

ENHANCING HEALTHCARE THROUGH RESEARCH

National Medical
Research Council

Annual Report
2014

National Medical Research Council

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To promote excellence in translational and clinical research, nurture a vibrant research community of clinicians and scientists in Singapore, and enhance knowledge translation for health and economic outcomes.

Promoting Research
Excellence

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The overall goal of NMRC is to get healthcare institutions ready to do research and facilitate the conduct of research.

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Message from Chairman

Translating Discoveries Into Practical Applications

The current funding tranche that is about to end (2011-2015) saw significant achievements for Translational and Clinical Research (TCR) and provided a further push for Singapore's biomedical development. Our support at National Medical Research Council (NMRC) in providing funds and resources has led to a rapid expansion of high quality translational research in Singapore.

The overall goal of NMRC is to get healthcare institutions (HI) ready to do research and facilitate the conduct of research. We have greatly increased the number of clinician scientists and investigators, and two academic medical centres were developed to further expand TCR – National University Health System, and the SingHealth and Duke-NUS Academic Medical Centre.

The NMRC-funded TCR programmes' performance exceeded well beyond expectations and has benefited the Singapore community in a number of ways, including advances in the treatment for cancer and dengue as well as new approaches in managing conditions such as dengue. It is clear that even within a short period of time, our investments are beginning to pay off.

However, how do we sustain the growth of TCR for the next phase? How do we turn new discoveries and findings into practical and useful tools for healthcare improvement and economic development? To address this, the next funding tranche aims to realise the fruits

of the first two phases and transform them into something useful for the Singapore community as well as reduce cost and improve quality. Our new National Health Innovation Centre (NHIC) will be a vehicle that will further expand by providing resources to translate discoveries into real world applications. In its very first year, there has been a massive interest in participating in NHIC funding schemes – a testament to the interest, curiosity and innovativeness of our clinicians.

In the next phase, NMRC will also add new programmes to facilitate two particular areas – Health Services Research (HSR) and Ageing. We hope to expand HSR further, translating research into practical clinical use in the hospital system by identifying and funding health services and health systems research within the HIs. For ageing, we will build and focus our efforts on helping the increasingly ageing population deal with medical and social issues.

NMRC remains focused on cancer stem cells, heart diseases, diabetes, neuroscience (brain conditions such as dementia) and infectious diseases (primarily viral diseases) and eye disease. At the same time, NMRC will continue to foster and fund innovation through individual research programmes in other areas.

NMRC will continue to sustain this rapidly growing ecosystem to transform research discoveries into real and useful healthcare tools.

Prof Ranga Krishnan
Chairman

Message from Executive Director

Pushing the Envelope in Translating Research into Healthcare Outcomes

Biomedical Sciences (BMS) is an important part of Singapore's Research, Innovation and Enterprise (RIE) 2015 Plan. The National Medical Research Council (NMRC), under the Ministry of Health (MOH), has been playing a key role in driving many of the BMS initiatives under RIE2015. As we draw towards the end of RIE2015, it is timely to reflect not just on the past year, but also on the whole of RIE2015 thus far.

RIE2015 started on 1 April 2011. NMRC has been actively involved in developing and running many of the BMS programmes under RIE2015, including the Singapore Translational Research (STaR) Investigator Award, the Translational and Clinical Research (TCR) Flagship Grant, the Clinician Scientist Award, the Centre Grant Programme and the Singapore Clinical Research Institute (SCRI). As at 1 May 2015, NMRC has given out about 130 Talent and Manpower Awards, \$900 million of research project grants and more than \$100 million of infrastructure grants under RIE2015. Many of the programmes have generated important academic, economic and healthcare outcomes. These have been highlighted in the rest of this Annual Report, as well as in the various NMRC Annual Reports since the start of RIE2015. It has also been encouraging to see the young talent that have been developed as part of the programmes, with nearly 120 young investigators receiving Transition Awards and New Investigator Awards. Importantly, we also helped make improvements to many of the systems and infrastructure needed to support these talents in their research work, such as establishing more streamlined national clinical trial processes.

Nevertheless, much more work needs to be done. In particular, there is an urgent need to develop our ability to better translate research into healthcare outcomes. Improving healthcare outcomes through research is a key goal of NMRC. However, without effective mechanisms in place to facilitate the translation of research into such outcomes, we would not be able to realise the full potential of the research that we support. Related to this is the development of our Health Services Research (HSR) capability. HSR can play a big role in improving healthcare outcomes and it is important to ensure that this area of research is adequately resourced, with a clear national HSR strategy.

Finally, on a more personal note, as I reach the end of my term as Executive Director of NMRC, I am grateful to have worked with many capable and committed colleagues in NMRC as well as elsewhere in MOH. I am thankful for the support and guidance of Permanent Secretary Tan Ching Yee and Director of Medical Services Benjamin Ong, as well as their predecessors and the rest of the MOH leadership and management. I thank the three Chairmen of NMRC whom I have had the privilege of working with, namely Professors Edward Holmes, Donald Tan and Ranga Krishnan, and also appreciate the strong cooperation and support from colleagues in the wider healthcare community and other BMS agencies. I extend a warm welcome to Tricia Huang as the next Executive Director of NMRC and wish her and all NMRC staff the very best as they continue the important work of NMRC and take it to greater heights.

A/Prof Tan Say Beng
Executive Director

“Improving healthcare outcomes through research is a key goal of NMRC.”





Supporting
Breakthroughs
in Medicine

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 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.

Under the Research, Innovation and Enterprise (RIE) 2015 plan, Singapore has earmarked \$16.1 billion over a five-year period (2011–2015) to fund research and innovation in a variety of sectors, including biomedical and life sciences research. 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.

Human capital plays a key role in the success of Singapore's translational and clinical research industry. Having a critical mass of clinician scientists is crucial for providing thought leadership and driving the translation of bench discoveries to bedside applications to improve human health. As such, NMRC actively supports clinician scientists with funding through research grants, human capital awards and talent development programmes. Under Singapore's Biomedical Sciences (BMS) Initiative Phase III (2011–2015), NMRC is stepping up its efforts to boost the number of clinician scientists in Singapore from around 80 in 2010 to 160 by 2015.

Since its inception, NMRC has supported over 300 clinicians with scholarships, fellowships and various talent development awards. The Council has also built up the translational and clinical research capabilities in Singapore through the funding of more than 1,900 competitive research projects and nine Translational and Clinical Research Flagship Programmes. To ensure that the budget is appropriately managed and optimally utilised, NMRC also evaluates the outcomes of the research projects it funds and facilitates the commercialisation of research findings.

NMRC Board

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 the Ministry of Health (MOH) and the Biomedical Sciences Executive Committee (BMS Exco), 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.

As of FY14, the NMRC Board consists of 17 members.

Board Members



Prof Ranga Krishnan
Chairman
National Medical
Research Council



A/Prof Tan Say Beng
Executive Director
National Medical Research Council



Prof Edward Holmes
Senior Fellow
Agency for Science, Technology
and Research (A*STAR)



Prof Ivy Ng
Group Chief Executive Officer
SingHealth



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



Dr Anand Tharmaratnam
Senior Vice President and
Head of Clinical Development
Quintiles Asia-Pacific



Prof John Wong Eu Li
Chief Executive
National University Health System



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



Prof Ian D. Graham
Professor
Epidemiology and Community
Medicine, University of Ottawa



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



Dr Benjamin Seet
Executive Director
Biomedical Research Council



Prof Sir Patrick Sissons
Emeritus Regius
Professor of Physics
Department of Medicine,
University of Cambridge



Prof Donald Tan
Senior Advisor
Singapore National Eye Centre



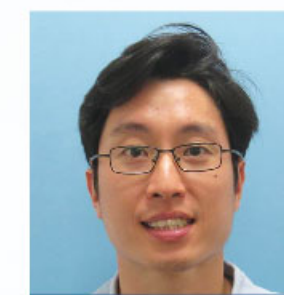
Prof Wong Tien Yin
Medical Director
Singapore National Eye Centre



A/Prof Allen Yeoh Eng Juh
Senior Consultant
Department of Paediatrics,
National University of Singapore



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



Mr Philip Ong
Deputy CEO
National Research Foundation

NMRC Funding Portfolio

Under Singapore's Biomedical Sciences (BMS) Initiative Phase III (2011–2015), NMRC continues to drive translational and clinical research (TCR) through sustained and strategic investment in three key areas: research grants, talent development programmes, and knowledge exchange and enablers.

Talent Development Programmes

In order to grow, nurture and anchor the pool of clinician scientists in Singapore, NMRC offers a range of human capital awards and talent development programmes aimed at supporting individuals in their research and career progression.

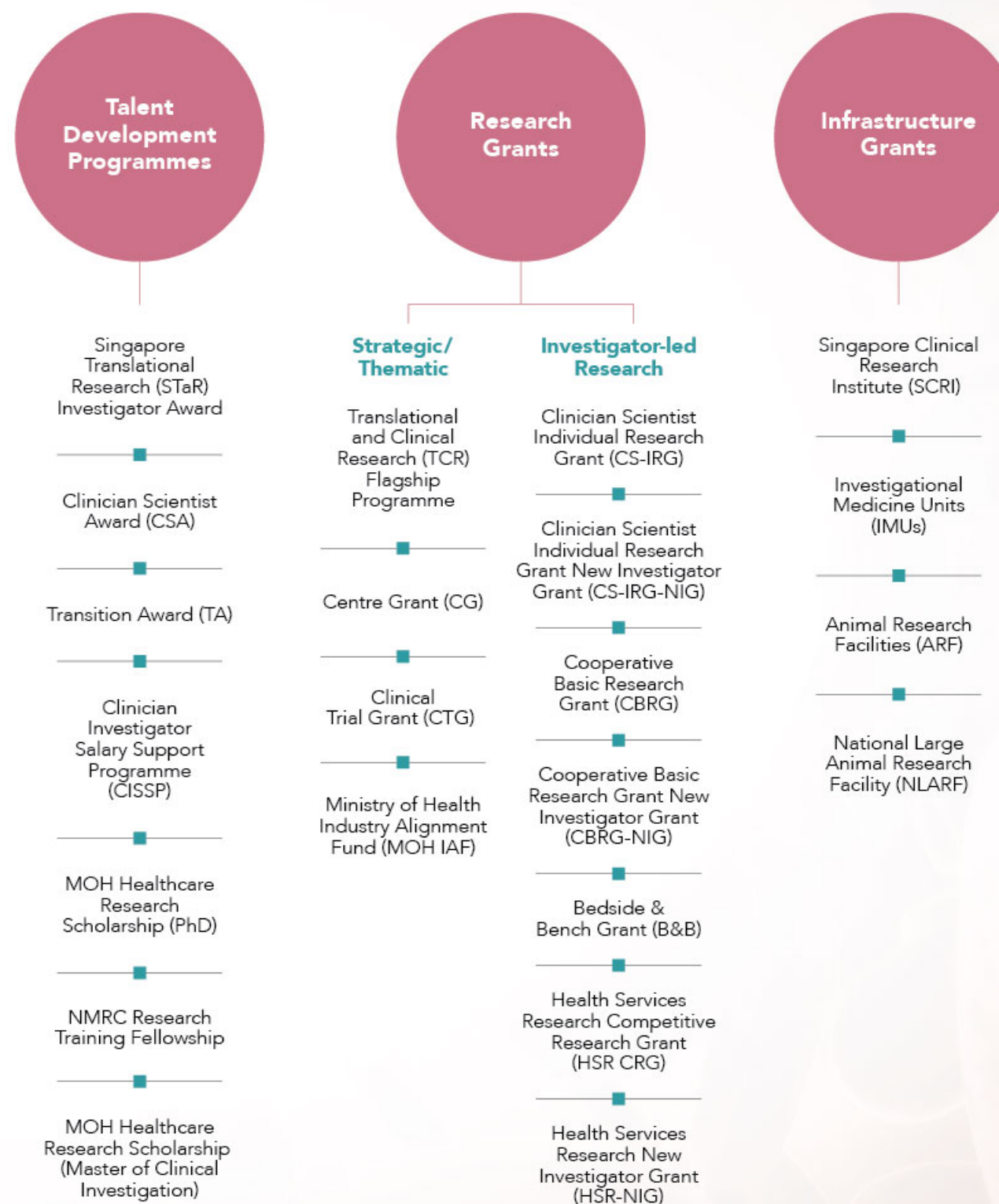
Research Grants

NMRC directly supports research initiatives through a series of competitive grants. These grants are defined as either strategic/thematic or investigator-led, allowing NMRC to support specific areas of research as well as promising individual researchers.

Knowledge Exchange and Enablers

NMRC strives to grow and strengthen Singapore's TCR ecosystem by facilitating various events and platforms that foster interactions and knowledge exchange among researchers; supporting the development of core clinical research infrastructure; and implementing new strategic research grant initiatives.

NMRC Portfolio – At a Glance





Nurturing
Clinician
Scientists

Human Capital & Talent Development Programmes

A key objective in Biomedical Sciences (BMS) Initiative Phase III is to grow the pool of clinician scientists in Singapore. Clinician scientists play a critical role in translational and clinical research (TCR): their close interactions with patients enable them to identify gaps related to causes, diagnosis and treatment of diseases, while their experience and expertise as scientists allow them to frame these clinical insights as relevant research questions.

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 eventually result in positive outcomes for patients.

Through its Human Capital Awards and Talent Development Programmes, NMRC offers comprehensive support to clinician scientists at every stage of their career, ranging from fellowship and scholarship programmes, which sponsor budding clinician scientists for local or overseas training, to prestigious awards that support excellent TCR researchers. These awards and programmes include:

Human Capital Awards

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

Talent Development Programmes

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

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 (TCR) 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. This, 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 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 (STaR) Investigator Award Recipients

Professor Aung Tin

Executive Director
Singapore Eye Research Institute
Deputy Medical Director (Research)
Senior Consultant and Head
Glaucoma Department,
Singapore National Eye Centre
Eye ACP Vice Chair of Research
Duke-NUS Graduate Medical School
Professor
Dept of Ophthalmology,
Yong Loo Lin School of Medicine



Singapore Angle Closure Glaucoma Programme: Characterisation, Prevention and Management

Glaucoma is the leading cause of irreversible blindness worldwide, with primary angle closure glaucoma (PACG) being a major form of glaucoma in Singapore and Asia. By using a collective approach,

which includes epidemiological studies, identification of new risk factors, and development of a risk prediction model, we aim to provide a customised ability to manage patients with PACG. The team plans to determine the incidence, progression, and risk of blindness among persons with PACG. We also aim to identify new risk factors for the disease, which are based on imaging, genetics and biomechanics. Following this, we plan to develop a risk-prediction model to

identify those subjects who are at greatest risk of progressing to the severe stage of disease. To collect tissues and fluids (e.g. aqueous humour) that is relevant to PACG, we also intent to set up a laboratory based biobank. Lastly, in order to develop guidelines for screening and management of angle closure, we plan to conduct a systematic meta-analysis.

Harvest of Myelodysplastic Syndrome (MDS) Deep Sequencing: BCOR and ZRSR2

A major focus of our lab is understanding the cause and thinking creatively about the treatment of acute myeloid leukemias (AML) and myelodysplastic syndromes (MDS). In a collaborative effort, we deep sequenced 1,400 MDS samples, identifying their major genomic changes and proposing a new diagnostic classification for MDS. In addition, we have chosen to focus on two genomically aberrant genes that we discovered in our DNA sequencing, which epitomise major alterations in both MDS and AML. The first is BCOR; we are learning how the abnormal gene product effects regulation of other genes. The second gene is ZRSR2, a spliceosome gene. We were the first group to discover that up to 80% of all MDS samples have mutations of this family of genes. These proteins are critical to "splice-out" introns from exons in order to generate functioning proteins. To date, no



Professor Philip Koeffler

Senior Principal Investigator
Cancer Science Institute of Singapore
National University of Singapore
Professor
Department of Medicine,
Yong Loo Lin School of Medicine
Deputy Director (Research)
National University Cancer Institute
of Singapore
National University Health System

one understands how alterations of spliceosome genes produce cancer. Understanding how mutations of the BCOR and ZRSR2 genes cause MDS and other cancers is critically important to be able to therapeutically correct the disease. Our studies will use a full range of cellular, molecular and animal related techniques and will receive help by many local and international collaborators to attack and find treatments for MDS/AML.

Clinician Scientist Award (CSA) Recipients

Professor Mark Richards

Director
Cardiovascular Research Institute
National University Heart Centre
Singapore
National University Health System

Improving outcomes in acute Myocardial infarction through reversal of early and Late cardiac remodeling (IMMACULATE study)

In Singapore, the death rate following a heart attack exceeds other Organisation for Economic Cooperation and Development countries by more than 60%, despite patients here receiving treatments recommended by clinical guidelines. A major cause for death and heart failure following a heart attack is dilatation of the heart. We seek to identify causes of



heart dilatation in patients with heart attacks using new scanning technologies and analysis of biological chemicals and proteins in the blood. We will also test a new approach to managing patients after their heart attack. This new approach incorporates telemedicine, which allows patients and healthcare providers to share information via a continuous electronic link. We will test to see if this new approach can lower a key chemical in patient's blood, NTproBNP, which is a powerful marker of whether a patient's heart dilates and leads to death after a heart attack. We will also test, in animals, a new compound to reverse heart dilatation after a heart attack. By reversing dilatation of the heart, we expect this compound to reduce the complications of death and heart failure after a heart attack.

Genomic, Functional and Therapeutic Studies of Chromatin Enzymes in Asian Cancer

Using the latest DNA sequencing technology, we have previously characterised the genetic profiles of different types of Asian cancer, which have resulted in numerous original papers in high-impact journals. We identified novel genetic alterations in these cancers that may be potentially developed into effective diagnostic and therapeutic targets.

One common scientific theme that emerges from our studies is the frequent mutations of a group of genes called chromatin enzymes, which are proteins that mainly function to regulate gene expression. They can add biochemical marks to DNA or histone, the protein that DNA wraps around.

The genetic alterations of these enzymes most likely will impact the expression of cancer genes but exactly how they contribute to cancer formation and progression remains unknown. Our proposal involves



Professor Teh Bin Tean

Professor
Laboratory of Cancer Epigenome,
National Cancer Centre Singapore
Principal Investigator
Cancer Science Institute of Singapore
Institute of Molecular and
Cellular Biology
Agency for Science, Technology
and Research

a comprehensive research programme to address this very important question. Several lines of studies are proposed, including genomic profiling and clinical correlation; establishment of cell lines and animal models; and functional and biochemical studies of chromatin enzymes. Our studies will shed light on the roles of chromatin enzymes in cancer.

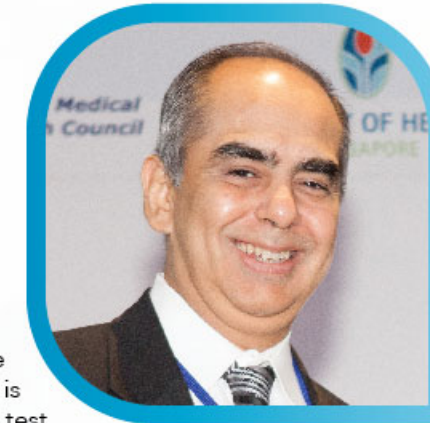
We are hoping to translate our discoveries into clinical applications, and find novel cancer drugs that can target the alteration of these chromatin enzymes.

Automated Isolation of Fetal Cells from Maternal Blood and Clinical Application Using High-Throughput Massively Parallel Sequencing for Non-Invasive Prenatal Diagnosis

Fetal cells derived from maternal blood are the Holy Grail of non-invasive prenatal diagnosis (NIPD). Although cell-free fetal DNA from maternal blood plasma have shown that fetal aneuploidy screening is possible with high detection rates, this test can only screen and cannot be diagnostic.

Prenatal diagnostic methods remain invasive and associated with a clinically-significant risk of miscarriage. If fetal cells, such as fetal nucleated red blood cells (FNRBCs) and trophoblast, could be reliably enriched and the whole genome amplified (WGA), it would be a purer source of fetal DNA.

We have shown in our previous work that we consistently enrich FNRBCs from fresh maternal blood and these cells are suitable for genetic testing. Recently, we are able to detect genetic abnormalities



Associate Professor Mahesh Choolani

Senior Consultant
National University Hospital
Associate Professor
Yong Loo Lin School of Medicine
National University Health System

from single FNRBCs from placental tissues using massive parallel sequencing (MPS).

This proposed project is a logical extension of our earlier work to bring our sorting and genetic analysis techniques towards clinical application. We hypothesise that we can (1) enrich sufficient fetal cells from maternal blood; (2) automate our novel fetal cell isolation process to aid large-scale clinical studies and applicability; and (3) establish a standard WGA-MPS method for fetal genetic analysis for NIPD.

Professor Tazeen Hasan Jafar

Professor
Program in Health Services &
Systems Research,
Duke-NUS Graduate Medical
School
Visiting Consultant
Department of Renal Medicine,
Singapore General Hospital

Management of Hypertension and Multiple Risk Factors to Enhance Cardiovascular Health – A Cluster Randomised Trial in Singapore Polyclinics

High blood pressure (BP) is a serious public health problem responsible for heart attack, stroke and kidney failure. One in three adults in Singapore has hypertension. We propose a cluster randomised trial in eight polyclinics in Singapore, where four polyclinics deliver a structured multi-component intervention and four deliver usual care. A total of 1000 adults with uncontrolled hypertension will be followed for two



years. The intervention includes (1) algorithm-driven antihypertensive treatment for all patients using fixed-dose combination and lipid lowering for high risk patients; (2) motivational conversation for high risk patients; and (3) telephone-based follow-ups of all patients by a team of physician-supervised nurse practitioners and nurses. The change in BP will be compared between intervention and control groups.

The structured care, including the above mentioned components, is likely to be more effective than usual care in lowering BP levels of patients with uncontrolled hypertension. Such a programme is also likely to be more cost-effective in terms of money spent for improving the quality of patients' lives. If successful, the findings will be informative for policymakers to roll out intervention in all polyclinics and primary care centres across Singapore, as well as other countries with similar healthcare infrastructure.

**Associate Professor
Ooi Eng Eong**

Associate Professor and
Deputy Director
Programme in Emerging
Infectious Diseases,
Duke-NUS Graduate Medical School

**Defining the Early Molecular
Interactions in Antibody-
Dependent Dengue**

An estimated 400 million people are infected with dengue each year. Without a licensed preventative vaccine, this disease is poised to spread further, as exemplified by the recent outbreaks of dengue in Florida and Mediterranean Europe. The lack of a vaccine is not for want of effort.

In fact, the World Health Organisation's coordinated initiative to develop a dengue vaccine was started 36 years ago. However, despite this effort, a dengue vaccine has remained elusive. A clinical trial of the



most advanced vaccine candidate only showed partial protection, at best, which is insufficient for practical use. A major hurdle to successful vaccine development is the incomplete understanding of the molecular basis of immunity and disease.

These two biological processes must be understood in dengue as they both utilise a common factor: antibodies. While antibodies are produced by the body to protect against re-infection by the same virus, they can paradoxically enhance infection with other types of dengue viruses. The molecular processes underlying immunity and disease development are thus necessary information to propel vaccine development forward, which is the goal of this study. If successful, this work could provide the knowledge that enables the design of an evidence-based dengue vaccine.

**Understanding Ethnic Differences
in Insulin Resistance and Obesity
Dependent/Independent Pathways
Leading to Insulin Resistance by
Studying Substrates Involved in
Insulin Signalling in Human
Myoblasts**

After a meal, insulin is produced. This makes tissues in the body (especially muscle) take up glucose, keeping the level of glucose in the blood normal. In type 2 diabetes (T2D), the muscle does not respond well, exhibiting insulin resistance (IR). IR also causes the liver to produce excessive amounts of fats/lipids, which can lead to heart disease.

Insulin binds to the insulin receptor, which modifies multiple proteins by adding or removing phosphate groups. This signals the cells to take up glucose. Many of the proteins involved in insulin signalling have not even been identified. Existing data from the fat cells of mice may not be relevant to T2D in humans. We will study human muscle cells before and after insulin



**Associate Professor
Tai E Shyong**

Head and Senior Consultant
National University Hospital
National University Health System
Associate Professor
Department of Medicine,
Yong Loo Lin School of Medicine
Saw Swee Hock School of Public
Health
Duke-NUS Graduate Medical School

stimulation to identify proteins involved in insulin signalling.

We will also compare the levels of these proteins between muscle taken from (a) Chinese and South Asians (Indians) to try to explain why South Asians are more insulin resistant than Chinese; and (b) lean and obese Chinese to try to understand how obesity results in IR. These findings could result in new drugs to treat T2D by reducing IR, lowering blood glucose and improving blood lipids.

**Study to Elucidate the Influence of
Cerebral White Matter Disease in the
Pathogenesis of Alzheimer's Disease and
Parkinson's Disease Dementia with
Combined Structural-Functional Imaging**

Preliminary findings from National Neuroscience Institute have demonstrated a high prevalence of silent strokes among Asians. Among patients with Alzheimer's dementia, the prevalence of silent strokes is as high as 70%. This prevalence among Asians is significantly higher than the reported prevalence among Caucasians. As there are no available disease modifying drugs for AD and PD, if silent strokes is proven to have a significant role in the development of AD and PD dementia, treatment strategies to manage silent strokes could become a leading treatment priority. In this proposal, we will study how silent strokes change the pattern of functional connection in the brains of patients with dementia. This will



**Dr Nagaendran
Kandiah**

Senior Consultant
National Neuroscience Institute
Assistant Professor
Duke-NUS Graduate Medical
School

allow better understanding into how silent strokes worsen dementia. Clinical trials to optimise blood pressure control and other vascular risk factors in AD and PD with silent CVD as trial outcomes may become major clinical priorities. This could potentially result in lower incidence and prevalence of dementia, a major public health problem in Singapore and globally.

Dr Khoo Chin Meng

Senior Consultant
Department of Medicine
National University Hospital
Assistant Professor
Yong Loo Lin School of Medicine
National University Health System



**A Prospective Randomised
Study to Examine Mechanisms
of Diabetes Remission
Between Sleeve Gastrectomy and RYGB Surgery**

Sleeve gastrectomy and Roux-en-Y gastric bypass surgery are the two most common bariatric surgeries to promote weight loss for people with morbid obesity. In addition to weight loss, people with diabetes experience resolution in diabetes, if not a significant improvement in diabetes control. The mechanisms that underpin the resolution in diabetes in these

bariatric surgeries are not well known. This is a prospective randomised study that aims to determine the changes in the metabolic factors that are associated with diabetes mellitus, following sleeve gastrectomy or Roux-en-Y gastric bypass surgery. Using gold-standard tools, we will accurately measure insulin secretion and insulin sensitivity. We will use mixed meal challenge test to test for changes in glucose, insulin, gut hormones, and metabolites. These measurements will be performed pre-surgery, at 3-month and at 6-month after surgery. We will also examine changes in gene and protein expression in the fat and muscle cells at surgery and at 6-month after surgery. Understanding the mechanisms that improve diabetes may help to identify a new therapy to treat obesity and diabetes, and also may help us in the choice of surgery to reduce weight and to improve diabetes.

**Customisable Circulating Tumour Nucleic
Acid Assays to Monitor Disease Burden,
Detect Known Drug Resistance
Mutations and Identify Novel Drug
Resistance Mutations in Patients with
Metastatic Gastrointestinal Cancers**

Treatment monitoring is constantly required to enable treatment decisions based on each patient's evolving clinical course. In clinical practice, blood tests or tumour markers are routinely used by doctors as convenient tests to assist doctors in monitoring patients. Some conditions do not currently have tumour markers (tumour marker negative metastatic colorectal cancer and metastatic gastrointestinal stromal tumour). Beyond treatment monitoring, there are no tests available to explain the mechanism by which treatment stopped working.



Dr Iain Tan Bee Huat

Consultant
National Cancer Centre Singapore
Assistant professor
Duke-NUS Graduate Medical School

Cancers constantly release cell-free nucleic acids into the blood. We capitalise on this phenomenon to develop "liquid biopsies" as next generation blood tests to monitor treatment outcomes and investigate why treatments fail in patients with tumour marker negative metastatic colorectal cancer and metastatic gastrointestinal stromal tumour.

Transition Award (TA) Recipients

Dr Anita Chan Sook Yee

Senior Consultant
Dept of Ocular Inflammation
and Immunology,
Singapore National Eye Center
Adjunct Assistant Professor
Clinical & Academic Faculty Affairs,
Duke-NUS Graduate Medical School

Neuroglobin in a Primate Experimental Model of Glaucoma: A novel Neuroprotectant in Glaucoma

Neuroglobin (Ngb) is a hemoglobin-like protein that is naturally present in our bodies and is involved in oxygen-binding functions. This protein is found in abundance in the brain and 100 times more in the retina of the eye. In our previous studies using mice in an acute high eye pressure model, mice with an abundance of this protein showed no retinal damage



as compared to normal mice that showed usual damage seen in acute high eye pressure. This study aims to show the role of Ngb in a monkey model of glaucoma to demonstrate the protective effects of this protein in glaucoma by injecting this protein into the eye of the monkeys with induced glaucoma.

Demonstration of protection of the nerve cells in the group of monkeys with Ngb injection when compared to the group without the injections will lead to translation into possible therapy of Ngb as a potential therapeutic agent that can be used in addition to the current glaucoma medicine. The imaging studies that will be performed as the monkeys develop nerve damage will also help develop new imaging methods for the early detection of glaucoma damage in humans.

Discovery of Biomarkers for Intrinsic Radiation Sensitivity in Asian Patients with Late Normal Tissue Toxicities Following Radiotherapy

56,316 men and women were diagnosed with cancer over the period of 2008 to 2012 in Singapore, majority of whom received radiotherapy. Of these, approximately 1 in 5 individuals will develop late side effects from this treatment in their lifetimes. These toxicities are unrelated to the acute reactions observed during radiation treatment, and typically occur between 3 months to a year post-treatment.

Although permanent, these adverse effects are mild for the most part, but in rare circumstances (<1%), patients can suffer from physically debilitating toxicities. This proposed study is intended to investigate the potential usefulness of a simple blood



Dr Melvin Chua

Associate Consultant
Department of Radiation Oncology,
National Cancer Centre Singapore

test in predicting a radiotherapy patient's risk of late side effects after treatment. If validated, this test will allow radiation oncologists to accurately select patients for intensification of radiotherapy, which could in turn enhance their chances of tumour control and cure.

Relationship of Haptoglobin Phenotype to Vascular Changes and Response to Vitamin E Supplementation in Patients with Diabetes Mellitus Type 2: The EVAS Trial

Diabetes Mellitus is associated with higher risk for heart diseases with acute ischemic heart disease being the most common cause of mortality. Although we know that the other complications of diabetes mellitus can be controlled with stricter control of hyperglycemia, the evidence for reduction of heart attacks, foot complications and stroke is still not known.

In this study, we aim to see whether a specific blood phenotype can help to predict the risk of these complications and whether this group of patients will benefit from vitamin E supplementation. We will recruit 300 subjects with diabetes mellitus type 2 and



Dr Rinkoo Dalan

Senior consultant
Dept of Endocrinology,
Tan Tock Seng Hospital
Assistant Professor
Lee Kong Chian School of Medicine

assess their Hp phenotype and other blood markers and their cardiovascular risk. We will also do an in-vitro test to see whether this particular blood group causes more endothelial cell damage (cells that line the blood vessel). We will then supplement them with vitamin E and compare with a placebo group to see whether vitamin E helps to reduce the risk. The study allows us to understand the possible mechanism of increased risk in diabetes.

Dr Kuan Win Sen

Consultant
Dept of Emergency Medicine,
National University Hospital
Assistant Professor
Yong Loo Lin School of Medicine
National University Health System

Defining Circulating MicroRNA Biomarkers for the Early Diagnosis and Prognosis of Sepsis

Sepsis arises from the body's immune response to an infection. If the inflammatory response goes into overdrive, the body's organs may be damaged. Many clinical and laboratory markers for sepsis are only detected late in the disease process when the organ damage has already occurred. The delay in recognition and initiation of treatment for sepsis leads to a high death rate. MicroRNAs are small



molecules in the body known to be master regulators of the human genome. Circulating microRNAs in the blood have been shown to be useful diagnostic markers in various diseases.

The aims of the study are to obtain a panel of microRNAs that are sepsis-specific, investigate the ability of microRNAs to prognosticate and predict response to treatment in sepsis, and assess its biological function during sepsis. We postulate that the development of a panel of sepsis-specific microRNAs will be useful for the early and accurate diagnosis of sepsis before its clinical manifestation, thus allowing clinicians to recognise patients in sepsis at an earlier stage and initiate life-saving interventions to prevent morbidity and death.

Dr Li Lingjun Queenie

Clinical Research Fellow
Singapore Eye Research Institute
Singapore National Eye Centre
Instructor
Duke-NUS Graduate Medical School

Accessing Placental Perfusion and Fetal Growth by Examining Maternal Retina During Pregnancy

Decreased uterine blood flow and smaller placental size during normal pregnancy may reduce placental perfusion and lead to fetal growth restriction. However, the role of vasculature in vivo is still unclear, because placental function is difficult to assess by ultrasonography due to its low inter/intra-rater reliability. The eye is a "window" to the human circulation and retinal blood vessels can now be captured and visualised non-



invasively by advances in retinal imaging. Recent epidemiological and clinical studies have implicated that retinal vasculature mirrors systemic microvasculature in vivo. Hence, we hypothesise that maternal retinal vasculature can reflect the placental circulation and fetal growth pattern in very early pregnancy.

This prospectively-designed cohort study will be the first group worldwide to evaluate utero-placental circulation by assessing retinal vascular parameters throughout the whole gestation. This study can potentially help researchers better understand the possible morphology of placental microvasculature through retinal vascular imaging, and how changes in maternal microvasculature in vivo may reflect fetal growth (e.g. slow fetal growth) during pregnancy.

Reactivating autologous natural killer cells to target nasopharyngeal cancer

Cancer patients have impaired immune responses to recognise and kill cancer cells. This is often due to the ability of the cancer cells to escape immune surveillance by the host. Natural killer (NK) cells are the first line of attack against cancer cells. The ability to expand and activate NK cells ex-vivo is now possible using the K562-mb15-41BBL system which is pioneered by Professor Dario Campana at our centre.

These reactivated NK cells have been successfully used to treat patients with blood cancers and good safety profiles. Since nasopharyngeal cancer expresses Epstein-Barr virus antigens and epidermal



Dr Lim Chwee Ming

Consultant
Dept of Otolaryngology-Head and Neck Surgery, National University Health System
Assistant Professor
Yong Loo Lin School of Medicine

growth factor receptor (EGFR), using these reactivated NK cells plus cetuximab (antibody targeting EGFR) allow specific homing of these NK cells against NPC. This proposal aims to investigate the safety, feasibility and effectiveness of this approach to treat patients with refractory nasopharyngeal cancer.

Dr Damien Tan Meng Yew

Consultant
Department of Gastroenterology and Hepatology,
Singapore General Hospital
Adjunct Assistant Professor
Duke-NUS Graduate Medical School

Novel Metabolomics Markers for Characterization and Early Detection of Malignancy in Pancreatic Cysts

Pancreatic cysts can transform into pancreatic cancer. Currently cyst characterisation is not accurate as 40% of cysts undergoing surgery are benign. New technology like metabolomics may help differentiate between the different types of cysts. Pilot data on 16 cyst fluid samples (four malignant, four premalignant and eight benign) identified four unknown metabolites present in high amounts in the malignant



cyst but absent or significantly lower in the benign cysts. The project aims to confirm whether metabolites found in our pilot study are present exclusively or are significantly more in a larger sample of malignant cysts, and to assess whether these metabolites can predict when premalignant cyst transforms into cancer.

A prospective study, of 100 patients undergoing endoscopic ultrasound fine needle aspiration or surgery, would be carried out, with their cyst fluid analysed.

Levels of metabolites will be correlated to clinical diagnosis. Studied metabolites are expected to present exclusively or significantly higher amounts in malignant cysts and with increasing amounts in premalignant cyst. If successful, this study can potentially lead to a new generation of novel markers for cancer risk stratification and guiding of therapy for pancreatic cysts.

Talent Development Programmes

MOH Healthcare Research Scholarship (PhD)

This scholarship provides support to Basic Specialist Trainees, Advanced Specialist Trainees and Residents who wish to enrol in a PhD programme locally or overseas. It is targeted at young clinicians who wish to pursue a career in translational and clinical research. The scholarship provides funding for salary, tuition fees and maintenance allowance (for overseas PhDs), as well as protected time for research during the clinical training period. Seed funding for post-doctoral research is also available.

NMRC Research Training Fellowship

The NMRC Research Training Fellowship aims to provide doctors and health science professionals with the necessary training 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 (MCI)

This scholarship aims to encourage clinicians to pursue advanced clinical research training through the Master of Clinical Investigation (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.

List of Awardees for 2014

MOH Healthcare Research Scholarship (PhD)

There was one awardee under the MOH Healthcare Research Scholarship (PhD) in 2014.

Name	Institution and Type of Training	Area of Research and Project
Joshua Tay Kai Xun	NUHS PhD Degree (Full-time overseas)	CANCER The therapeutic potential of targeting CD271 in head and neck squamous cell carcinoma

Completed in 2014

Three awardees completed their training under the NRF-MOH Healthcare Research Scholarship (PhD) in 2014.

Name	Institution and Type of Training	Area of Research and Project
Dr Yeo Joo Guan	KKH PhD Degree (Full-time local)	INFLAMMATORY AND IMMUNE SYSTEM Novel cellular substrate for complement protease C1s: implications in the pathogenesis of systemic lupus
Dr Iain Tan Bee Huat	NCCS PhD Degree (Full-time local)	CANCER Paradigms in translating next generation technologies to clinical care
Dr Sharon Low Yin Yee	NNI PhD Degree (Full-time local)	CANCER MicroRNAs as a tool to elucidating intra-tumoral heterogeneity in glioblastoma multiforme

NMRC Research Training Fellowship

There were nine awardees under the NMRC Research Training Fellowship in 2014: two awardees are undergoing training leading to a PhD, two awardees are undergoing training leading to a Master's degree, and two awardees are doing an overseas research attachment.

Name	Institution and Type of Training	Area of Research and Project
Ms Hu Jing	NCCS Master's Degree (Part-time overseas)	CANCER Adaptive radiotherapy planning for local-regionally advanced nasopharyngeal carcinoma – a dosimetric comparison amongst intensity-modulated radiation therapy, RapidArc™, helical tomotherapy and intensity-modulated proton therapy
Mr Eric Pang Pei Ping	NCCS PhD Degree (Full-time overseas)	CANCER Evaluation of the use of a non-invasive 3D ultrasound clarity system in real-time tracking of the target volume in prostate RapidArc™ therapy
Dr Lee Eng Sing	NHGP Master's Degree (Part-time overseas)	MENTAL HEALTH Multimorbidity in primary care and its association with depression, anxiety and quality of life (MDAQ)
Dr Louis Chai Yi Ann	NUHS Fellowship (Full-time overseas)	INFLAMMATORY AND IMMUNE SYSTEM Diagnostics of immunodeficiency diseases in adults
Dr Kewin Siah Tien Ho	NUHS Fellowship (Full-time overseas)	ORAL AND GASTROINTESTINAL Using multimodal brain imaging to identify the brain substrate underlying language dependent IBS symptom reporting between Chinese & Caucasians and between two Chinese populations, speaking Mandarin and English
Ms Christine Teng Bee Choon	NUS Fellowship (Full-time overseas)	INFECTION Rapid identification and susceptibility testing of pathogens growing in blood culture bottles – a quality improvement theragnostic stewardship project

Dr Candice Chan Yuen Yue	SGH PhD Degree (Full-time local)	RESPIRATORY INFECTION Addressing diagnostic dilemmas in immunocompromised patients with pneumonia
Dr Tan Ek Khoon	SGH Fellowship (Full-time overseas)	INFLAMMATORY AND IMMUNE SYSTEM Hepatic oval cells and their roles in liver regeneration after ischemic reperfusion injury
Dr Tay Kae Jack	SGH Fellowship (Full-time overseas)	RENAL AND UROGENITAL MRI-fusion biopsy with cell cycle proliferation signature assessment: A novel approach to active surveillance in prostate cancer

Completed in 2014

Six awardees completed their training under the NMRC Research Training Fellowship in 2014.

Name	Institution and Type of Training	Area of Research and Project
Dr Teo Wan Yee	KKH Fellowship (Full-time overseas)	CANCER Genomic profiling of medulloblastomas
Dr Lena Lim Hui Xiang	NUS PhD Degree (Full-time overseas)	NEUROLOGICAL Neuroimaging correlates of physical abuse in childhood
Dr Dong Yan Hong	NUHS PhD Degree (Full-time overseas)	STROKE Cognitive Outcome After STroke (COAST). Improving the diagnosis of vascular cognitive impairment by prospective longitudinal clinical studies
Dr Amos Loh Hong Pheng	KKH Fellowship (Full-time overseas)	CANCER Comprehensive Preclinical Testing of Molecular Targeted Therapies Against the PI3K/Akt/mTOR Pathway for Paediatric Solid Tumors
Ms Christine Teng Bee Choon	NUS/TTSH Fellowship (Full-time overseas)	INFECTION Rapid identification and susceptibility testing of pathogens growing in blood culture bottles – a quality improvement theragnostic stewardship project
Dr Tan Ek Khoon	SGH Fellowship (Full-time overseas)	INFLAMMATORY AND IMMUNE SYSTEM Hepatic oval cells and their role in liver regeneration after ischaemic reperfusion injury

MOH Healthcare Research Scholarship (MCI)

Awarded in 2014

There were 17 awardees under the MOH Healthcare Research Scholarship (MCI) for the NUS Master of Clinical Investigation in 2014.

Name	Institution and Department	Project
Dr Chia Seng Hup	NCCS Radiation Oncology	Study of the radiobiological effects of anti-androgen on prostate cancer cell lines
Dr Chong Shu-Ling	KKH Emergency Medicine	Nasal biomarkers to predict the severity of Bronchiolitis
Dr Chua Ser Kenon	SGH Orthopaedics	The use of cord derived mesenchymal stem cells on an acellular scaffold for the treatment of a critical sized bone defect
Dr Chua Wei Ling Clarinda	NCCS Medical Oncology	Establishing a patient derived xenograft (PDX) metastasis model and whole exome sequencing of PDX in colorectal cancer
Dr Huang Guoxian James	NUHS Paediatrics	Dietary influences on disease activity and the gut microbiota in an Asian paediatric cohort with inflammatory bowel disease
Dr Hum Yin Mei Allyn	TTSH Palliative Medicine	Validating a palliative prognostic model incorporating functional and biologic variables in advanced cancer
Dr Lim Shir Lynn	NUHS Cardiology	Nitrates In Combination with Hydralazine in cardiorenal syndrome (NICHE) Study
Dr Liu Desheng Issac	NUHS Paediatrics	Dietary influences on disease activity and the gut microbiota in an Asian paediatric cohort with inflammatory bowel disease

Dr Low Lian Leng	SGH Family Medicine and Continuing Care	Prediction of 30-day readmission risk (30-RR) for elderly medical patients
Dr Lu Jirong	NUHS Urology	Metabotyping of prostate cancer using two-dimensional gas chromatography time-of-flight mass spectrometry
Dr Ng Kok Pin	NNI Neurology	Study to elucidate the influence of neuroinflammation including "damage associated molecular patterns (DAMPs)" in the syndrome of Alzheimer's disease with small vessel cerebrovascular disease
Dr Tan Hong Chang	SGH Endocrinology	Hepatic & peripheral insulin resistance in lean and obese non-diabetic individuals using the hyperinsulinemic-euglycemic clamp with stable isotope technique
Dr Tan Meng Yew Damien	SGH Gastroenterology and Hepatology	Role of micro-optical coherence tomography in the evaluation of ex-vivo pancreatic and bile duct neoplasia
Dr Tan Tse Yeun	KKH Obstetrics & Gynaecology	The effect of local endometrial injury (LEI) in women with repeated implantation failures (RIF) during in-vitro fertilisation (IVF): a pilot study
Dr Tang Yu Zheng Charmaine	IMH General Psychiatry	A 24-week, randomized double-blind, placebo-controlled trial of metformin for antipsychotic-induced weight gain in patients with first episode psychosis: a pilot study
Dr Wan Yi Min	AH Psychiatry	The effects of melatonin vs haloperidol vs placebo in delirium
Dr Wang Ziting	NUHS Surgery	Combination of mTOR inhibitors and intravesical chemotherapy in bladder cancer

Completed in 2014

Nine awardees completed their NUS Master of Clinical Investigation training under the NRF-MOH Healthcare Research Scholarship (MCI) in 2014.

Name	Institution and Department	Project
Hey Hwee Weng Dennis	NUHS Orthopaedic Surgery	Comparison of two techniques in obtaining lumbar spine flexion and extension x-rays
Nadira Binte Hamid	NHCS Cardiology	Prospective study on the validation of the new adenosine independent index of stenosis severity from coronary wave-intensity analysis in the Asian population
Colin Ngeow	St Luke's Hospital Medical Services	Will an isolation and decolonization bundle reduce methicillin-resistant staphylococcus aureus (MRSA) transmission rates in Intermediate Long-Term Care?
Go Yun Yun	NHCS Cardiology	What are the mechanisms of increased mortality following acute myocardial infarction in patients with diabetes mellitus?
Goh Jia Jun	NNI Neurosurgery	A randomized controlled trial to study the effectiveness of red blood cells (RBC) transfusion on brain tissue oxygenation in patients with traumatic brain injury and anemia
Goh Ting Hui Angeline	NUHS Medicine	Validation of glomerular filtration rate estimation equations in kidney transplant recipients
Dharmaraj Rajesh Babu	NUHS Surgery	Quantitative flow assessment of lower extremity endovascular interventions by iFlow
Tay Bee Gek, Laura	TTSH Geriatric Medicine	Serial changes in blood-based biomarkers and frailty state transitions among community-dwelling older adults with early alzheimer's disease in a multi-modal rehabilitation programme
Wu Mei Wen, Fiona	NUHS Urology	The use of intravesical Lactobacillus rhamnosus GG as a safe and efficacious alternative treatment for bladder transitional cell carcinoma

Clinician Scientists In The Spotlight

BREAKING NEW GROUNDS

There is a dearth of tools available to physicians, especially those working in the Emergency Department (ED), to utilise history and physical examination in the diagnosis of sepsis. The silver tsunami and improved medical care that prolongs lifespan, particularly in those with chronic conditions such as diabetes and cancer, unfortunately masks the traditional physical signs of sepsis in patients due to a depressed or altered immune state.

Dr Kuan Win Sen

*Consultant
Dept of Emergency Medicine,
National University Hospital*

*Assistant Professor
Yong Loo Lin School of Medicine
National University Health System*

Dr Kuan Win Sen attained the Transition Award for his research that aims to provide an in-depth view of the immunological state of patients with atypical presentations of sepsis early in the ED. "I hope that the research will break new grounds and provide insights into the immune system's reaction to an infection, particularly to the identification of related microRNAs and their functions. In the long term, novel therapeutic developments using these microRNAs may be formulated and mortality reduced," described Dr Kuan. Despite an upcoming major publication of a revised set of definitions for sepsis, he and his team are optimistic that the results of their research would complement the new definitions.

Dr Kuan became interested in this research area and realised its global prevalence when he joined the ATLAS (Asian neTwork to reguLAtE Sepsis care) study in 2008. Selected by his current Head of Department, A/Prof Malcolm Mahadevan, the study involved a multinational quality improvement observational project to look at severe sepsis management in Asian countries. Research in this area largely occurs in critical care and is relatively scarce in emergency medicine, even though the proportion of patients with sepsis in the ED outnumbers those in the intensive care unit. Dr Kuan's recently completed NMRC NIG investigated a management angle on severe sepsis, which is now one of the focal research areas of his department.

Dr Kuan feels very privileged and honoured to have received the TA grant. "I am deeply appreciative of the advice and support from my mentors, the Clinician Scientist Unit of Yong Loo Lin School of Medicine and colleagues in my department," he expressed. Furthermore, given a heavy clinical workload in the ED, the award provides him with protected time for research. It also fosters and enhances collaborations, and further develops research ideas. The funding also greatly helps in the recruitment of patients and assistance in the research laboratory.

"I think mentorship, support – from both department and institution – and passion are essential. I was fortunate to have been "nudged" to embark on the research path by my mentor and then Head of Department, A/Prof Shirley Ooi, to undergo training in the Master of Clinical Investigation (MCI) course. A/Prof Allen Yeoh, who helms the Clinician Scientist Unit, has been very encouraging and proactive in helping clinicians interested in research," said Dr Kuan. He believes that identifying such clinicians early and investing in their development are crucial to ensure a pipeline of clinician scientists in the future.

KNOWLEDGE IS KEY

One would normally associate strokes with paralysis or numbness. However, silent strokes are a totally different ball game.

Dr Nagaendran Kandiah had published a paper that showed that almost 40% of people with dementia have severe burden of silent strokes in their brains. They are found in scans as patients with silent strokes only present with memory problems but not clinical strokes.

Having received the Clinician Scientist Award, Dr Kandiah's research aims to prove and find out how silent strokes worsen dementia and make Alzheimer's Disease (AD) progress faster, and if they do, develop methods of intervention to prevent or reduce silent strokes from getting worse.

It involves studying patients at baseline and following up with them for 3 years, looking at imaging changes, and using animal models. "There are a few potential medications. We are trying them and lifestyle measures to prevent silent strokes. We also have some proven data to show that as silent strokes get worse, so does dementia," explained Dr Kandiah.

He also feels a sense of accomplishment and endorsement for receiving this award. "It tells me that I am in the right direction and opens up new avenues to further my research interest." These avenues include dedicated time for research, support as well as collaborations with other institutes locally (e.g. Duke-NUS and NTU) and internationally (e.g. Jacobs Neurological Institute, US).

Collaborations are important as they allow him to access new tools that are not commercially available and give him credibility as a clinician scientist. Due to his credibility, Dr Kandiah achieved more research partners to collaborate with him on a dementia screening tool he developed.

Despite challenges of high imaging costs like MRI scans, the award helps him to fund this current project. Getting more patients to participate in the study is also another challenge. "I believe this is where public knowledge in Singapore is important. If the public knows that NMRC or MOH is doing these kinds of research and what's the value to the public, then they are more likely to participate," expressed Dr Kandiah. He hopes that more patients with mild symptoms of dementia would come forward so treatment can start early, thus delaying the worsening of dementia.

What is his advice for budding clinician scientists? "Don't neglect clinical experience. I think that researchers need to be good clinicians." With clinical knowledge and acumen, a clinician scientist would be able to convince peers to adopt his or her new tools.

Dr Nagaendran Kandiah

*Senior Consultant
National Neuroscience Institute*

*Assistant Professor
Duke-NUS Graduate
Medical School*



SEEING THE DIFFERENCE

Why do Asians get afflicted with type 2 diabetes? A/Prof Tai E Shyong intends to answer this question by studying the impact of ethnicity on the risk of type 2 diabetes.

A/Prof Tai was awarded the CSA-Senior Investigator from NMRC for his research, which is based on previous findings that show that individuals of South Asian descent (Indians) are more susceptible to type 2 diabetes and heart disease than Chinese and Malays in Singapore. It was found that one reason for this is that the cells and tissues from individuals of Indian ancestry don't respond as well to insulin as those from Chinese and Malays. To find out another reason, A/Prof Tai's research will compare the levels of proteins involved in insulin signalling between muscle taken from Chinese and Indians.

"Singapore is a unique place to conduct this research. As a country with a multi-ethnic population and ethnic differences in susceptibility to type 2 diabetes, Singapore provides opportunities that are not available elsewhere," A/Prof Tai elaborated. His research is also built on a long series of studies that have been carried out in Singapore over the past several decades.

Recent findings from his research have suggested that Indians' greater susceptibility to type 2 diabetes relates to specific changes in the muscles of these individuals, thus leading to the inability of insulin to

stimulate glucose uptake. Through his research, A/Prof Tai is able to try to understand why this happens at a molecular level.

If this research is successful, it could help A/Prof Tai and his team to finally understand why Indians are more frequently susceptible to type 2 diabetes than other ethnic groups. He added, "More importantly, our work could identify pathways that could be modulated by new drugs designed to treat and prevent diabetes."

With the renewal of this award, A/Prof Tai is able to dedicate his time and efforts to valuable work. He feels that it is an important recognition that motivates him to do work beyond his daily routine. Despite the uncertainty of whether the research will lead to new therapies and the difficulties of translating it into actual interventions, he is determined to unravel the basis of ethnic difference on the risk of type 2 diabetes.

Associate Professor Tai E Shyong

*Head and Senior Consultant
National University Hospital
National University Health System*

*Associate Professor
Department of Medicine,
Yong Loo Lin School of Medicine
Saw Swee Hock School of
Public Health
Duke-NUS Graduate Medical School*



THE RIPPLE EFFECT

As glaucoma is prevalent and significant in Asia and is the leading cause of irreversible blindness, particularly closed-angle glaucoma, it is an important research area that needs to be delved into by clinician scientists in this region.

As a STaR-Investigator Awardee, Prof Aung Tin is using this grant to discover how and why people develop closed-angle glaucoma; its risk factors; early detection and ways of understanding disease profile of patients; and how it can be treated better and earlier.

It is not easy to prevent blindness because the disease is aggressive and visual loss of the central vision occurs at the last stages. "This is the challenge of our research. Early detection is thus one of the many areas of our research," Prof Aung remarked. He aims to find out if there is a genetic test that can be done or methods to detect the disease earlier, such as imaging and combination of tests.

Another aspect of his research, entitled "Singapore Angle Closure Glaucoma Programme: Characterisation, Prevention and Management", is genetics. Prof. Aung explained, "We believe that glaucoma is related to genetics and we have discovered the first ever genes in 2012 but have not done so for specific genes in Chinese people." He hopes that in the long run, the genes can be found to develop specific treatments to prevent or treat glaucoma.

A major part of the genetics aspect of his research is setting up a multi-national, multi-centre collaborative network. So far, a network of more than 15-20 countries has been set up and the number of patients for this study has doubled to 8,000-9,000 cases globally.

Prof Aung feels honoured to receive the competitive STaR Award. It not only provides crucial research funding and resources but also enables clinical support when he is engaged in his research efforts. His research will go a long way to detecting and treating glaucoma early and he is driven to thread this path. "Doing research has a multiplier effect. I'm able to make an impact beyond my own patients. If we find a way to manage or treat a disease, and everyone practises it, it can impact the community and the world."

He feels that the most important thing is to press on with glaucoma research, as support for it is mostly

exclusive within Asia. NMRC as well as Singapore Eye Research Institute (SERI) and Singapore National Eye Centre (SNEC), the leading centres in the world for close angled glaucoma, can make this possible.

Professor Aung Tin

*Executive Director
Singapore Eye Research Institute
Deputy Medical Director (Research)*

*Senior Consultant and Head
Glaucoma Department,
Singapore National Eye Centre*

*Eye ACP Vice Chair of Research
Duke-NUS Graduate Medical School*

*Professor
Dept of Ophthalmology,
Yong Loo Lin School of Medicine*





Research Grants

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.

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

- 1 Strategic/programmatic research
- 2 Investigator-led research

The first category consists of TCR Flagship Programmes, Clinical Trial Grant, Ministry of Health Industry Alignment Fund and Centre Grants.

- ◆ The TCR Flagship Programmes provide significant levels of funding to large-scale strategic studies that span across the spectrum of basic, translational and clinical research.
- ◆ The Clinical Trial Grant (CTG) provides funding 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: CTG Investigator Initiated Trials – Early Phase (CTG IIT-E), Late Phase (CTG IIT-L) and CTG Co-Development (CTG Co-D).
- ◆ The Ministry of Health Industry Alignment Fund (MOH IAF) provides funding for clinicians working with industry partners, strengthening the public-private collaboration in biomedical sciences (BMS) research and encouraging commercially relevant research for better health outcomes. This programme was jointly developed with the Singapore Economic Development Board and comprises 2 schemes, Category 1 and 2.
- ◆ The Centre Grants are awarded via a performance-based competitive mechanism to provide core research funding to clinical institutions with the aim to strengthen the overall research competitiveness of the institutions.

The second category supports different types of investigator-led studies via the following grant schemes:

- ◆ Clinician Scientist Individual Research Grant (CS-IRG)
- ◆ Clinician Scientist Individual Research Grant New Investigator Grant (CS-IRG-NIG)
- ◆ Cooperative Basic Research Grant (CBRG)
- ◆ Cooperative Basic Research Grant New Investigator Grant (CBRG-NIG)
- ◆ Bedside & Bench Grant (B&B)
- ◆ Health Services Research Competitive Research Grant (HSR-CRG)
- ◆ Health Services Research Competitive Research New Investigator Grant (HSR-NIG)
- ◆ Individual Research Grant (IRG)*
- ◆ Exploratory/Developmental Grant (EDG)*

*While there are still ongoing projects that were funded via the IRG and EDG schemes, the final grant call for these schemes was held in May 2011. The newer grant schemes were launched in November 2011.

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.

Strategic/ Thematic Research

Translational and Clinical Research (TCR) Flagship Programme

The TCR Flagship Programme is a strategic initiative that was launched by NMRC in 2007 to fund TCR in key disease areas that are clinically relevant to Singapore. The programme's aims are:

- ◆ To bring together the best complementary research strengths in hospitals, national disease centres, universities and A*STAR research institutes to focus on diseases or research themes of strategic importance.
- ◆ To build up a critical mass of experienced high-level researchers to facilitate a broader research platform, and increase collaboration both locally and internationally.
- ◆ To establish Singapore as a global leader in the study of key strategic medical research fields by integrating, coordinating and leveraging the full spectrum of research capabilities in Singapore from basic science to clinical research in a comprehensive manner.

Under the S&T 2010 funding, five TCR Flagship Programmes in the areas of gastric cancer, neuroscience (schizophrenia), eye diseases, infectious diseases (dengue) and metabolic diseases, were each awarded \$25 million to carry out research over a period of five years under the leadership of a well-qualified clinician-scientist.

In view of the success of these programmes, further funding of \$175 million has been secured from the National Research Foundation's (NRF) Research, Innovation and Enterprise 2015 (RIE2015) Open Collaborative Funds (OCF) for this important initiative. The money will be distributed across three grant calls to provide opportunities for new programmes to be funded and existing programmes to be renewed on a competitive basis.

Under RIE2015, two tiers of TCR Flagship Programme funding are available:

Tier-1: Capped at \$9 million, inclusive of indirect costs, over a period of five years.

Tier-2: Capped at \$25 million, inclusive of indirect costs, over a period of five years.

Progress update

As of Q1 CY2014, a total of thirteen TCR Flagship Programmes have been awarded: five funded under the S&T 2010 funding, and eight under the RIE2015 framework (four Tier-1 Programmes and four Tier-2 Programmes). Three of the Tier-2 awards were renewals of the pioneer TCR Flagship Programmes under the S&T 2010 funding.

Overview of TCR Flagship Programmes awarded to date (as at 30 April 2015)

S/N	Title	Area of Research	Lead PI (Institution)	Year/ Tier of Award
01	The Singapore Gastric Cancer Consortium – Improving Outcomes for Our Patients	Oncology (Gastric cancer)	A/Prof Yeoh Khay Guan (NUS)	2007
02	Vulnerability, Disease Progression, and Treatment in Schizophrenia and Related Psychoses	Neuroscience (Schizophrenia)	A/Prof Chong Siow Ann (IMH)	2008
03	Singapore Eye Research Institute TRIOS Programme (Translational Research Innovations in Ocular Surgery)	Eye diseases (Glaucoma & corneal diseases)	Prof Donald Tan (SERI)	2008
04	Developmental Pathways to Metabolic Disease	Metabolic disease (Developmental origins)	A/Prof Chong Yap Seng (NUS)	2008
05	Scientific Exploration, Translational Research, Operational Evaluation of Disease Prevention and Preventative Measures Through New Treatment Strategies Against Dengue (STOP Dengue)	Infectious diseases (Dengue)	Prof Leo Yee Sin (TTSH)	2008
06	Genetic Predisposition, Epigenetic Change, MicroRNA Profiling and Experimental Therapies in Heart Failure	Cardiovascular disease (Heart Failure)	Prof Mark Richards (NUHS)	2013 (Tier-1)
07	Non-Small Cell Lung Cancer: Targeting Cancer Stem Cell and Drug Resistance	Oncology (Lung cancer)	A/Prof Tan Eng Huat (NCCS)	2013 (Tier-1)
08	Eye Surgery and Innovative Technologies (EyeSITe) - <i>Renewal</i>	Eye diseases (Glaucoma & corneal diseases)	Prof Donald Tan (SERI)	2013 (Tier-2)
09	Singapore Gastric Cancer Consortium – Redefining Gastric Cancer Management - <i>Renewal</i>	Oncology (Gastric cancer)	A/Prof Yeoh Khay Guan (NUHS)	2013 (Tier-2)
10	National Lymphoma Translational Research Program: From Genomics to Therapeutics	Oncology (Lymphoma)	A/Prof Lim Soon Thye (NCCS)	2014 (Tier-1)
11	Singapore Programme of Research to Investigate New approaches – to drug discovery and clinical translation – to deliver improved treatments for Tuberculosis (SPRINT)	Infectious Diseases (Tuberculosis)	Prof Nicholas Paton (NUHS)	2014 (Tier-1)
12	Developmental Pathways to Health and Disease: metabolic, neurodevelopment and related outcomes - <i>Renewal</i>	Metabolic Diseases (Developmental origins)	A/Prof Chong Yap Seng (NUHS)	2014 (Tier-2)
13	Translational Clinical Research Programme in Parkinson's disease	Neuroscience (Parkinson's disease)	Prof Tan Eng King (NNI)	2014 (Tier-2)
14	The Eradication of Chronic Hepatitis B	Infectious Disease (Hepatitis B)	Prof Lim Seng Gee (NUHS)	2015 (Tier-2)

Key achievements of the five pioneer TCR Flagship Programmes under the S&T2010 funding

(as at 30 April 2015)

Human Capital		Intellectual Capital	
PhD students trained and graduated:	27	Invention disclosures:	30
Master's degree students trained and graduated:	20	Publications in peer-reviewed journals:	501
Post-docs employed:	75	Presentations at major conferences:	847
		Patents (primary & secondary) filed:	80 (based on no. of filing)
		Patents granted:	8
		Patents commercialised:	3
Industry Relevance			
Industry funding:		\$29.815 million (cash)	
		\$7.346 million (in-kind)	
Spin-offs and start-ups emerging from research programmes:	15		
New clinical trials initiated:	22		

Schizophrenia TCR Flagship Programme: Vulnerability, Disease Progression, and Treatment in Schizophrenia and Related Psychoses

Launched in July 2008, this TCR Flagship Programme aims to identify key genetic, biological, cognitive, clinical and social risk factors for psychotic disorders, and to establish the efficacy and safety of a neurocognitive-enhancing agent for patients with schizophrenia. The programme comprises three projects:



- ◆ A comprehensive genetic study of schizophrenia and its neurocognitive impairments.
- ◆ The Longitudinal Youth At-Risk Study (LYRIKS), a public health initiative that aims to identify the biomarkers of disease vulnerability, progression and therapeutic response for psychosis.
- ◆ A double-blind randomised clinical trial to evaluate the efficacy and safety of a putative neurocognitive-enhancing agent for patients with schizophrenia.

Principal Investigator:

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

Dengue TCR Flagship Programme: Scientific Exploration, Translational Research, Operational Evaluation of Disease Prevention and Preventative Measures Through New Treatment Strategies Against Dengue (STOP Dengue)

Launched in December 2008, this TCR Flagship Programme has a simple objective: to stop dengue by studying the major gaps in treatment and management of dengue diseases. Specifically, the programme aims to:

- ◆ Create a global centre of excellence for the clinical study and management of dengue diseases.
- ◆ Improve dengue prevention through epidemiological studies and entomological control.
- ◆ Elucidate pathogenesis of adult dengue disease and identify those at risk of poor outcomes from dengue through better diagnostic and prognostic tools.
- ◆ Improve clinical management of dengue illness through the evaluation of current therapeutic strategies and development of new ways to treat dengue.

Principal Investigator:

Prof Leo Yee Sin
Clinical Director
Communicable Disease Centre,
Tan Tock Seng Hospital



Heart Failure TCR Flagship Programme: Genetic Predisposition, Epigenetic Change, MicroRNA Profiling and Experimental Therapies in Heart Failure

Launched in March 2013, this Tier-1 TCR Flagship Programme aims to improve the understanding of inherited factors for risk of heart failure, with a view to improving prediction of heart disease and identifying new treatments. This will be achieved through genetic studies and the identification of specific gene products.



The research under this programme will focus on four key areas:

- ◆ Differences in genetic background.
- ◆ Different activation and de-activation of genes (epigenetics).
- ◆ The role of intermediate gene products (microRNAs).
- ◆ The potential of gene targets.

Principal Investigator:

Prof Mark Richards
Department of Medicine,
National University of Singapore

Lung Cancer TCR Flagship Programme: Non-Small Cell Lung Cancer: Targeting Cancer Stem Cell and Drug Resistance

Launched in March 2013, this Tier-1 TCR Flagship Programme, which focuses primarily on individuals with lung cancer who have never smoked (termed "never-smokers"), has the following four objectives:

- ◆ To conduct a comprehensive analysis of the cancer genome of never-smokers with lung cancer in order to gain a complete or near-complete view of the genomic mutations.
- ◆ To look for novel genomic mutations other than those already known that can potentially be treated by new targeted agents. These new targeted agents can be used in combination with standard treatment in order to enhance the efficacy of standard therapies, thereby prolonging quality survival.
- ◆ To determine the spectrum of acquired genomic alterations that can contribute to the onset of resistance to targeted agents and to design rational clinical studies combining newer targeted agents with standard therapies to address these mechanisms of resistance in patients.
- ◆ To understand more deeply the behaviour of cancer stem cells that are believed to be the source of cancer cell proliferations and to develop strategies to target this subset of cancer cells that may lead to more durable remission of lung cancer and therefore improve survival outcomes.



Principal Investigator:

A/Prof Tan Eng Huat
Department of Medical Oncology,
National Cancer Centre Singapore

Eye Diseases TCR Flagship Programme: Eye Surgery and Innovative Technologies (EyeSITE)

Launched in August 2013, this Tier-2 TCR Flagship Programme is a continuation of the previous eye diseases TCR Flagship Programme titled "Translational Research Innovations in Ocular Surgery (TRIOS)" and is carried out from July 2008 to July 2013. It builds on the notable achievements of the previous programme, with aims to develop novel clinical therapies and diagnostic applications to help alleviate ocular morbidity from major eye diseases, including corneal disease, infection, glaucoma, refractive errors and retinal disorders. The specific objectives are:

Principal Investigator:

Prof Donald Tan
Medical Director
Singapore National
Eye Centre



- ◆ To develop new classes of antimicrobial small peptide and peptoid molecules that will help treat various types of corneal infection.
- ◆ To develop sustained drug delivery carriers to provide prolonged drug release without relying on patient compliance.
- ◆ To develop a novel artificial cornea to treat severe corneal blindness via a bionic cornea programme.
- ◆ To develop a new treatment for keratectasia, keratoconus and presbyopia utilising femtosecond laser refractive technology.
- ◆ To develop new diagnostic and prognostic approaches to primary angle closure glaucoma (PACG).

Gastric Cancer TCR Flagship Programme: Singapore Gastric Cancer Consortium – Re-defining Gastric Cancer Management

Launched in February 2013, this Tier-2 TCR Flagship Programme is a continuation of the previous gastric cancer TCR Flagship Programme carried out by the Singapore Gastric Cancer Consortium (SGCC) from August 2007 to January 2013. It builds on the notable achievements of the previous programme, with aims to improve the management of gastric cancer and patient outcomes for those suffering from the disease, through research spanning three key themes:

- ◆ Early detection. This theme will focus on developing a cost-effective gastric cancer screening strategy for Singapore patients by identifying suitable blood-based diagnostic biomarkers from candidate biomarkers identified in a previously assembled pre-disease high-risk cohort (Gastric Cancer Epidemiology Programme).
- ◆ Therapeutics. This theme will focus on new and ongoing clinical trials aimed at establishing the clinical usefulness of the genomic classification of gastric cancer previously discovered by the team to be able to predict patient survival and drug responses in cell lines and patients, and testing the efficacy of new treatment options. The ultimate aim is to improve treatment.
- ◆ Gastric carcinogenesis. This theme will focus on understanding the molecular biology of gastric cancer. The team aims to identify new therapeutic targets and early detection biomarkers through the use of animal models that faithfully recapitulate various aspects of gastric cancer development, including transitions from normal gastric tissue to precancerous states and eventual cancer.

Principal Investigator:

A/Prof Yeoh Khay Guan
Department of Medicine,
National University of Singapore



Tuberculosis TCR Flagship Programme: Singapore Programme of Research to Investigate New approaches – to Drug Discovery and Clinical Translation – to Deliver Improved Treatments for Tuberculosis (SPRINT)

Launched in July 2014, this Tier-1 TCR Flagship Programme, which focuses on investigating new approaches to overcome obstacles that stand in the way of delivering improved treatments for tuberculosis (TB), will do the following through five research themes:

- ◆ Utilising novel approaches based on chemical genetics to identify promising compounds that will then be developed, with industry partnership, into new drugs for pre-clinical and clinical development.
- ◆ Identifying existing drugs – licensed for other indications – that have activity against TB targets and taking these forward into early clinical trials.
- ◆ Assessing the potential of a new imaging method, PET/MRI used with different labels that can detect cellular metabolic activity, to assess anti-TB drug activity and seek to create a novel monoclonal antibody PET label that may have additional value for imaging TB lesions.
- ◆ Establishing an Asian TB clinical trials network to strengthen research capacity in the region.
- ◆ Conducting a proof of concept clinical trial to test a new immune-based adjunctive treatment for drug sensitive TB and a phase 2/3 clinical trial to test a 2-month treatment regimen for drug-sensitive TB that will optimise the use of new and old drugs in an innovative strategic approach.

Principal Investigator:

Prof Nicholas Paton
Department of Medicine
Yong Loo Lin School of Medicine
National University of Singapore



Lymphoma TCR Flagship Programme: National Lymphoma Translational Research Program: From Genomics to Therapeutics

Launched in February 2014, this Tier-1 TCR Flagship Programme, which focuses on lymphoma, will do the following through three research themes:

- ◆ Using the latest molecular technologies to help understand the molecular mechanisms driving these cancers, and how genetic and environmental factors, particularly infections, contribute to the risk of developing lymphomas.
- ◆ Performing experiments to translate genetic findings into practical targets that can be used to improve diagnosis and treatment.
- ◆ Translating research findings for daily clinical use through the development of a simple laboratory technique that can classify and prognosticate lymphomas better as well as conducting of clinical trials that test targets discovered.

Principal Investigator:

A/Prof Lim Soon Thye
Department of Medical Oncology,
National Cancer Centre, Singapore



Parkinson's Disease TCR Flagship Programme: Translational Clinical Research Programme in Parkinson's Disease

Launched in March 2013, this Tier-1 TCR Flagship Programme aims to improve the understanding of inherited factors for risk of heart failure, with a view to improving prediction of heart disease and identifying new treatments. This will be achieved through genetic studies and the identification of specific gene products.



Principal Investigator:
Prof Tan Eng King
Department of Neurology,
National Neuroscience Institute

- ◆ Clinical and Epidemiology. The theme will focus on conducting prospective population cohort and developing body sensor devices and novel signal processing techniques.
- ◆ Genetics. This theme will focus on conducting large-scale population-based whole genome and exome sequencing and genomic studies.
- ◆ Disease Models/Pathophysiology. This theme will focus on developing specific and novel disease in vivo models (Mouse, Drosophila), particularly those that are unique or simulate disease models in ethnic Chinese.
- ◆ Stem cells and Brain Transplant. This theme will focus on developing human disease model using patient stem cells and augmenting effective cellular replacement/brain transplant therapies in animal models for potential clinical application.
- ◆ Experimental Therapeutics. This theme will focus on conducting drug screening in both animal and human stem cell models, and evaluating new drugs in preclinical/clinical models through joint industrial collaborations.

Metabolic Disease TCR Flagship Programme: Developmental Pathways to Health and Disease: Metabolic, Neurodevelopment and Related Outcomes

Launched in June 2014, this Tier-2 TCR Flagship Programme is a continuation of the previous TCR Flagship Programme titled "Developmental Pathways to Metabolic Disease" and is carried out from June 2009 to May 2014. It builds on the notable achievements of the previous programme with aims to understand how pregnancy and early childhood conditions may affect later growth and development, as well as metabolic, neurodevelopmental and other disorders, which have major public health and economic importance, not only in Asia, but globally. The research will span across four themes, conducting studies directly designed with the goal of developing public health, clinical and commercially-valuable, testable interventions to reduce the burden of childhood obesity, non-communicable diseases, and improve the neurodevelopmental outcomes in children:

- ◆ Metabolic outcomes of early development influences. The theme will focus on continuing the study of children in the Growing Up in Singapore Towards healthy Outcomes (GUSTO) cohort. The children will be between 4 and 9 years of age, which is a critical phase in metabolic development.
- ◆ Maternal health and offspring neurodevelopment. This theme will focus on identifying the relevant intermediate pathways by which specific risk factors influence health and capacity, thus identifying critical targets for intervention, as well as defining naturally-occurring conditions that promote resistance within children.
- ◆ Pre-conceptual and early influences on maternal and offspring health. This theme will focus on pre- and periconceptual influences through a second cohort, GUSTO-Mum, that would be set up based on the extant infrastructure.
- ◆ Therapeutic reversal of developmental programming in NHP models. This theme will focus on 'proof of concept' studies that inform potential clinical interventions.



Principal Investigator:
A/Prof Chong Yap Seng
Department of Obstetrics and
Gynaecology,
Yong Loo Lin School of Medicine
National University of Singapore

Clinical Trial Grant

The Clinical Trial Grant (CTG), launched in late 2012, is intended to support clinicians to carry 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:

- 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 per cent or less of the total project cost. An industry partner must provide co-investment (either cash or in-kind contributions) representing 50 per cent 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 \$5 million over five years. The IIT-E scheme grant calls are made twice a year, with closing dates on 1 June and 1 December.
- 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 \$2 million over five years. The IIT-L scheme grant calls are made twice a year, with closing dates on 1 June and 1 December.

Period	Proposals Reviewed	Grants Awarded	Total Sum Awarded (\$ millions)
May 2014	8	3	4.00

Ministry of Health Industry Alignment Fund

The Ministry of Health Industry Alignment Fund (MOH IAF) is a strategic initiative that was launched by NMRC to strengthen public-private collaboration in biomedical sciences (BMS) research and encourage commercially relevant research for better health outcomes. This programme was jointly developed with the Singapore Economic Development Board and comprises 2 schemes:

- 1 The Category 1 (Cat 1) funding under the MOH IAF was launched in early 2013 to support both clinicians and non-clinicians in their partnerships with industry in pre-clinical and clinical research. Joint funding from industry is a prerequisite, with an industry partner covering at least 70 per cent of the total project cost via cash or in-kind contributions. The quantum for MOH IAF Cat 1 funding is up to \$500,000 for pre-clinical projects and \$1 million for clinical projects. In the case of projects involving both pre-clinical and clinical research, the funding quantum is up to \$1.5 million. Cat 1 funding is provided for up to two years and is open throughout the year.

Period	Proposals Reviewed	Grants Awarded	Total Sum Awarded (\$ millions)	Industry dollars attracted (\$ millions)
FY2014	20	20	5.036	11.269

- 2 The Category 2 (Cat 2) funding under the MOH IAF was launched in late 2013 to support both clinicians and non-clinicians in pre-clinical and clinical research that will pre-position Singapore as a desirable location for industry to undertake TCR activities. Industry interest is a prerequisite. Cat 2 funding is up to \$3 million and is provided for up to three years. There is one pilot grant call in 2013 (future call is to be confirmed).

Period	Proposals Reviewed	Grants Awarded	Total Sum Awarded (\$ millions)
May 2014	8	3	4.00

Centre Grant Funding Framework

The aim of the revised Centre Grant (CG) funding framework is to provide core funding support to the public hospitals and national disease-specific centres to build up their core research capabilities in terms of common research platforms, shared equipment and core research manpower. One of the key aspects of the CG funding model is to also provide longer-term research funding to sustain core research activities in the eligible research institutions.

The revised CG funding framework adopts a competitive performance-based mechanism to award funding. It evolved from two previous NMRC research funding frameworks: the Institutional Block Grant/Enabling Block Grant (IBG/EG)¹ and the Centre Grant/Programmatic Project Grant (CG/PPG)², with integration of key successful components from the previous models.

NMRC launched the first grant call of the revised CG funding framework in August 2012 and received applications from 17 eligible centres/institutions. Each application underwent two levels of evaluation: (1) looking at the institution's research performance over

the past three years, and (2) assessing the institution's proposed four-year strategy for building up its core research capabilities. The 17 centres/institutions were awarded funding quanta ranging from \$3 million (for developing centres) to \$26 million (for established centres) for a funding period from 1 April 2013 to 31 March 2017.

The funded entities have completed their second year of CG funding. In the coming year, a Centre Grant Scientific Advisory Board (CG-SAB) consisting of members from the NMRC Board and International Expert Panel will be formed to conduct a mid-term review on the progress of the 17 centres'/institutions' CG programmes. It is to ensure that the funded entities are utilising the research funds appropriately and also to provide guidance (where necessary) to redirect them on track to their proposed CG research. The outcome of the mid-term review will determine if funding for the particular centre/institution will continue or cease.

Investigator-led Research

Over the past five years, NMRC has funded a total of 529 investigator-led research projects via the Individual Research Grant (IRG) scheme (251 grants), Exploratory/Developmental Grant (EDG) scheme (141 grants) and New Investigator Grant (NIG) scheme (137 grants). The final grant call for these three schemes was held in May 2011.

To date, these projects have generated more than 3,000 high impact journal papers and contributed to the training and local employment of about 370 PhD-level scientists.

In addition, NMRC has also funded investigator-led research via the following five grant schemes launched in 2011:

Clinician Scientist-Individual Research Grants

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, with closing dates on 1 June and 1 December.

Period	Proposals Reviewed	Grants Awarded	Success Rate	Total Sum Awarded (\$ millions)
Nov 2013	54	18	33.3%	22.45
May 2014	45	16	35.6%	20.14
Total	99	34	34.3%	42.59

CS-IRG New Investigator Grants

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)
Nov 2013	22	9	40.9%	2.02
May 2014	19	6	31.6%	1.30
Total	41	15	36.6%	3.32

Cooperative Basic Research Grants

Cooperative Basic Research Grants (CBRGs) are provided to non-clinician researchers to carry out basic and translational clinical research that is relevant to human health, as well as research that looks at the causes, consequences, diagnosis and treatment of human diseases. CBRGs also aim to promote basic biomedical sciences (BMS) research collaborations across institutions in Singapore. The quantum supported for CBRGs is up to \$1.5 million over a period of three years. CBRG grant calls are made twice a year, with closing dates on 1 June and 1 December.

Period	Proposals Reviewed	Grants Awarded	Success Rate	Total Sum Awarded (\$ millions)
Nov 2013	126	13	10.3%	16.80
May 2014	69	13	18.8%	17.70
Total	195	26	13.3%	34.50

CBRG New Investigator Grants

The CBRG New Investigator Grant (CBRG-NIG) is a sub-category of the CBRG that is targeted specifically at new non-clinical investigators. The CBRG-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 CBRG-NIGs is up to \$200,000 over a period of two years.

Period	Proposals Reviewed	Grants Awarded	Success Rate	Total Sum Awarded (\$ millions)
Nov 2013	33	8	24.2%	1.83
May 2014	20	8	40.0%	1.85
Total	53	16	30.2%	3.68

Bedside & Bench Grants

Bedside & Bench (B&B) Grants aim to foster closer interactions between basic scientists and clinicians in order to translate scientific discoveries in the laboratory into clinically useful and commercially viable applications to improve health outcomes.

For B&B Grants, each Co-Principal Investigator must provide symmetrical intellectual inputs for the project. Partnerships with industry collaborators are strongly encouraged and additional consideration will be given to proposals that demonstrate industrial interest or engagement. The scheme supports up to \$5 million per project depending on the host institutions of the Co-Principal Investigators, with funding provided for up to three years. B&B grant calls are made once a year, with the closing date in mid-January.

Period	Letters of Intent Received	Full Proposals Reviewed	Grants Awarded	Success Rate	Total Sum Awarded (\$ millions)
Sep 2012	44	12	5	11.4%	12.34 ³

Health Services Research Grants

The Health Services Research Competitive Research Grant (HSR CRG) is a MOH research grant established in 2009. This Competitive Research Grant aims to promote the conduct of HSR and enable the translation of HSR findings into policy and practice. The quantum supported for HSR CRG is up to \$1 million over a period of two years. HSR CRG grant calls are made once a year, with the closing date on 1 June.

Period	Proposals Reviewed	Grants Awarded	Success Rate	Total Sum Awarded (\$ millions)
May 2012	38	10	24.8%	4.0

Health Services Research New Investigator Grants

In November 2012, a New Investigator Grant (HSR NIG) subcategory of the HSR CRG was launched with the aim to support new HSR researchers. The quantum supported for this new subcategory is \$100,000 over 2 years. The HSR NIG grant calls are made once a year, with the closing date on 1 December.

Period	Proposals Reviewed	Grants Awarded	Success Rate	Total Sum Awarded (\$ millions)
Nov 2012	14	6	42.9%	0.719

¹The IBG/EG scheme was launched in 1994 and it provided annual block funding to national disease-specific centres and research units in public hospitals.

²The CG/PPG scheme was implemented in 2009 to replace the IBG/EG scheme. CGs/PPGs were awarded through a competitive scientific review process to support research programmes involving a team of investigators working towards central research themes, as well as being awarded to administration units.

³This includes \$3.73 million in funding from the Biomedical Research Council (BMRC) for B&B projects that involve BMRC scientists.



Events

National Medical Excellence Awards 2014

The National Medical Excellence Awards (NMEA) is held annually to honour and recognise clinicians, clinician scientists and healthcare professionals for their invaluable contributions toward medical excellence in the areas of clinical care, clinical research, clinical quality, training and mentorship in Singapore. The awards also provide an opportunity to celebrate successes and hold up role models for the younger generation of clinicians and clinician researchers.

In 2014, the NMEA recognised seven individuals and one four-member team for their outstanding contributions to medical research, training and clinical practice. Awards were given out in six categories:

- National Outstanding Clinician Award
- National Outstanding Clinician Scientist Award
- National Outstanding Clinician Mentor Award
- National Outstanding Clinician Educator Award
- National Outstanding Clinical Quality Activist Award
- National Clinical Excellence Team Award

The recipients of this year's awards represented a wide range of disciplines, including gynaecology, paediatrics, gastroenterology, anaesthesiology and emergency medicine. Despite their diverse backgrounds, the award winners all share a common commitment to excellence, which is reflected in their selfless dedication to raising the standards of medicine ever higher in Singapore.



NMEA 2014 Award Winners



Professor Wong Peng Cheang

Head and Senior Consultant
Division of Endocrinology and Infertility
Department of Obstetrics and Gynaecology
National University Health System

National Outstanding Clinician Award 2014

Professor Wong Peng Cheang is a pioneer in the fields of infertility and assisted reproduction. He is a medical professional held in high regard by his patients for the joy and hope his work has brought to their lives. Prof Wong's illustrious career spans more than three decades, with a milestone in 1983, when he was part of the team that helped to bring about Singapore's first in-vitro fertilisation baby. The team was conferred the National Science and Technology Award for the achievement in 1988.

Currently the Director of the Centre for Reproductive Education and Specialist Training at NUH, Prof Wong was the first president of the Asia Pacific Initiative on Reproduction (ASPIRE) and was awarded the Honorary Membership to the International Federation of Fertility Societies last year for his contribution to reproductive medicine.

Prof Wong also founded the first specialised training centre for assisted reproduction in the Asia Pacific Region, Centre for Reproductive Education & Specialist Training (CREST) at NUH in March 2011.

For his outstanding contributions and extraordinary dedication in the growth and development of Obstetrics and Gynaecology in the area of assisted reproduction, Professor Wong Peng Cheang is awarded the National Outstanding Clinician Award 2014.

National Outstanding Clinician Scientist Award 2014

Associate Professor Allen Yeoh is devoted to developing cost-effective treatments to improve treatment outcomes for children with acute lymphoblastic leukaemia (ALL) in Singapore and Asia.

He led the highly successful multi-centre Malaysia-Singapore ALL 2003 study that changed the way childhood ALL was treated in Singapore and Malaysia. A/Prof Yeoh is among the first in the world to show that gene expression profiling of leukaemia cells can accurately diagnose and subtype all the clinically important groups of childhood ALL with great accuracy. In recognition of his work, he is the first Singapore doctor to be awarded the American Society of Haematology Merit Award. A/Prof Yeoh's work enjoys international recognition where he was awarded the Viva-Goh Foundation Associate Professorship in Paediatric Oncology in 2012.

As the Programme Director of the NUS Master of Clinical Investigation programme and Chairman of the NUHS Clinician Scientist Unit, A/Prof Yeoh devotes much effort to mentoring young clinicians to assist them in kick-starting their research journey.

For his outstanding contributions and achievements in research in the field of paediatric leukaemia, by improving patient outcomes and achieving better understanding of the disease, Associate Professor Allen Yeoh is awarded the National Outstanding Clinician Scientist Award 2014.



Associate Professor Allen Yeoh Eng Juh

Viva-Goh Foundation Associate Professor
in Paediatric Oncology

Senior Consultant
Khoo Teck-Puat – National Children's Medical Institute
Department of Paediatrics,
National University Cancer Institute
National University Health System



Professor Chay Oh Moh

Campus Director
Education Office

Senior Consultant
Respiratory Medicine Service
Department of Paediatrics
KK Women's and Children's Hospital

National Outstanding Clinician Mentor Award 2014

For more than 20 years, Prof Chay has been an outstanding mentor and educator par excellence, making significant contributions to the professional initiation and development of innumerable medical students in the areas of paediatrics and paediatric respiratory medicine, with her teaching and mentorship. Having been at the forefront of paediatric respiratory medicine, she has diligently nurtured and groomed a new generation of paediatric respiratory physicians, who are now furthering the advancement of paediatric respiratory care and medical education in Singapore. Prof Chay also spearheaded the development and formalised communications courses and workshops, based on experiential learning.

Prof Chay is instrumental in shaping the education for the next generation of healthcare providers and strongly promotes interprofessional learning, overseeing the education and training of medical, nursing and allied health professionals. In 2007, she was made the first Paediatric Clerkship Leader for Duke-NUS, where she played a pivotal role in structuring the Paediatric programme. As the first Academic Chair of the SingHealth-Duke NUS Paediatric ACP, she established a robust framework that has effectively cultivated strong mentor-mentee relations across all levels of doctors at KKH as well as the academic system.

For her distinguished and outstanding contributions as a mentor, teacher, researcher and clinician to the development of Paediatric Medicine in Singapore, Prof Chay is being awarded the National Outstanding Clinician Mentor Award 2014.

National Outstanding Clinician Mentor Award 2014

Throughout his career, Prof Quak has held various roles with verve, panache and passion – a caring doctor, a committed mentor and rigorous academician. He provided guidance in the training and mentoring of medical students and junior doctors. A pioneer in paediatric gastroenterology and hepatology in Singapore, Prof Quak is the principal driver of the Paediatric Liver Transplant Programme. He developed the full set of paediatric gastrointestinal and hepatology services at NUH since its inception in 1985.

Prof Quak trained several overseas fellows in his subspecialty and built up a strong team of specialists, providing one of the best paediatric gastrointestinal and hepatology services in the region, complete with the ability to perform liver transplantation. From the first paediatric liver transplant in 1984 in Singapore, Prof Quak and his team have steadily built a liver transplantation programme that is comparable to the best paediatric liver transplant centres in the world. As a teacher, Prof Quak's belief in a strong foundation in medical undergraduate education where he is actively involved in curriculum reformation, playing a great role in the career development of paediatric trainees.

For his distinguished and outstanding contributions as a mentor, teacher, researcher and clinician in the development of paediatric gastroenterology and hepatology in Singapore, Professor Quak Seng Hock is awarded the National Outstanding Clinician Mentor Award 2014.



Professor Quak Seng Hock

Head and Senior Consultant
Division of Gastroenterology, Hepatology and Nutrition,
Khoo Teck Puat – National University Children's Medical Institute
Department of Paediatrics,
National University Cancer Institute
National University Health System



Associate Professor Chow Wan Cheng

Chairman

Division of Medicine

Senior Consultant

Department of Gastroenterology and Hepatology,
Singapore General Hospital

National Outstanding Clinician Educator Award 2014

A strong believer that sharing and caring are the hallmarks of medical profession, A/Prof Chow's care, compassion and concern for her patients have touched and inspired many clinicians and young doctors. A/Prof Chow strives to be one who teaches through both words and deeds passing on knowledge, and the ethos of a good clinician and the values of public service.

A/Prof Chow's patients have always been at the heart of all that she does. A/Prof Chow is a respected clinician who has gained regional recognition and won multiple awards for her research in chronic viral hepatitis. She actively contributes to the field of hepatology through sharing her insights in medical textbooks, local, international medical journals and key international scientific meetings.

Passionate about education and training, A/Prof Chow is also heavily involved in continuous medical educational programmes for clinicians in primary healthcare and public education. She also played a vital part in charting the academic training and professional development of the physicians. As the programme director, A/Prof Chow was instrumental in developing the curriculum for the Residents of Internal Medicine.

For being the epitome of a teacher, clinician and leader in nurturing the next generation of doctors and defining tomorrow's academic medicine, A/Prof Chow Wan Cheng is awarded the National Outstanding Clinician Educator Award 2014.

National Outstanding Clinical Quality Activist Award 2014

Associate Professor Ong Biauwei Chi's passion for patient safety and clinical care has been evident throughout her medical career that spans 28 years. Leading a team of anaesthesiologists, she played a pivotal role in clinical governance, patient safety and quality improvement.

A/Prof Ong was instrumental in leading a network of committed patient safety officers from across the healthcare sector to a successful implementation of the WHO "High 5s" Correct Site Surgery protocol, an achievement which put Singapore on the world map for surgical safety.

Within SGH, A/Prof Ong is a familiar face when it comes to initiating, building and sustaining various programmes to advance Patient Safety, Quality Improvement and Clinical Governance. She formalised the clinical governance structure, a system which ensures better accountability of care; and kick-started a clinical review programme to analyse potential limitations in patient care so that systemic improvements can be implemented. She was also part of the team which led SGH to become the world's second largest teaching hospital to be awarded Joint Commission International (JCI) accreditation. She continues to contribute in her current position as Chairman Medical Board for Sengkang Health.

For her outstanding contributions, foresight and extraordinary dedication in advocating best practices, quality improvement and gold standards in patient safety and clinical care; A/Prof Ong Biauwei Chi is awarded the National Outstanding Clinical Quality Activist Award 2014.



Associate Professor Ong Biauwei Chi

Director

Clinical Governance and Patient Safety

Chairman

Medical Board, Sengkang Health

Senior Consultant

Department of Anaesthesiology,
Singapore General Hospital

National Clinical Excellence Team Award 2014

Severe community-acquired pneumonia (SCAP) is a common and potentially fatal condition. Pneumonia was the 4th leading cause for hospitalisation in Singapore in 2011, accounting for 2.7% of all hospital discharges, which was the 3rd commonest cause of mortality.

With perseverance and the goal to reduce the mortality rates for SCAP patients, a team headed by Associate Professor Malcolm Mahadevan, with members from the hospital's Emergency Medicine Department (EMD) and Division of Respiratory and Critical Care Medicine (RCCM), University Medicine Cluster, embarked on a quality improvement project to develop a multidisciplinary programme that improved pre-ICU resuscitation and reduced hospital mortality for SCAP patients from 23.8% to 5.7%. This translated to significant savings in hospital bills for the patients.

The programme was carried out over seven years and involved early identification of SCAP patients followed by protocolised and aggressive resuscitation and management in the EMD and the ICU. The positive results received drove steps to implement the programme in the other local hospitals.

For their outstanding contributions to improve the management of patient conditions, the team represented by Associate Professor Malcolm Mahadevan, Dr Kuan Win Sen, Professor Lim Tow Keang and Dr Lim Hui Fang of the National University Hospital is awarded the National Clinical Excellence Team Award 2014.



Associate Professor Malcolm Mahadevan

Head and Senior Consultant

Emergency Medicine Department

Dr Kuan Win Sen

Consultant

Emergency Medicine Department

Professor Lim Tow Keang

Senior Consultant

Division of Respiratory and Critical Care Medicine

Dr Lim Hui Fang

Consultant

Division of Respiratory and Critical Care Medicine

National University Health System

NMRC Awards Ceremony and Research Symposium 2015

In 2015, 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 on 18-19 March 2015, the event recognised clinicians and researchers for their achievements and contributions to the continuous improvement of care for patients, and also to provide 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 (PhD and MCI) and NMRC Research Training Fellowship, are recognised and honoured. The guest of honour was A/Prof Benjamin Ong, Director of Medical Services.

This year, we invited Dr Edward W. Campion, Executive Editor and Online Editor, The New England Journal of Medicine, as the plenary speaker for the event's opening session, speaking on 'The Challenges of Ageing'. This was followed by experience sharing sessions by the Singapore Translational Research (STaR) Investigator awardees, each with different clinical and research backgrounds, and different experiences, sharing some of their insights from their journey. The morning session ended with presentations by notable and accomplished clinician scientists who shared their achievements and experiences thus far.

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, the lead PIs and collaborators of the TCR Flagship and grants programmes, industry partners and many other clinician researchers are invited to join us at the symposium for the two-day worth of knowledge exchange and networking with the research community of Singapore.

Day One concurrent sessions took off after the Awards Presentation, with parallel sessions for Innovative Technologies and Health Services Research. The day came to an end with a Wine and Cheese Reception, a platform for industry, clinical and research community participants to further network and explore collaborative opportunities after the forum discussions.

The workshops continued on Day Two with parallel sessions for Clinical Trials and Medical Entrepreneurship, all of which are key areas in fostering new directions in translational biomedical research. Over one and a half days, there were a total of 20 speakers featured from healthcare institutions and industry.

Participants also had a chance to visit the exhibition booths during break times, and these booths showcased the services and latest projects undertaken by various Institutions (please refer to the full listings below).

List of Exhibitors

- National Health Innovation Centre
- NUHS Clinician Scientist Unit
- NUHS Metabolic Diseases
- NUHS Investigational Medicine Unit
- SHS Investigational Medicine Unit
- Singapore Clinical Research Institute



Biomedical Sciences International Advisory Council Meeting 2014

On 4-5 November 2014, Singapore's Biomedical Sciences International Advisory Council (BMS IAC) held its annual meeting. The main focus of the BMS IAC meeting was to discuss the Biomedical Sciences Review Panel (BMS RP)'s recommendations on the BMS landscape, the proposed Research, Innovation and Enterprise 2020 (RIE2020) strategies for academic, economic and healthcare missions, and how to integrate the three sets of strategies into a national BMS strategy.

Chaired by Sir Richard Sykes, the BMS IAC members discussed the recommendations of the BMS RP, as well as the academic, economic and healthcare research strategies. The BMS IAC members noted the importance of a well-articulated and coherent national vision and strategy to rally the research performers in the ecosystem towards a common goal, and enable Singapore to stay competitive and reap social and economic benefits from our BMS investments.

Planning the national BMS Strategy for RIE2020

The BMS Review Panel (RP), chaired by PS (Law), was appointed by Chairman (NRF) after the 18th BMS IAC meeting in 2013. The BMS RP was tasked to review the vision, objectives and strategies of BMS research in Singapore, and to evaluate the extent to which the ecosystem is "fit for purpose" for the next stage of development. The BMS RP evaluated complex issues involving multiple agencies, identified policy and operational impediments, and made recommendations to the BMS Executive Committee (BMS EXCO) on how to improve the ecosystem.



Progress in BMS efforts

BMS has been a strategic initiative for Singapore since its inauguration in 2000 and the opening of Biopolis in 2003. Since 2000, employment in the BMS manufacturing industry has grown 2.8 times, from 6,000 to 16,700, in 2013. BMS manufacturing output has increased by nearly four-fold, from \$6B to \$23.7B, in 2013. In 2013, the value-added (VA) of the industry rose to \$11.8B, contributing 20.5% of Singapore's total manufacturing VA. The last ten years have also seen a rise in BMS R&D activities in Singapore, with the total R&D expenditure in BMS growing more than six-fold from 2000 to 2013.

Systemic health outcomes from R&D in the form of healthcare cost savings and improved patient care are some of the highest VA outcomes. Singapore has developed excellent clinical research capabilities in the public hospitals and research institutes over the past years. Initiatives have also been put in place to groom clinician scientists and support their research. Health impact from Singapore's BMS research can be illustrated by MOH's investment in Translational and Clinical Research (TCR). The TCR Flagship programmes span from basic science through translational research to clinical application, and have generated promising results that have made a positive impact on healthcare.

Overview of Fund Commitment in FY 2014

Overall funding distribution for NMRC funding initiatives

