on to develop diabetes and misclassify other people as being high risk when in fact they are not."

With his project, "We are looking for the magic bullet that allows us to tell someone, "You're going to get diabetes" - 10 years before they actually do. And accuracy is everything."

Moving Science and Clinician Scientists Forward

Prof Chambers said, "Getting the STaR award is a huge privilege and recognition of the work I've done to date. I'm very deeply appreciative. This is a fantastic opportunity to push forward things of interest which I think are important in the coming years."

Making his dream reality won't be easy, he admitted. "The nature of science and research is that everything we try to do is a challenge," said Prof Chambers. To do groundbreaking research, his team will have to use techniques that nobody's used before, study samples that nobody's studied before, and use analytic approaches that to some extent need inventing from scratch.

However, he is unfazed, and feels that with the experience in this type of work that he has accumulated over 20 years, he is confident that he can put together a team and guide that team through to delivering these objectives.

He also feels a responsibility to nurture the next generation of clinician-researchers, and is now turning his attention towards getting the next generation of scientists onto the same path as him.

"To the next generation of researchers – success in medical research means working in teams," advised Prof Chambers. "Nobody in medical research nowadays succeeds by working in isolation. Success means collaboration and partnership," Clinician scientists, he suggested, also need to innovate. "Always question what you're told. Challenge every assumption, challenge every statement and think about how you can come up with a better understanding of the way the world works."

Lastly, he pointed out that what matters is retaining health – diabetes, cancer, the big diseases that really threaten human life. In other words, if you are going to choose a problem to tackle in research, choose something important.

STAR AWARD
Prof John Campbell Chambers
Professor
Lee Kong Chian School of Medicine, Nanyang Technological University

"To the next generation of researchers – success in medical research means working in teams. Nobody in medical research nowadays succeeds by working in isolation. Success means collaboration and partnership."

Leading The Way For Clinician Scientists

STAR AWARD

Prof Chng Wee Joo

Director
National University Cancer Institute, Singapore

Senior Consultant
Department of Haematology-Oncology, National University Hospital

Professor
Yong Loo Lin School of Medicine, National University of Singapore

Deputy Director
Cancer Science Institute of Singapore National University Health System

Having received the National Outstanding Clinician Scientist Award in 2016, and faced with the need to renew his research funding, Professor Chng Wee Joo was encouraged by his hospital to apply for the STaR Award in 2017.

But he wasn't so sure about his chances.

"Balancing clinical work as well as outstanding research is very hard. Most of the people who have gotten (the award) are no longer seeing patients, no longer practicing clinicians like me," said Prof Chng.

Indeed, most of the STaR awards over the years have been given to overseas professors of international renown.

"So I was really very very pleased, a bit surprised and very proud to be one of the few Singaporeans to get it, while being a clinician scientist who still does get to see quite a fair bit of patients. And for me to be in the company of these fantastic scientist-researchers is of course very gratifying." he added.

The challenges however have been manyfold. An increase in the number of medical schools in Singapore today means clinician scientists have to compete for grants against other high calibre investigators. Plus, because successful research takes time, Prof Chng faced the additional challenges of having to constantly position his work to win new grants in order to see his projects through to completion.

Thankfully, Prof Chng persevered. And he hopes younger doctors will, too.

You Are Not Alone

Said Prof Chng, "I hope this recognition will help inspire others because we do need more clinician scientists. We are important to bridge the research that we have been investing so much into doing in Singapore, and seeing the results translated into something that is effective in the clinic."

He also emphasised the importance of always remembering their reasons for pursuing this path in the first place. "Be convinced that there is a greater good in it, cherish your love for science and the process of discovery, and always be pure and true to this, because along the way you will have many difficulties and you may feel like it is not worth trying so hard. But you cannot be someone who gives up easily or who cannot take rejection," said Prof Chng.

> "Feel confident that there is a group of mentors, people like me and others. We are quite happy to provide guidance. With our support we can help you through this difficult process."

What he has achieved is luminary. Over the last couple of years, a number of results from his research in blood cancers have been translated into the clinical setting. One application is the use of genetic markers in clinical practice - rather than treating everyone the same way, we now have a way of stratifying patients. Some newer models of treatment have also been developed: rather than treating patients intensively in hospital, they can now also be treated in outpatient settings. This reduces costs to the patients, improves quality of life and sometimes reduces side effects.

Lastly, he said, "Feel confident that there is a group of mentors, people like me and others. We are quite happy to provide guidance. With our support we can help you through this difficult process."

Biomarkers for the Prediction of Cognitive Impairment and Dementia

Associate Professor Christopher Chen remembers the advice he received when he first applied for a research fellowship in the United Kingdom. He said, "I recall Bryan Matthews, the Professor of Neurology in Oxford advising me never to forget that being able to perform research was a great privilege."

It was only later that colleagues told him of how Prof Matthews had started off as a busy solo clinical neurologist in a very unfashionable part of England, and that it was with clinical acumen and perseverance that he had become a leading academic. "He knew how precious the opportunity was," said A/Prof Chen.

Then after his fellowship, as he prepared to return home for a clinical post at SGH, he was encouraged by Professor John Newsom-Davis, who had succeeded Bryan Matthews as Professor of Neurology, that he should do his best to "ringfence" time for research. Said A/Prof Chen, "He knew only too well how busy and intense clinical practice could be."

Sure enough, A/Prof Chen found it always a struggle to reconcile clinical and research responsibilities. He said, "At SGH I was blessed with supportive and brilliant colleagues in stroke and dementia: Wong Meng Cheong, Chang Hui Meng, Deidre de Silva and Alex Auchus. But it soon became clear that continuing as we were was not globally competitive."

Hence, A/Prof Chen feels a deep and abiding sense of gratitude for the awards and grants he has received from NMRC. The CSA-SI award, he said, provides immense help in terms of funding and continuity, and more importantly, protected time to focus on research, thinking, planning, execution, writing and networking.

His research aims to provide clinicians with better screening and assessment tools, and reliable blood and imaging biomarkers for diagnosis and prognosis, as well as treatment targets, so as to achieve effective therapies and outcomes for the common causes of cognitive impairment and dementia such as cerebrovascular lesions and Alzheimer's Disease.

He faces several challenges. The early stages of cognitive impairment and dementia are insidious and hence often difficult to recognise and diagnose, while the later stages are a challenge to develop effective treatments for, given the severity of pathology and the frailty of patients. He added that Singapore lags behind other areas in funding and recognition too.

Research is a Privilege, Be Ready for Opportunities

Even though the work is challenging, A/Prof Chen maintains that it is an honour to be able to spend time and resources on research, to work on improving the lives of our patients, and to work with colleagues who are equally passionate.

And he believes that there is no sweeter experience for a researcher than to identify a worthwhile problem, recognise a possible solution, fail, fail, and fail again but eventually succeed and find that it helps fellow human beings.

"So be enthusiastic, don't listen to naysayers but do take well-meant advice from mentors," advised A/Prof Chen. "Enjoy success but take criticism and rejection constructively. Have clear but not fixed ideas and be ready to run with opportunities to develop them."

"Be enthusiastic, don't listen to naysayers but do take well-meant advice from mentors. Enjoy success but take criticism and rejection constructively. Have clear but not fixed ideas and be ready to run with opportunities to develop them."

CLINICIAN SCIENTIST AWARD (SI)
A/Prof Christopher Chen Li Hsian
Visiting Senior Consultant & Associate Professor
Department of Psychological Medicine
Yong Loo Lin School of Medicine,
National University of Singapore
Director
Memory Aging & Cognition Centre,
National University Health System

Improving Adult Vaccination Through Research

Associate Professor Jenny Low thinks statins can weaken an adult's immune responses to vaccination. And when she received the Clinician Scientist Award (Investigator) from NMRC in 2017 to investigate this hypothesis, she was absolutely delighted.

A/Prof Low said, "The older adult's immunity response to vaccines is actually not very well studied. How do their immune responses to vaccines differ from otherwise healthy adults not taking statins? That's the gist of the project."

An infectious diseases physician by training, A/Prof Low's primary interest is translational medicine, and her main interest is in how the scientific community can respond rapidly in an outbreak situation.

CLINICIAN SCIENTIST AWARD (INV)

A/Prof Jenny Low Guek Hong

Senior Consultant
Department of Infectious Diseases, Singapore General Hospital

Associate Professor
Duke-NUS Medical School

Statins work very well for lowering cholesterol, observed A/Prof Low, but people who are on statins may also have a poorer immunity response to vaccines, because statins have anti-inflammatory properties.

She added, "If statins knock out an adult's innate inflammatory response, then his or her adaptive immunity will not be as good, resulting in a poorer outcome for any mass-vaccination program."

Faster, Better Herd Immunity

The impact of the project could be tremendous. "If we have to mass vaccinate people to protect them during an outbreak, then we need to know how drugs interact and interfere with immunity, because that will have an impact on how to achieve herd immunity," said A/Prof Low.

Her goal is to prove that the way we think about vaccinations in the adult population needs changing. "Our strategy has to be different from the way we vaccinate children. We cannot assume that if it works in children, it will work in adults. And we cannot assume that if it works in adults, it can work in all types of adults," said A/Prof Low.

This study will play a key part in her research pipeline. "Once we have proved the hypothesis that adults taking statins have different responses in terms of antibodies, we can then go on to investigate how we can achieve the kind of antibody response that we want them to achieve, or at least design strategy that will overcome this poorer response," said A/Prof Low.

Stay Positive, Ask For Help

Have a medical hypothesis that you want to prove through research?

A/Prof Low advises, "Have a lot of perseverance. It needs a lot of hard work, no doubt about it. Stay positive even if the study doesn't seem as if it is going smoothly - there are always hiccups and problems. Always stay positive and don't be afraid to ask for help."

Also, collaboration is important. "Today in modern medicine and science we work as a team and as a group. Everybody has to bring something different to the table: different perspectives, ideas and questions - and we all work together to find the solutions."

She added, "I alone cannot profess to know everything about the immune system, all the vaccines and all the statins. Therefore I work with people who have (relevant) domain expertise, and that's how the project can move along."

"Have a lot of perseverance. It needs a lot of hard work, no doubt about it. Stay positive even if the study doesn't seem as if it is going smoothly - there are always hiccups and problems. Always stay positive and don't be afraid to ask for help."

Growing from Strength to Strength

When Dr Teo Wan-Yee from Duke-NUS Medical School received NMRC's Medical Research Fellowship Award 10 years ago, the path as a clinician scientist was an un-walked path.

Reflecting on her journey thus far, Dr Teo said, "Back then, few in the local medical field knew what the term clinician scientist meant. I was treading on uncertain grounds - unsure of where this clinician scientist journey would lead to – would it be a dead end?"

Her career was nurtured at Texas Children's Cancer Centre, Baylor College of Medicine, Houston, USA, as a paediatric neuro-oncologist, and today, she is making a difference in the field of paediatric brain tumours as a clinician scientist.

Now, she is glad that she went with her leap of faith. "Today, the clinician scientist is a real entity in Singapore. It is pretty awesome to see how our healthcare landscape has changed. This is a completely different path, which presents different challenges. Being the pioneer batch to set out in this path clearly came with an additional layer of challenges. Good vision and wise resource management are important. Academic medicine is relatively young in Singapore, compared to mature academic centers in USA. The arrival of Duke-NUS in Singapore was strategic and timely, and the evolving SingHealth Duke-NUS Academic Medical Centre (AMC) is vibrant and constantly exciting," said Dr Teo.

Since her return, she has established a dynamic lab unit, Paediatric Brain Tumour Research Office (PBTRO) at SingHealth Duke-NUS AMC, with competitive grants she managed to secure. Her goal in research is to derive findings that enable a reflective change in the practice of medicine. Her team (PBTRO), said Dr Teo, shares a common dream to present globally competitive research findings in the field of neuro-oncology, addressing these areas in the practice of medicine through science.

In March 2017, her efforts were recognised with another NMRC award. The TA will, Dr Teo said, allow her to give her best shot at making a difference in the field. "Both awards I received from NMRC were crucial. The first Fellowship award led me to the path to acquire the knowledge and training in the specialised field of paediatric neuro-oncology. The TA will allow me to expand my research and build up my lab in Singapore, as a local platform to transform global health in brain tumours."

Step into the Unknown

She has these words of advice to offer to her mentees and juniors who wish to pursue her path as a clinician scientist: "Step into the unknown. It will take courage." She shared that there was a recent interview when she was asked if she sees herself as a clinician or a scientist. "I said actually neither, I see clinician scientists as a disruptive innovation. Clinician scientists may look like an odd fit at first, but the practice of medicine is changing rapidly with science, so clinician scientists will become very useful in the development of our future healthcare ecosystem which will be well aligned with science. These have to be individuals who can look at health care needs in a fresh perspective for patients in the near future, and step ahead with preparatory research."

"It's uncomfortable not knowing where each step will take you in this journey, but with every step, you are growing, and growing stronger. Stretch and believe. It will prepare you for the next level."

She concluded, "Multiplication and sustainability should be the core model to lay our foundation in academic medicine and developing the breed of clinician scientists. Alongside with my research, I also teach an interesting curriculum at Duke-NUS Medical School, it gives me an avenue to mentor medical students into residency, to help them grow in different fields for our future healthcare landscape."

TRANSITION AWARD

Dr Teo Wan-Yee

Clinician Scientist
National Cancer Centre Singapore & KK Women's & Children's Hospital

Assistant Professor
Cancer & Stem Cell Biology Program, Duke-NUS Medical School

Course Director (Practice Course 4)
Medical Education, Research & Evaluation Department, Duke-NUS Medical School

Principal Investigator
Paediatric Brain Tumour Research Office, SingHealth Duke-NUS Academic Medical Centre

"It's uncomfortable not knowing where each step will take you in this journey, but with every step, you are growing, and growing stronger. Stretch and believe. It will prepare you for the next level."

Research Grants

Funding Translational and Clinical Research

The funding of translational and clinical research (TCR) is one of the core pillars of NMRC's mandate. To carry out this function, NMRC offers several grant programmes that support small-scale and large-scale Singapore-based research initiatives covering a broad spectrum of biomedical sciences.

To ensure that its limited funds are put to the best possible use by funding the best science, NMRC awards all of its research grants on a competitive, peer-reviewed basis.

NMRC's competitive grant programmes are divided into two main categories:

NMRC-Funded/Managed Grants

The category supports research on a programme level and different types of investigator-led studies via the following grant schemes:

- Centre Grant (CG)
- Clinical Trial Grant (CTG)
- Clinician Scientist Individual Research Grant (CS-IRG)
- Clinician Scientist Individual Research Grant New Investigator Grant (CS-IRG-NIG)
- Health Services Research Research Grant (HSRG)
- Health Services Research Competitive Research New Investigator Grant (HSR-NIG)

Open Fund Grants

The objective of the Open Fund is to fund the best ideas, through competition, to support individual and collaborative research that is aligned with RIE2020's vision for the Health and Biomedical Science (HBMS) domain: to be a leading centre that advances human health and wellness, and creates economic value for Singapore and Singaporeans, through the pursuit of excellence in research and its applications. Under RIE2020, NMRC will be administering the Open Fund grants on behalf of the HBMS EXCO and the funding agencies (A*STAR, MOE, MOH, NRF).

The category is supported via the following grant schemes:

- Open Fund - Large Collaborative Grant (OF-LCG)
- Open Fund - Individual Research Grant (OF-IRG)
- Open Fund - Young Individual Research Grant (OF-YIRG)

NMRC-Funded/Managed Grants

Centre Grant

The Centre Grant (CG) funding framework aims to support the public healthcare institutions/clusters to build up their core research capabilities in terms of common research platforms, shared equipment and core manpower. To better realise the RIE2020 healthcare goals, the RIE2020 funding framework further seeks to enhance collaborative and transdisciplinary research productivity.

Under the RIE2020 CG framework, there were two funding opportunities - Main Centre and Collaborative Centre. Applicants were also encouraged to focus on one of the RIE2020-prioritised therapeutic areas of research: cancer, cardiovascular diseases, diabetes mellitus and related metabolic/endocrine disorders, infectious diseases and neurological & sense disorders; as well as address translational medicine & implementation science research, health systems research, primary care research or population health research.

Main Centre

Entity	Title
CGH	Enhancing Disease Management across the Continuum of Care at Changi General Hospital
IMH	Population, Clinical, Systems and Services Research Programme
KKH	Improving the Outcomes of Women and Children Health in Singapore - An Integrative Translational Research Programme
NCCS	Translating Cancer Science into Clinical Impact
NCIS	Development of Novel Therapeutics and Biomarker-Directed Strategies in Refractory Solid Tumours and Haematological Malignancies
NHCS	National Heart Centre Singapore Centre Grant
NNI	Translational Clinical Research in Neuroscience
NUHCS	Solving Cardiac Epigenetics, Remodelling and Repair (SCEPTRE)
NUHS	Diabetes, Tuberculosis and Neuroscience
SERI	Optimisation of Core Platform Technologies for Ocular Research (INCEPTOR)
SGH	Strategic Multi-Theme Approach to Translational Medicine (SMART II)
TTSH	Personalised Medicine for the Singapore Population

Collaborative Centre

Entities	Title
CDC, NUHS, SGH	Collaborative Solutions Targeting Antimicrobial Resistance Threats in Health Systems
CDC, TTSH	Strategic Alliance to Host Critical Research Infrastructure for Epidemic and Endemic Infectious Disease
CGH, KTPH, NUHS, SERI, TTSH	Singapore Imaging Eye Network
IMH, NHGP	Primary Health Care Research in Multimorbidity and Mental Health in a Multi-Ethnic Population (PRIME)
KKH, NCCS, NDCS, NNI, SGH	Transforming the Future of Oral Healthcare - A Clinical, Translational and Health Services Research Approach
KKH, NHGP, SHP	Integrated Platform for Research in Advancing Metabolic Health Outcomes in Women and Children
KTPH, NUHS	Common and Complex Chronic Conditions - Focusing on Cohorts and Clinical Epidemiology
NCCS, NUHS, SGH, TTSH	Targeted Therapy for Blood Cancer (TETRAD)
NCIS, NTFGH	Improving Cancer Outcome in Western Singapore through Collaborative Research
NHCS, NUHCS	Implementing a Partnership for Cardiovascular Trials
NSC, TTSH	Translational and Implementation Research: The Next Phase at the National Skin Centre, Singapore
NUHS	Singapore Population HEalth ImpRovement Centre (SPHERiC)
SHS	Developing a Population-Based, Unified, Learning System for Enhanced and Sustainable Health - The PULSES

Clinical Trial Grant

In RIE2015, the Clinical Trial Grant (CTG) was a strategic initiative launched in late 2012 to support clinicians carrying out clinical trial studies for the development of novel therapies, moving promising ideas from bench to bedside, to improve health outcomes. There are three schemes under the CTG programme:

Year	Proposals Reviewed	Grants Awarded	Total Sum Awarded ($ millions)
2016	16	10	16.41

1. The **Co-Development Scheme (Co-D)** supports clinical trial projects carried out via a public-private partnership (PPP) model in which a clinician collaborates with an industry partner. The clinician can apply for Co-D funding for 50 percent or less of the total project cost. An industry partner must provide co-investment (either cash or in-kind contributions) representing 50 percent or more of the total project cost. The quantum for Co-D funding is up to $5 million over five years. The Co-D scheme is open throughout the year.

2. The **Investigator-Initiated Trials – Early Phase Scheme (IIT-E)** supports investigator-initiated Phase I and II clinical trials carried out by clinicians. The scheme should preferably support the development of locally produced assets, ideas and compounds. Partnership with industry for carrying out the trial is optional. The quantum for IIT-E funding is up to $7 million over five years. The IIT-E scheme grant calls were made twice a year.

3. The **Investigator-Initiated Trials – Late Phase Scheme (IIT-L)** supports investigator-initiated Phase III and IV clinical trials carried out by clinicians. Partnership with industry for carrying out the trial is optional. The quantum for IIT-L funding is up to $4 million over five years. The IIT-L scheme grant calls are made twice a year.

In RIE2020, the CTG is revamped to include two schemes:

1. The **Industry Collaborative Trials Scheme (ICT)** supports clinical trials of strategic industry partnerships that are important for the development of the clinical trials landscape in Singapore. ICTs involve both clinician and company contributing intellectual inputs. and funds to conduct the trial and developing novel or pre-existing drugs/medical device/interventions for new indications. The prerequisite for application is PI's ability to obtain industry contribution of at least 70% (cash or in-kind) of the Total Project Costs (TPC). The PI can apply for up to 30% of the TPC (inclusive of 20% indirect costs). Funding for each project is open and for up to five years. The ICT scheme is open throughout the year.

2. The **Investigator-Initiated Trials Scheme (IIT)** supports IITs of both early and late phases which are initiated and driven by clinicians who are interested to conduct clinical trials on novel or pre-existing drugs/ medical device/interventions for new indications. These may possibly result in foreground intellectual property (IP) and collaboration with companies is optional. Funding for each project is up to $1.5mil (inclusive of 20% indirect costs) for up to five years.

Clinician Scientist-Individual Research Grant

Clinician Scientist-Individual Research Grants (CS-IRGs) are provided to clinician scientists to enable them to carry out medical research on a specifically defined topic for a period of three years in a local public institution. The focus of the research should be translational and clinical in nature. The quantum supported for CS-IRGs is up to $1.5 million over a period of three years. CS-IRG grant calls are made twice per year.

Period	Proposals Reviewed	Grants Awarded	Success Rate	Total Sum Awarded ($ millions)
May 2016	60	10	16.7%	12.82
Nov 2016	73	10	13.7%	14.38
Total	**133**	**20**	**15.2%**	**27.20**

CS-IRG New Investigator Grant

The CS-IRG New Investigator Grant (CS-IRG-NIG) is a sub-category of the CS-IRG that is targeted specifically at new clinical investigators. The CS-IRG-NIG is intended to serve as a career stepping stone, providing new investigators with their first independent national-level grant. Applicants with substantial research experience are not eligible to apply for this grant. The quantum supported for CS- IRG-NIGs is up to $200,000 over a period of two years.

Period	Proposals Reviewed	Grants Awarded	Success Rate	Total Sum Awarded ($ millions)
May 2016	25	6	24.0%	1.44
Nov 2016	29	6	20.7%	1.44
Total	**54**	**12**	**22.3%**	**2.88**

Health Services Research Grant

The Health Services Research Grant (HSRG) is a MOH research grant which aims to promote the conduct of HSR and enable the translation of HSR findings into policy and practice. HSRG grant calls are open twice a year.

Period	Proposals Reviewed	Grants Awarded	Success Rate	Total Sum Awarded ($ millions)
Jul 2016	47	10	21.3%	8.23
Dec 2016	26	6	23.1%	7.65
Total	**73**	**16**	**20.3%**	**15.88**

Health Services Research New Investigator Grant

The New Investigator Grant (HNIG) subcategory of the HSRG was launched with the aim to support new HSR researchers. The quantum supported for this new subcategory is $100,000 over 2 years. The HNIG grant calls are open twice a year, along with the HSRG grant calls.

Period	Proposals Reviewed	Grants Awarded	Success Rate	Total Sum Awarded ($ millions)
Jul 2016	16	4	25.0%	0.36
Dec 2016	11	2	18.2%	0.23
Total	**27**	**6**	**21.6%**	**0.59**

Open Fund Grants

Open Fund-Large Collaborative Grant

The Open Fund- Large Collaborative Grants (OF-LCGs) aim to support the best teams of researchers from public institutions to advance human health and wellness, and create economic value for Singapore and Singaporeans, through the pursuit of excellence in research and its applications.

They represent a unique opportunity to bring together investigators from across all of Singapore with the clinician scientists and clinical investigators in the hospitals and Academic Medical Centres.

Key elements include:

- Collaboration within as well as between the basic and clinical research communities; and interdisciplinary collaboration across institutions is important to integrate, coordinate and leverage on the full spectrum of research capabilities in Singapore from basic science to clinical research.
- Aim to make significant contributions to the advancement of study of therapeutic areas and help establish Singapore as a global leader.
- Facilitate the discovery and application of basic science ideas for the following, where pathway to impact should be clearly articulated:
  - Advancement of health, including the translation of clinical findings into practices and policies; and
  - Supporting industry sectors integral to HBMS economic strategy, including PharmBio, MedTech, Food & Nutrition and Personal Care.

A total of $275mil has been secured from the National Research Foundation (NRF) Singapore's Research, Innovation and Enterprise (RIE) 2020 Open fund to provide opportunities for new large collaborative programmes to be funded and existing ones to be renewed on a competitive basis. Each grant provides funding of up to $25mil (inclusive of 20% indirect cost) for over up to 5 years.

The OF-LCG is open to proposals of the highest quality across the breadth of disciplines relevant to its mission. To better realise the goals of Health and Biomedical Sciences (HBMS) in Singapore, the following five therapeutic areas have been identified as national priorities:

- Infectious diseases
- Diabetes mellitus and related metabolic/ endocrine disorders
- Cancers
- Cardiovascular diseases
- Neurological and sense disorders

Grant Call	Therapeutic Area(s) Emphasised	Set Theme(s)
May 2016	Infectious diseases	• Respiratory Tract Infection (RTI) & Pandemic/ Emerging Infectious Diseases (EID) • Antimicrobial Resistance & Healthcare-Associated Infections • Dengue & Vector Control
	Diabetes mellitus and related metabolic/ endocrine disorders	• Microvasculature Complications of Diabetes

For each grant call, themes will be set in two/three therapeutic areas to focus on issues of particular national interest.

The HBMS community is encouraged to address these themes. The table above shows the therapeutic areas and set themes emphasised for the first grant call launched.

The review process is two-stage, comprising a Letter of Intent (LOI) and full proposal for shortlisted LOI applicants. The success rate and details of the awardees of the grant call(s) launched up to FY16 are tabulated in the table below:

Period	Letters of Intent Received	Full Proposals Reviewed	Grant Awarded	Success Rate	Total Sum Awarded ($ millions)
FY16	10	4	1	10%	24.94

Awarded Programme	Research Area	Leadership Team (Institution)
DYNAMO: Diabetes studY on Nephropathy And other Microvascular cOmplications	Diabetes mellitus and related metabolic/endocrine disorders - Microvasculature Complications of Diabetes (within set theme)	**Lead PI/Corresponding PI** • Prof Thomas Coffman (Duke-NUS) **Theme PIs** • Prof Tai E Shyong (NUS) • Prof Wong Tien Yin (SNEC/SERI) • A/Prof Lim Su Chi (KTPH)

Open Fund-Individual Research Grant

The Open Fund Individual Research Grant (OF-IRG) is provided to support the conduct of research proposals in basic and translational clinical research that are relevant to human health and wellness as well as research that looks at the causes, consequences, diagnosis, prevention and treatment of human diseases. The OF-IRG will provide a funding quantum of up to S$1.5 million per project (inclusive of 20% indirect costs) for up to 5 years.

Period	Proposals Reviewed	Grants Awarded	Success Rate	Total Sum Awarded ($ millions)
Nov 2015	168	18	10.7%	25.38
May 2016	128	15	11.7%	19.22
Total	**296**	**33**	**11.2.%**	**44.60**

Open Fund-Young Individual Research Grant

The Open Fund - Young Individual Research Grant (OF-YIRG) is a subcategory of the OF-IRG. The OF-YIRG is a step for the new investigator towards a first independent national level grant. The OF-YIRG will provide a funding quantum of up to S$0.3 million per project (inclusive of 20% indirect costs) up to 3 years.

Period	Proposals Reviewed	Grants Awarded	Success Rate	Total Sum Awarded ($ millions)
Nov 2015	93	12	12.9%	6.21
May 2016	56	18	32.1%	5.34
Total	**149**	**30**	**22.5%**	**11.55**

Enablers and Infrastructure Grants

In RIE2020, MOH continues to develop, maintain and enhance enabling infrastructure to support healthcare research strategy and the clinical trial landscape. The enablers and infrastructure grants supported are:

Bioethics Advisory Committee (BAC) and Centre for Biomedical Ethics (CBmE)
The BAC was established in 2000 to examine ethical, legal and social issues arising from research on human biology and behaviour and its applications; and to develop and recommend policies to the Singapore Government, on legal, ethical and social issues, with the aim of protecting the rights and welfare of individuals, while allowing the biomedical sciences to develop and realise their full potential for the benefit of humankind.

Under the funding initiative, the CBmE focuses on capacity-building and fostering an ethically responsible scientific community through academic bioethics teaching and its training modules on research integrity (e.g. publication ethics, patenting the use of new discoveries, navigating potential conflicts of interest). It also seeks to grow a cadre of national bioethics experts at CBmE, the BAC Secretariat, and among Singapore's clinician researchers (in particular, leading clinician researchers and NMRC grant-holders) by assembling working parties to publish and widely disseminate position papers on important developments in translational science and medicine to engage the scientific community in consensus-building and debate.

Biomedical Sciences Industry Partnership Office (BMS IPO)
The BMS IPO was set up in Jun 2010 as a single point-of-contact for companies that wish to establish research and development (R&D) collaborations spanning across multiple Singapore public sector research and healthcare institutions. Specifically, it is responsible for acting as the liaison between companies and public institutions in dealing with issues that may arise and for ensuring that funding commitments by the companies are translated into actual research projects with the public institutions. It will also manage such interactions in a coordinated and strategic manner and assist in troubleshooting administrative and policy matters that can only be resolved at the national level. Hosted and funded by the Agency for Science, Technology and Research (A*STAR) since inception, it also receives funding from MOH, and the Economic Development Board (EDB) since Apr 2011.

Clinical Research Coordinators (CRCs)
A new funding initiative under RIE2020, funding was allocated to support a core group of CRCs and set up the national training and certification programme for CRCs, with the aim to retain this critical pool of talent and strengthen the clinical trial landscape and support in Singapore. Support for the CRCs is vital, as they assist to identify suitable patients for recruitment to clinical trials, hence ensuring rapid patient recruitment and timely completion of clinical trials. The national training and certification programme provides a structured training programme to ensure the high quality of the trials.

Health Sciences Authority (HSA) Cell Therapy Facility
A new funding initiative for RIE2020, the HSA Cell Therapy Facility serves as a neutral, Good Manufacturing Practice (GMP) certified, public sector wide infrastructure asset available to medical professionals and scientific researchers from public sector healthcare and academic research centres. The facility is established to be the national research and translational service for manufacturing and production of high quality cell therapy products for safe and affordable administration to patients, under the International Good Manufacturing Practice (GMP PIC/S) standards. This will serve as an enabler of research while providing the infrastructure, scientific know-how and technical expertise needed to support the evolving field of cell therapy, together with its potential health and economic benefits.

Institutional Review Boards (IRB)
IRB funding aims to enhance the capabilities of IRBs in the public health sector, to ensure rigour in the ethics review process for the protection of human research subjects. This will also facilitate them to achieve minimum standards laid out in the MOH IRB OG (Operational Guidelines) and other legislative requirements upon their eventual implementation. It has been supporting the SingHealth Centralised Institutional Review Board (CIRB) and the National Healthcare Group Domain Specific Review Board (NHG DSRB) to work towards building true capabilities in the funded IRBs and seeking improvement in standardising ethics reviews as well as protection of research subjects.

Investigational Medicine Units (IMUs)
In 2007, the two IMUs at the National University Health System and Singapore Health Services (SingHealth) were established, co-funded by NMRC. The IMUs aim to provide supporting infrastructure for clinician-investigators, such as dedicated space and beds for in-patient and outpatient research, computer hardware and software systems for data management and analysis, as well as manpower "infrastructure" such as clinical pharmacologists, specialised research nurses and biostatisticians. The IMUs focuses on early phase trials (Phase 1 and 2a), preferably first-in-man type; and encourages collaborative efforts across different trial units, institutions, across clusters and outside Singapore to develop innovative thought leadership and global competitiveness.

National Health Innovation Centre (NHIC) Singapore
The NHIC Singapore was set up in 2014 as an innovation and enterprise office (IEO) for the clinical community of the publicly funded healthcare institutions. It seeks to accelerate healthcare innovation by facilitating the translation of an innovation towards a commercial endpoint, with impact on health and healthcare; and it does so through three key functions: provision of translational funding, mentoring and facilitating deal formations with companies. As a system integrator, it works closely with the clinical and research community, accreditation boards, policy-makers and appropriate end-users, setting up a network that is critical to supporting the research translation pathway. First hosted as an office under BMS IPO/ A*STAR, it has since been brought back to the MOH family in 2016 as a business unit under Singapore Clinical Research Institution (SCRI) Pte Ltd.

National Large Animal Research Facility (NLARF)
The NLARF was funded since S&T2010 to serve as a national research support facility, comprising the breeding and quarantine of large animals, large animal holding space as well as research capabilities (e.g. surgery and imaging) which will serve the local research community, especially the academic users. It provides important unique capabilities not available elsewhere in Singapore, which includes vital services such as supply of locally-available large animals for scientific uses (i.e. in-house bred High Health Status (HHS) pigs and wild-caught Non-human Primates (NHPs)) and housing of large animals on long term care or with special health status.

Research Space Funding (RSF)
RSF was provided since 2011 to support public hospitals, national specialty centres and universities in defraying utilities and maintenance costs associated with research. Its goals are to promote and reward competitive research, level the playing field in a fair and transparent manner, encourage co-funding with the institutions and reduce their cost of research. The institutions have been supportive in promoting translational and clinical research by providing research space and protected time for clinicians to do research. Hence, with the increase in research activities and costs over time, the RSF would be able to partially support these institutions in their maintenance- and utility-related expenses. The eligible RSF amount for each institution will be computed based on the percentage of its ongoing NMRC competitive grant funding (including the talent development programmes and human capital awards) the institution held in each calendar year.

Singapore Clinical Research Institute (SCRI) Pte Ltd
Established in 2008, SCRI is a national academic clinical research organisation dedicated to enhancing the standards of human clinical research. It provides core services (including clinical, biostatistical data, project management expertise, and medical informatics solutions) and infrastructure at a national level for late phase clinical research. SCRI further took on a national clinical trial coordinating role in 2014; actively engaging companies and industries, and working closely with the IMUs, BMS IPO, EDB and MOH to foster public-private collaborations as well as provide leadership in the operational and methodological aspects of clinical trials. These efforts have helped Singapore become a more attractive place for private sector investors and will continue to contribute to the enhancement of the local clinical trials landscape in the years to come.

Events

National Medical Excellence Awards 2016

The National Medical Excellence Awards (NMEA) is held annually to honour and recognise clinicians, clinician scientists and healthcare professionals for innovations in healthcare, patient safety, clinical quality, biomedical research as well as training and education of clinicians.

In 2016, the NMEA recognised four individuals and one four-member team for their outstanding contributions to clinical practice, research, education and healthcare delivery. The following awards were given out:

- National Outstanding Clinician Award
- National Outstanding Clinician Scientist Award
- National Outstanding Clinician Educator Award
- National Outstanding Clinical Quality Champion Award
- National Clinical Excellence Team Award

NMEA 2016 Award Winners

National Outstanding Clinician Award 2016

Prof Roy Chan
Medical Advisor and Senior Consultant
National Skin Centre
National Healthcare Group
Clinical Professor
Yong Loo Lin School of Medicine,
National University of Singapore
Adjunct Professor
Saw Swee Hock School of Public Health,
National University of Singapore
Adjunct Professor
Duke-NUS Graduate Medical School
Adjunct Professor (Honorary)
Lee Kong Chian School of Medicine,
Nanyang Technological University

Professor Roy Chan was a President's Scholar and graduated from University of Singapore with MBBS in 1978. After completing his Health Manpower Development Plan (HMDP) training overseas in 1988, he returned to Singapore as Consultant with National Skin Centre (NSC), a member of the National Healthcare Group.

Prof Chan served as the Director of NSC from 2004 to 2014. Under his leadership, numerous new services in medical, surgical and laser dermatology were introduced. Owing to that, NSC is now recognised as a global centre of excellence in dermatology. Prof Chan was also Chair of the Dermatology Specialist Training Committee/Residents Advisory Committee from 2008 to 2014.

Besides his work with NSC, Prof Chan was also a pioneer of AIDS Education and Awareness in Singapore. In 1988, he founded Action for AIDS (AfA), a non-governmental organisation and charity dedicated to fighting AIDS/HIV infection. His clinical expertise gave him a head start in designing treatment programmes for infected individuals in Singapore in the early days of the epidemic. He is the President of AfA since 1998.

At AfA, Prof Chan spearheaded numerous innovative educational and prevention campaigns. So far, 10 biannual Singapore AIDS conferences have been held which has increased the public's awareness on HIV-related matters. He has introduced new testing paradigms and has been instrumental in bringing affordable and accessible medications to thousands of Singaporean patients. The projects target specifically the most-at-risk populations, which falls in the the lowest incidence and prevalence of the HIV disease in these groups in the world. In addition, Prof Chan advocates for the fair and humane treatment of HIV infected persons. AfA was awarded the 2010 World Health Organisation Dr Lee Jong-Wook Memorial Prize in Public Health, an accolade awarded to entities who have made an outstanding contribution to public health.

During his years of public service as a highly-respected dermato-venereologist, Prof Chan's expertise has been extensively tapped by local, regional and international medical communities. Other than being a long-serving member in the Governing Council of the International AIDS Society, he is also the Head of the National STI Control Programme from 1992 till today. During this period, innovative STI/HIV prevention programmes have been implemented and brought to scale. These programmes are central to the successful control of HIV and STI among sex workers, masseuses and their clients. These widely-acknowledged control and intervention programmes have been the major reasons for the relatively low level of HIV infection in Singapore.

In 2009, Prof Chan was nominated by the Ministry of Health and conferred the prestigious Queen Elizabeth II Gold Medal awarded by United Kingdom's Royal Society for Public Health (RSPH). The medal is awarded to individuals for their outstanding contribution towards public health and health promotion within the Commonwealth. With over 100 peer-reviewed publications, Prof Chan continues to be involved in research activities. In 2013, he took on the role of the Skin Research Institute of Singapore's Executive Director (Clinical).

For his outstanding work and dedication to HIV prevention and care that spans almost three decades, as well as his continued significant contributions to public health, Professor Roy Chan is awarded the National Outstanding Clinician Award 2016.

National Outstanding Clinician Scientist Award 2016

An accomplished haematologist, Professor Chng Wee Joo is an exceptional clinician scientist. His research in blood cancers translates scientific discoveries into clinical applications, improving patient outcomes.

Prof Chng has made significant contributions to the use of genetics and genomics in understanding disease biology as well as their use in clinical applications in blood cancers, in particular myeloma, acute myeloid leukaemia and lymphoma. Some of these methods are already employed in routine clinical care today, such as the sequencing and analysis of myeloma patients' DNA to stratify them into different risk groups which allow doctors to tailor their treatment accordingly.

With a clear focus on seeking innovations, Prof Chng has also pioneered new ways to deliver cancer treatment. Prof Chng played a pivotal role in the introduction of the first outpatient autologous stem cell transplant for myeloma, which was performed at the National University Cancer Institute, Singapore (NCIS) in 2011. He also headed the Bortezomib@Home programme, where myeloma patients can choose to have their injections for Bortezomib, a chemotherapy drug, administered by a nurse outside the NCIS specialist outpatient clinics.

Prof Chng has been instrumental in establishing key infrastructure and building research in haematology at NCIS and the Cancer Science Institute of Singapore. This includes providing training and mentorship to students and doctors, expanding the capacity, scale and scope of trial activities in haematology, and building an environment and culture that is conducive to research. Through the efforts of Prof Chng and his team, NCIS was one of the top recruiters in a global randomised controlled trial for a new chemotherapy drug called Carfilzomib for myeloma, results of which has led to the approval of the drug for clinical use.

Thanks to Prof Chng's contributions, drive and passion, NCIS is now a world-renowned centre for haematology; sought after by doctors, both local and overseas, for training; companies for clinical trials and by patients seeking the best care in Singapore.

In addition, as Prof Chng has established an international standing, he currently leads international efforts in various research areas, especially for myeloma. He became the first Asian member in the International Myeloma Working Group to lead a consensus guideline project. Besides setting up the Asian Myeloma Network (AMN), he spearheaded its clinical trial efforts. In particular, he completed the first AMN clinical trial, recruiting 100 relapsed myeloma patients across Korea, Singapore, Taiwan and Hong Kong over a relatively short 15 months, which is a significant achievement.

For his outstanding contributions and achievements in research in the field of blood cancers that have led to improved patient outcomes and better understanding of the diseases, Professor Chng Wee Joo is awarded the 2016 National Outstanding Clinician Scientist Award.

Prof Chng Wee Joo
Director
National University Cancer Institute, Singapore
Senior Consultant
Department of Haematology-Oncology, National University Hospital
Professor
Yong Loo Lin School of Medicine, National University of Singapore
Deputy Director
Cancer Science Institute of Singapore
National University Health System

National Outstanding Clinician Educator Award 2016

A/Prof Pang Weng Sun
Chairman, Medical Board
Yishun Community Hospital
Alexandra Health System
Vice Dean (Clinical Affairs)
Lee Kong Chian School of Medicine
Nanyang Technological University

Associate Professor Pang Weng Sun has dedicated his career to developing medical education to meet the needs of Singapore's ageing society. A caring clinician, whom colleagues describe as "one-in-a-million", A/Prof Pang is a passionate teacher who nurtures the human touch in those he teaches. His passion for teaching and his compassion for patients make him an impeccable mentor for medical students and senior doctors alike.

A pioneer in the fields of geriatric and palliative medicine, he is one of the founding practitioners who built, shaped and developed the training of both specialties and services, in which he instilled a teaching culture that remains to date.

A/Prof Pang was Chairman of the Geriatric Medicine Specialist Training Committee, now called the Geriatric Medicine Resident Advisory Committee, a role he holds until today.

He was actively involved in setting up the Graduate Diploma in Geriatric Medicine in the NUS Division of Graduate Medical Studies in the 90s, which has evolved into two programmes, the Graduate Diploma in Geriatric Medicine and the Graduate Diploma in Geriatric Medicine Staff Residency Scheme. A/Prof Pang assisted in teaching the doctors' course in Palliative Medicine initially organised by Hospice Care Association and later taken over by Singapore Hospice Council; as well as in developing hospital-based palliative care services at Tan Tock Seng Hospital.

Besides impacting service development in the community, especially community hospitals and nursing homes, A/Prof Pang also taught extensively in both geriatric and palliative medicine for community hospitals and nursing staff, including doctors and nurses. As the Vice-Dean for Clinical Affairs, A/Prof Pang played a pivotal role in the establishment of the Lee Kong Chian School of Medicine (LKCMedicine), a partnership between Nanyang Technological University (NTU Singapore) and Imperial College London, including curriculum development. He continues to be involved in teaching and engaging the clinicians from the School's healthcare partners.

A/Prof Pang's wisdom and ability to inspire and engage his clinical colleagues has been critical to the progress of LKCMedicine. His personal engagement with medical students, particularly those who are finding the path difficult to navigate, exemplifies his quiet and effective manner of providing pastoral care.

For his tireless dedication and unwavering commitment to improving patient care, A/Prof Pang has been recognised with a number of awards, including Outstanding Doctor of the Year Award from Tan Tock Seng Hospital in 1998, a Healthcare Humanity Award in 2005, Public Administration Silver Medal in 2012 and Singapore Medical Association Merit Award in 2014.

A/Prof Pang has also been a great role model to many clinicians, during his previous appointments as Head of the Department of Geriatrics and the Chairman of Medical Board at Alexandra Hospital. Currently Chairman of the Medical Board at Yishun Community Hospital, A/Prof Pang continues to be a mentor to many. He spends time and effort to teach, advise, coach and counsel individual doctors, inspiring many to become better doctors, exemplary in both clinical capabilities and character.

For his outstanding contributions and exemplary dedication to advancing medical education and training to address the needs of ageing societies in Singapore and beyond, Associate Professor Pang Weng Sun is awarded the National Outstanding Clinical Educator Award 2016.

National Outstanding Clinical Quality Champion Award 2016

Mr Wu Tuck Seng is a steadfast champion for quality who has had an illustrious career in hospital pharmacy over the past 29 years. A keen advocate for safety, quality and productivity, he has led numerous multi-disciplinary and multi-institutional programmes and initiatives.

Mr Wu conceptualised and led the development of the Outpatient Pharmacy Automation System (OPAS), a joint initiative by NUH, Tan Tock Seng Hospital, National Healthcare Group Pharmacy and Integrated Health Information Systems (IHiS). The pharmacy at National University Hospital's (NUH) Medical Centre operates on this system that is regarded as a world-class innovation for its ability to incorporate automation in box picking, loose tablet picking, packing, capping and labelling, as well as RFID technology. OPAS integrates locally developed software with internationally sourced robots for the fully automated system to function seamlessly. It reduces wait time, improves patient safety and enables work redesign for staff. The initiative won numerous awards including the Ministry of Health (MOH) Health IT Excellence Award 2014, 1st Runner Up of the National Infocomm Award 2014 and HIMSS Asia-Pacific Elsevier Digital Healthcare Award 2015.

Mr Wu also played a vital role in successfully implementing the Closed Loop Medication Management System (CLMMS) in NUH wards in 2009 to reduce human errors, enhance patient safety and improve operational efficiency. A first in the Asia-Pacific, the CLMMS won two national awards - National Infocomm Awards 2010 and PS21 Gold Award 2011.

Under Mr Wu's leadership, NUH Department of Pharmacy received 38 NUH quality improvement project awards since 2010, many of which were for multi-disciplinary projects involving other departments. Significant programmes introduced by the department include:

- NUH's first Outpatient Anticoagulant Clinic in 1996, which has since developed into a hospital-wide anticoagulant service led by pharmacists, supported by haematologists, for both inpatients and outpatients;
- The NUH Antibiotic Stewardship Programme in 2009 to ensure appropriate and cost-effective use of antibiotics;
- Implementation of a 24/7 Pharmacist Service in 2011 to provide comprehensive and safe patient service after hours;
- Inpatient Diabetes Mellitus (DM) Management Programme in 2013 to reduce hypoglycaemic incidents in DM patients.

A firm believer in the quality development of future generations of pharmacists, Mr Wu is responsible for many key changes in the training of pharmacists. He was instrumental for the introduction of Singapore's first part-time post-graduate Masters in Clinical Pharmacy with the University of South Australia which focuses on advancing practicing pharmacists' pharmacotherapy knowledge and skills. In 2012, he established Singapore's first Post Graduate Year 1 (PGY1) Pharmacy Residency programme at NUH, a foundation training programme for aspiring clinical pharmacists.

Mr Wu's contributions to the field of pharmacy span beyond the grounds of the National University Health System (NUHS). He is the President of the Singapore Pharmacy Council and Chairperson of the MOH National Medication Safety Committee. As Vice-Chairman of the National Pharmacy Landscape Steering Committee, Mr Wu played a significant role in the development of the National Pharmacy Strategy 2015 – a 10-year plan, endorsed by MOH, to transform pharmacy practice and the provision of pharmacy services in Singapore.

For his outstanding contributions and extraordinary dedication to innovation and leadership in providing the highest level of safety, quality and productivity in pharmaceutical services to public healthcare in Singapore, Mr Wu Tuck Seng is awarded the National Outstanding Clinical Quality Champion Award 2016.

Mr Wu Tuck Seng
Deputy Director and Head
Department of Pharmacy,
National University Hospital
National University Health System

National Clinical Excellence Team Award 2016

Diabetic Kidney Disease (DKD) is the leading complication that arises from poorly controlled diabetes. Nearly one in two diabetic patients evaluated between 2006 and 2009 at the National Healthcare Group Polyclinics (NHGP) had DKD. More worryingly, DKD is the leading cause of end stage kidney failure in Singapore. Nevertheless, optimal control of diabetes, early detection and management of its complications, including DKD, at primary care can avert the progression of the disease. Previous studies have also shown that the progression of DKD can be slowed down by keeping blood pressure under control and treating albuminuria, which is elevated levels of protein in the urine, with full or maximally tolerated doses of medications such as Angiotensin Converting Enzyme Inhibitors (ACEi) or Angiotensin II Receptor Blockers (ARB).

Recognising this, a team from the National University Health System (NUHS) and NHGP, the primary healthcare arm of the National Healthcare Group, set up a kidney disease work group in 2010 to devise a strategy to manage albuminuria and blood pressure in DKD patients and to reduce the rate of progression of DKD at primary care. With funding from the Ministry of Health, a strategy for Nephrology Evaluation, Management and Optimisation (NEMO) of DKD among patients on follow-up at the NHGP was implemented in 2011.

In preparation for NEMO, the National University Hospital (NUH), the tertiary care hospital of NUHS, and NHGP leveraged on good teamwork and identified key obstacles to optimising drug doses in patients, established drug protocols to achieve target blood pressure, to reduce albuminuria and to deal with complications of treatment, and developed tailored solutions for individual polyclinics. In addition, the team shared valuable knowledge on kidney disease management with stakeholders by holding talks on DKD and its management for physicians at all nine polyclinics under NHGP. Through its efforts, selected polyclinic doctors became designated renal champions in each polyclinic to help drive NEMO.

10 Allied Health personnel, known as NEMO Coordinators, were also trained and a Coordinator deployed to each of the polyclinics under NHGP to help coordinate care. With the help of Information Technology, the NEMO Coordinators screened and identified patients with early DKD for recruitment into the NEMO programme; counseled the recruited patients on DKD, its risks and the need for the treatment to prevent progression; assisted doctors at NHGP in coordinating the drug optimisation and tracked the results and outcomes.

As a result of these efforts, 54% of the 9,015 patients who had enrolled since 2011, have undergone drug optimisation. Of these, 20% saw normalisation of urine albumin levels while 10% saw an improvement and went from having late to early stage DKD.

Overall, the NEMO programme has demonstrated that medications such as ACEi or ARBs can be used safely in primary care to delay progression of DKD and significant proportions of DKD patients may be averted from the ravages of kidney failure requiring dialysis or kidney transplantation. More importantly, the programme has demonstrated that by focusing on goals and by developing a management plan, a team comprised of doctors and coordinators can implement changes in patient care to improve outcomes.

Following this success, plans are underway to roll out NEMO beyond polyclinics under NHGP to those which are under the SingHealth Group. In early 2016, NEMO was rolled out to Queenstown Polyclinic under the SingHealth Group. The team also hopes to expand the strategy to other healthcare institutions subsequently.

For their outstanding contributions and achievements in developing a collaborative approach to providing optimal care for Diabetic Kidney Disease patients at the primary care level and finding ways to slow down the progression of the disease to end stage kidney failure, the team from NUHS and NHGP is awarded the National Clinical Excellence Team Award 2016.

NEPHROLOGY EVALUATION, MANAGEMENT AND OPTIMIZATION (NEMO) PROGRAMME

Dr Loh Ping Tyug
Co-Director, NEMO Programme
Senior Consultant
Division of Nephrology,
University Medicine Cluster
National University Health System

Prof A Vathsala
Director, NEMO Programme
Senior Consultant
Division of Nephrology,
University Medicine Cluster
National University Health System

Dr Lim Chee Kong
Co-Director, NEMO Programme
Family Physician & Consultant
Deputy Director, Clinical Services
National Healthcare Group Polyclinics

Ms Ong Shih Hui Samantha
Programme Manager,
NEMO Programme
Division of Nephrology,
University Medicine Cluster
National University Health System

NMRC Awards Ceremony and Research Symposium 2017

In 2017, the NMRC Awards Ceremony and Research Symposium were held concurrently during a one-and-a-half day event that attracted about 300 leading clinician scientists, researchers and other key players in the field of biomedical research. Held at Grand Copthorne Waterfront Hotel Singapore on 7 and 8 March 2017, the event recognised the clinicians and researchers for their achievements and contributions to the continuous improvement of care for patients, and also provided a useful platform for networking and collaborations amongst the many individuals from the healthcare institutions, academia and industry.

One of Ministry of Health's key priorities for this year is to promote Research to improve Care Outcomes, which aims to encourage innovative ideas that can future-proof our healthcare system in Singapore. With the theme "Research for a Better Future", NMRC hopes that this year's event provides the platform for fostering stronger collaborations towards research excellence and better healthcare outcomes for a better future.

Awards Presentation

The NMRC Awards Ceremony is a platform where the awardees under the NMRC Human Capital and Talent Development Programmes, namely Singapore Translational Research (STaR) Investigator Award, Clinician Scientist Award (CSA), Transition Award (TA), MOH Healthcare Research Scholarship (MCI) and NMRC Research Training Fellowship, are recognised and honoured. The Guest of Honour was Permanent Secretary (Health), Mr Chan Heng Kee.

This year, we invited 4 overseas experts to share their experience and research work in the area of Cardiovascular Diseases, Cancer, Neurological and Sense Disorder and Health Services Research. We had the privilege to have Professor Paul Zimmet from Monash University, who is also the Honorary President of the International Diabetes Federation, to share on "The Rise and Rise of Diabetes: Tackling a Global and Asian Health Crisis". We also had the opportunity to hear from Prof Patrik Brundin, Associate Director of Research at the Van Andel Research Institute, on "Elucidating Causative Mechanisms and Trying to Slow Parkinson's Disease Progression" and Prof Andrew Roberts, who is the Metcalf Chair of Leukaemia Research from the University of Melbourne, on

"Partnership to Develop Novel Drugs: Not Easy, But Essential". Lastly, we also had Prof Junichi Sadoshima, Professor and Chair of the Department of Cell Biology and Molecular Medicine at Rutgers New Jersey Medical School, speak on "Regulation of Myocardial Growth and Death by the Hippo Pathway: The Role of the Hippo Pathway during Heart Failure".

Research Symposium

The Research Symposium is a platform to promote and inculcate the spirit of translational clinical research in Singapore's biomedical and healthcare research landscape. For the event this year, recipients of NMRC-administered grant programmes, clinicians and researchers in the clinical community and industry were invited to join us at the symposium for two days of knowledge exchange and networking with the research community of Singapore.

Day One concurrent sessions took off after the Awards Presentation, with parallel sessions on Cardiovascular Diseases, Infectious Diseases, Neurological and Sense Disorder, and Diabetes Mellitus and Related Metabolic/Endocrine Disorders. The day came to an end with a wine and cheese reception, providing a comfortable networking platform for industry, clinical and research community participants to explore collaboration opportunities after the forum discussions.

The workshops continued on Day Two with parallel sessions on Cancer and Health Services Research. The parallel sessions spanning over the one and a half days covered key strategic research areas which we hope to drive translational biomedical research in. A total of 30 local and overseas experts were featured in the session.

Participants also had a chance to visit the exhibition posters during break times, and these posters showcased projects undertaken by our Translational and Clinical Research (TCR) Flagship Programme grantees and our STaR awardees.

Health and Biomedical Sciences International Advisory Council Meeting 2016

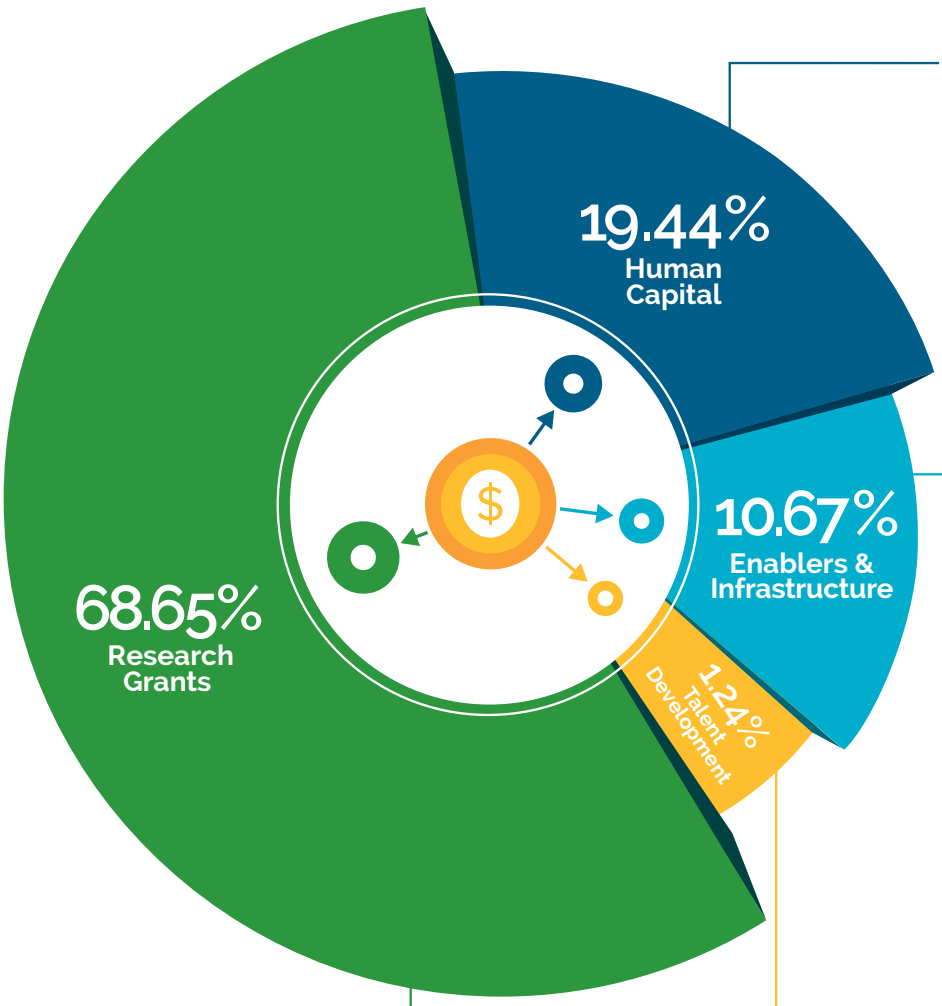
On 11–12 Oct 2016, Singapore's Health and Biomedical Sciences International Advisory Council (HBMS IAC) held its annual meeting. The HBMS IAC members were consulted and provided their views on the integrated HBMS strategy for Research, Innovation and Enterprise 2020 (RIE2020). Chaired by Sir Richard Sykes, the meeting centred around innovation and enterprise in RIE2020, including the role of translational vehicles in drug discovery and diagnostics; value capture strategies for the Food and Nutrition and Consumer Care clusters; and the development of R&D roadmaps for national priority areas to capture health and economic value.

In RIE2020, public research agencies plan to develop an ecosystem that better enables translation of research to improving health outcomes, including greater emphasis on Health Services Research to contain healthcare costs and transform and enhance the efficiency of health services delivery. To better realise the goals of HBMS in Singapore, the following five priority therapeutic areas have been identified as national priorities: Cancer, Cardiovascular Disease, Metabolic Disease, Infectious Disease and Neurological & Sense Disorders. Expert taskforces have been formed to conduct deep dives in each of the five priority areas. The recommendations from the taskforces will guide our funding priorities, as well as help us to address some of the gaps in the current research ecosystem.

The HBMS IAC commended the integrated HBMS strategy, in particular the setting of research themes to guide large-scale programmatic funding and the requirement for researchers to articulate pathways to impact in their research proposals. The HBMS IAC emphasised the need for a public engagement strategy, to seek public understanding and support for continued investment in HBMS R&D and greater public participation in research. Beyond the emphasis on economic value, there was also focus on improving health outcomes and better health costs effectiveness. HBMS R&D should seek to bring products to market and improve public health at the same time.

Overview of Fund Commitment in FY2016

Overall funding distribution for NMRC funding initiatives (FY2016)



$95.8 million
Human Capital
STaR *(3 awardees)*
CSA *(22 awardees)*
TA *(12 awardees)*
CS/CISSP

$52.6 million
Enablers & Infrastructure Grants
BAC & CBmE *($6 million)*
IRBs *($13 million)*
HSA Cell Therapy Facility *($18.3 million)*
RSF *($15.25 million)*

$240.6 million
NMRC-Funded/ Managed Grants
CG *(25 projects)*
CS-IRG *(20 projects)*
CS-IRG-NIG *(12 projects)*
HSRG *(16 projects)*
HSR-NIG *(6 projects)*

$81.1 million
Open Fund Grants
OF-LCG *(1 project)*
OF-IRG *(33 projects)*
OF-YIRG *(30 projects)*

$16.5 million
Clinical Trial Grant
CTG *(10 projects)*

$6.1 million
Talent Development
33 Scholars & Fellows

National Medical Research Council
#09-66 Harbourfront Centre,
1 Maritime Square (Lobby C),
Singapore 099253
Email: moh_nmrc@moh.gov.sg