

GROUP RESEARCH

Research is an integral part of NHG's *River of Life* strategy as there is a strong push to translate R&D to better patient outcomes, better healthcare, and a healthier population.

As such, NHG Group Research works towards three global outcomes:

- i) To raise research intensity
- ii) To build international peaks of excellence
- iii) To provide real-world evidence to transform population health.



Prof Benjamin Seet, Deputy Group CEO (Education & Research), on the ground with staff at a migrant worker dormitory.

NHG PACT PROGRAMME

The Partnerships for Capability Transformation (PACT Programme) is a pioneering collaboration between NHG and Enterprise Singapore's (ESG) Clinician-driven Innovation (CDI) initiative. Under PACT, NHG's Centre for Medical Technologies and Innovations (CMTi) catalyses partnerships between clinicians and Singapore MedTech companies to co-develop and commercialise innovative healthcare products and solutions that are clinically impactful, and which address global health needs. The first of its kind in public healthcare, the success of the PACT programme in NHG has helped proliferate the adoption of the programme in SingHealth and NUHS.

SUPPORTING THE COVID-19 BATTLE

Together with the Infectious Disease Research Training Office at National Centre for Infectious Diseases (NCID), NHG Group Research helped coordinate multi-agency R&D efforts in the fight against COVID-19. Some of the initiatives included:

- Coordination of COVID-19 R&D efforts across Singapore to better characterise and understand the pathogen and local outbreak.
- Clinical evaluation and participation in multi-centre trials of novel and repurposed therapeutic agents against COVID-19.
- Technical evaluation, selection, and procurement of vaccine candidates for the national vaccination programme.
- Development of network analysis of COVID-19 outbreaks in migrant worker dormitories.
- Survey of perceptions towards COVID-19 vaccines in healthcare workers, as well as support public communication efforts to drive vaccine uptake by the Singapore population.
- Expedition of approval for surge in Domain Specific Review Board (DSRB) applications for COVID-19 related studies, with more than 460 submissions approved within a mean record time of 21 days and eight days for new and amended proposals, respectively.
- As part of the Joint Task Force set up by Ministry of Manpower (MOM) and Ministry of Health (MOH), NHG Group Research officers were deployed to coordinate medical support for 14 migrant worker dormitories in the north of Singapore.

"We have to collaborate with the right partners, be it other healthcare institutions, academia, or industry, to achieve our goals and deliver quality care to our patients and population."

Professor Benjamin Seet Deputy Group CEO (Education & Research), NHG, & Assistant CEO (Corporate Services), Tan Tock Seng Hospital & Central Health

RESEARCH TALENT DEVELOPMENT

The NHG-Lee Kong Chian School of Medicine (LKC Medicine) clinician-scientist development programmes were extended to nurses, pharmacists, and allied health professionals from July 2020. These healthcare professionals made up about 45 per cent of successful awardees of the Clinician-Scientist Preparatory Programme (CSPP). Dr Ng Tat Ming, a Principal Pharmacist (Clinical) at Tan Tock Seng Hospital (TTSH), was awarded the Clinician-Scientist Career Scheme, which would provide him with post-doctoral funding support to prepare him to compete for national grants and awards.

FIRST BIODESIGN FELLOW IN NHG

Dr Chen Kok Pun, Associate Consultant Gastroenterologist, TTSH, returned to NHG in March 2021 after completing a six-month training with the Singapore Biodesign Innovation Fellowship Programme, which focused on the biodesign process of healthtech innovation. He worked with multidisciplinary teams, comprising engineers, healthcare professionals, and business/industry professionals. Together, they learnt to implement a rigorous and methodical framework to develop innovative solutions to meet real-world problems, and the know-how to commercialise products successfully.



NOTABLE STAFF ACHIEVEMENTS

- **National Clinician Scientist Awards 2020**
Associate Professor Rupesh Agrawal, TTSH, and Dr Yew Yik Weng, National Skin Centre, received the Clinician Scientist Award and the Transition Award, respectively, given out by the National Medical Research Council (NMRC).
- **National Outstanding Clinician Scientist Resident Award 2020**
Dr Xu Chuanhui (*left*), clinician-scientist resident from NHG, was bestowed the National Outstanding Clinician Scientist Resident Award 2020 by the NMRC. This annual award honours and recognises Residents who excelled in clinical training and have made significant research contributions with actual or potential clinical translational applications to improve clinical care. Dr Xu is currently enrolled in the NHG Rheumatology Residency Programme and is the first resident in NHG to receive the award.

THE NEXT STEP IN BIOMEDICAL RESEARCH

The National Precision Medicine (NPM) strategy was launched in 2017 as a 10-year plan to enhance and accelerate Singapore's biomedical research, health outcomes, and economic growth. To achieve this, Precision Health Research, Singapore (PRECISE), was set up as the central entity to drive NPM. In NPM Phase II, which started in April 2021, PRECISE collaborates with research and clinical partners from the Singapore ecosystem, including NHG and LKC Medicine, to study the genetic makeup of 100,000 healthy Singaporeans and up to 50,000 people with specific diseases. The genetic data will be integrated with detailed lifestyle, environmental, and clinical data to yield rich insights into factors that contribute to Asian diseases and conditions. PRECISE is supported by the National Research Foundation Singapore and the National Medical Research Council.



Dr Chen Kok Pun, Associate Consultant Gastroenterologist, TTSH, completed a six-month training with the Singapore Biodesign Innovation Fellowship Programme.



THE CONVERGING OF INNOVATIVE MINDS

The fruits of collaboration.

ASSOCIATE PROFESSOR STEVEN THNG
CHIEF DERMATOLOGIST // SKIN RESEARCH INSTITUTE OF SINGAPORE // DIRECTOR // TRANSLATIONAL RESEARCH OFFICE // NHG // ASSOCIATE PROFESSOR // LEE KONG CHIAN SCHOOL OF MEDICINE

PROFESSOR BENJAMIN SEET
DEPUTY GROUP CEO (EDUCATION & RESEARCH) // NHG // ASSISTANT CEO (CORPORATE SERVICES) // TAN TOCK SENG HOSPITAL & CENTRAL HEALTH // PROFESSOR // LEE KONG CHIAN SCHOOL OF MEDICINE

ASSOCIATE PROFESSOR TAN CHER HENG
DEPUTY CLINICAL DIRECTOR // CENTRE FOR HEALTHCARE INNOVATION // TAN TOCK SENG HOSPITAL // COMMITTEE MEMBER // CENTRE FOR MEDICAL TECHNOLOGIES AND INNOVATIONS // NHG // ASSISTANT DEAN (CLINICAL RESEARCH) // LEE KONG CHIAN SCHOOL OF MEDICINE

IF THE COVID-19 PANDEMIC HAS TAUGHT US ANYTHING, IT IS THE IMPORTANCE OF COLLABORATION.

Transcending traditional sector boundaries and international borders, many of the solutions and interventions to complex issues caused by the global crisis were developed through cross-discipline and cross-industry approaches. Singapore, too, has benefitted from such strategic partnerships.

At the IT Leader Awards 2021 – the country’s longest-running local tech awards, organised by the Singapore Computer Society, held in March – Tan Tock Seng Hospital (TTSH) was a co-winner (Infrastructure) with the

Agency for Science, Technology and Research (A*STAR) for their joint development of RadiLogic, an artificial intelligence (AI)-powered tool that can rapidly detect COVID-19 pneumonia (lung infection) on chest X-rays. The innovation was driven by both organisations’ common goal to fight the disease more effectively and provide timely, appropriate care to infected patients.

Indeed, strategic and timely collaborations are key to delivering quality care and improving the health of our population. NHG is working in synchronicity with its partners to achieve its vision of “Adding years of healthy life” to the people of Singapore.

WORKING IN CONCERT

Our research works towards three global health outcomes, says Professor Benjamin Seet, Deputy Group Chief Executive Officer (Education & Research), NHG. The first is to raise research intensity, largely by orchestrating research activities across NHG institutions “so that the collective effort comes across as a symphony, rather than as a compilation of soloists”, as Prof Seet puts it.

Second, NHG seeks to build international peaks of excellence in areas where it has clinical strengths, such as infectious diseases, dermatology, and mental health, which centres on research at

the National Centre for Infectious Diseases (NCID), National Skin Centre (NSC), and the Institute of Mental Health (IMH), respectively.

Third, NHG’s research aims to provide real-world evidence to transform population health. “We don’t plan for research to end with only papers or patents. There has to be a strong push to translate research and development (R&D) to better patient outcomes, better healthcare, and a healthier population. R&D will be an integral part of NHG’s population health strategy and programmes,” Prof Seet advocates.

Collaboration is fundamental to achieving all three goals. In today’s world, it is not possible to do everything by ourselves, says Prof Seet, “Diverse resources are needed to turn the best research into new drugs, devices, or clinical protocols.”

“Research at the cluster level will take on major health challenges where there are unmet needs or big gaps in knowledge. This often remains underfunded because of the difficulty in stringing together a coherent programme,” he elaborates. Examples of healthcare areas that have significant gaps to fill include frailty and depression in the elderly, multi-morbidity and polypharmacy (or the use of multiple medications by an individual), and the primary prevention of chronic diseases.

The success of a collaboration largely hinges on having the right partner. In the area of research, NHG frequently works with the Lee Kong Chian School of Medicine (LKCMedicine) at Nanyang Technological University (NTU) and

BOOSTING BRAIN RESEARCH

In 2021, National University of Singapore’s (NUS) Yong Loo Lin School of Medicine became a partner of Brain Bank Singapore. A research repository for brain and spinal cord tissues from donors who have passed away, the joint partnership was set up in 2018 by NHG, LKCMedicine, and National Neuroscience Institute (NNI).



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Professor Benjamin Seet
Deputy Group CEO
(Education & Research), NHG

A*STAR. Earlier this year, NHG, LKCMedicine, and A*STAR signed a tripartite Memorandum of Understanding (MOU) to jointly establish a healthtech accelerator – Co11ab @ Mandalay – to facilitate the clinical adoption of new technologies that will create value for patients.

BUILDING BRIDGES FOR INNOVATION

Associate Professor Tan Cher Heng likens his job as a radiologist to being a detective, “Radiologists pick up clues from medical images and combine our understanding of anatomy, pathology, and physics to solve diagnostic puzzles that would be useful for helping clinicians better manage patients.” He adds that research and innovation are natural extensions of his passion for the science behind the subject. His spirit of curiosity and enterprise fits his three concurrent roles as Deputy Clinical Director of TTSH’s Centre for Healthcare Innovation (CHI), Committee Member of NHG’s Centre for Medical Technologies and Innovations (CMTi), and Assistant Dean (Clinical Research) of LKCMedicine. A/Prof Tan sees himself as a ‘human bridge’ connecting these institutions to collectively achieve desired health outcomes.

“I enjoy bringing like-minded clinicians and scientists together into a community where ideas are translated into projects so that technology can enable healthcare

transformation,” he explains. “Clinicians are best positioned to define and articulate the problem statement, while scientists and engineers are best suited to develop relevant solutions. Without a collaborative approach, the process will likely fail.”

Officially opened in 2019, CHI is a co-learning platform that drives thought leadership in healthcare innovation through technology and workforce transformation. Together with diverse partners, CHI co-creates healthcare innovations and seeks to redesign ways of working and learning.

WHAT CMTi HAS DONE

<p>→ Supported NHG clinicians in over 100 projects</p> <p>→ Filed over 87 patents</p>	<p>→ Secured more than \$28 million in industry funding</p> <p>→ Created 20 commercialisable products</p>
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Fourier Intelligence's RehabHub™.

“As science and technology continue to deepen, the need for multi-faceted interdisciplinary collaborations will become greater.

This calls for an accelerated pace at which we develop solutions to ideas.”

Associate Professor Tan Cher Heng
Deputy Clinical Director,
Centre for Healthcare Innovation,
Tan Tock Seng Hospital



CMTi, which was set up in 2017 and is a close alliance of CHI, serves a complementary role of matching NHG clinicians with local and global technical experts from industry and academia, facilitated by Singapore government agencies, to co-develop innovative medtech solutions to address unmet healthcare needs.

CMTi provides administrative support to help turn prototypes into market-ready and commercially-viable products. “Even if the cross-disciplinary teams function well together, the lack of funding opportunities or of a business mindset may hinder them from taking their projects beyond the initial prototyping or proof-of-concept phase,” says A/Prof Tan. “These challenges are addressed by our administration team, who advises our clinicians on appropriate partnerships and funding agencies, intellectual property protection, and business contract negotiations.”

A/Prof Tan himself is part of the TTSH-A*STAR team behind the AI tool, RadiLogic. Their collaboration began when they participated in CMTi's Open Innovation Challenge, a platform to catalyse the co-development of novel healthtech products. “Since then, we have developed an AI model ready for licensing to a commercialisation partner,” he discloses.

Two other notable collaborations facilitated by CMTi in the past year are with Trendlines Medical Singapore, a medtech incubator; and Fourier Intelligence, a Shanghai-based robotics company. In November 2020, NHG and Trendlines Medical renewed their existing MOU to continue co-developing innovative healthcare solutions. The partnership will leverage on NHG's clinical strengths as well as Trendlines Medical's market knowledge and technological expertise.

➤ NEXT STOP: THE CLINIC

The close partnership between NHG and Trendlines Medical has led to the formation of nine new companies in just three years. Out of these, three are commencing clinical trials at NHG institutions, in the hope that these would solve some of today's most acute clinical challenges.



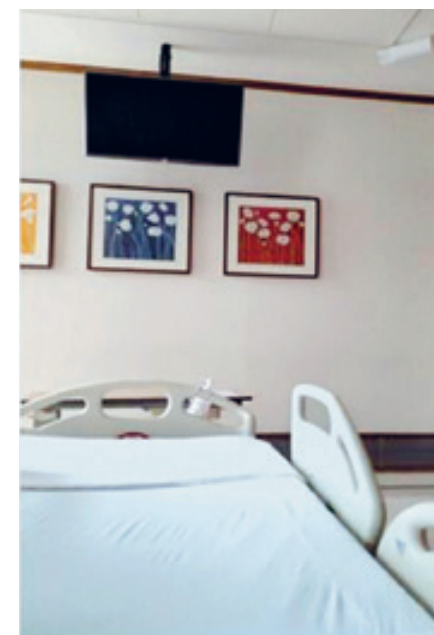
➤ **Medulla Pro** is developing an ultrasound-guided, real-time imaging system to increase the safety and accuracy of lumbar puncture (spinal tap) procedures. Clinicians from Khoo Teck Puat Hospital (KTPH) and TTSH are adapting the system for clinical use to better meet patient needs.

➤ **Szone** is developing an easy-to-use, accurate, real-time, and non-invasive hydration monitoring device, in collaboration with TTSH, to benefit patients with kidney failure or cardiovascular heart disease. The device will enable them to manage their daily fluid intake, and avoid complications from under- or over-hydration.

➤ **interVaal** is developing a uniquely-designed urinary catheter to reduce the risk of catheter-associated urinary tract infections, one of the most commonly reported hospital-acquired conditions. Clinical trials will be carried out at KTPH and Woodlands Health (WH).

In March, NHG and Fourier Intelligence signed an MOU to build on NHG's clinical strengths in rehabilitation medicine and the latter's RehabHub™ concept to co-develop cutting-edge rehabilitation technologies and robotics solutions. Such innovations will be designed to prevent falls and preserve mobility in frail older adults – an area of growing concern among ageing populations in Singapore, and globally.

Elsewhere, some medtech products backed by CMTi are already in the market. For example, TTSH nurses worked with local start-up CoNEX Healthcare to develop PreSAGE, a smart bed-exit prediction and falls prevention system currently deployed in TTSH's general wards for safer patient care. It alerts nurses whenever a patient tries to get out of bed, giving nurses more time to reach the bedside. There is also the attractive Suu Balm range of products, which provides rapid itch relief for atopic dermatitis (eczema) and other skin problems. Formulated by NSC and commercialised in collaboration with homegrown company Good Pharma Dermatology, the products are now available internationally.



PreSAGE, a bed-fall surveillance and prevention prediction system.

IN WITH SKIN

The success of Suu Balm points to dermatology, where NHG intends to build an international peak of excellence. A milestone was established in 2013 with the launch of the Skin Research Institute of Singapore (SRIS), a collaboration between A*STAR, NHG, and NTU that links scientists with clinicians and engineers to improve skin health and reduce the burden of skin diseases for Asian populations and globally.

“Gone are the days when one could just focus on an area of science, like skin biology, and be able to make a significant impact with that research. I am a strong believer that great outcomes will only come with the convergence of many disciplines in science,” says Associate Professor Steven Thng, Chief Dermatologist of SRIS. “That is why SRIS brings skin biologists, biomedical engineers, clinicians, and digital scientists into each of our research programmes – to ensure that clinical problems are tackled holistically.”

As one of SRIS' founding partners, NHG brings to the table its clinical expertise and large patient base. “We provide clinical insights, problems, and questions to help focus and direct the scientists' research. When a new technology or drug is developed, our patients are key for testing and validation,” A/Prof Thng explains. He often represents SRIS whenever a commercial enterprise expresses interest in working with the Institute. He also runs all of SRIS' clinical trials at the P.H. Feng Research Centre, located at NCID.

Two areas of research hold great potential. One is clinical bedside, non-invasive imaging. While skin imaging tools can now diagnose skin cancer without the need for a biopsy, SRIS is working with A*STAR's Singapore Bioimaging Consortium (SBIC) to develop a machine capable

➔ UNITED AGAINST COVID-19

A BRIEF LOOK AT HOW EVERYONE IS COMING TOGETHER TO BEAT A GLOBAL PANDEMIC.

➔ BETWEEN LOCAL INSTITUTIONS

PLAYERS INVOLVED: A*STAR, TTSH, MiRXES (a biotech company)

WHAT THEY DID: Developed a diagnostic test kit, called the **Fortitude Kit**, to detect the SARS-CoV-2 virus (which causes COVID-19) quickly and accurately. A newer version is now able to differentiate between SARS-CoV-2 and the seasonal flu, which exhibit similar symptoms. More than five million kits have been sold locally and globally.

PLAYERS INVOLVED: Integrated Health Information Systems (IHIS), TTSH, ST Engineering

WHAT THEY DID: Launched the **Command, Control and Communications (C3)** system, believed to be the first smart hospital system in the world. C3 provides real-time analytics so that TTSH and NCID can optimise operations and resource flow in response to the pandemic.

➔ BETWEEN GOVERNMENT AND COMMUNITY

PLAYERS INVOLVED: Emerging Stronger Taskforce, industry, civil society

WHAT THEY DID: Formed **Alliances for Action (AfAs)**, a new model of private-public partnership to address pressing economic and social issues as Singapore enters the recovery phase. As of March 2021, there were 19 AfAs covering areas such as robotics, the built environment, digital literacy and access, and work-life harmony.

➔ BETWEEN COUNTRIES

PLAYERS INVOLVED: Gavi, the Vaccine Alliance; Coalition for Epidemic Preparedness Innovations (CEPI), World Health Organization (WHO)

WHAT THEY DID: Created the **COVID-19 Vaccine Global Access (COVAX)** platform. COVAX works with governments and manufacturers to ensure global equitable access to COVID-19 vaccines, especially for lower-income countries.

PLAYERS INVOLVED: Scientists all over the world

WHAT THEY DID: Uploaded SARS-CoV-2 genome sequences on the **Global Initiative on Sharing All Influenza Data (GISAID)** platform, which had more than 1.2 million submissions from 172 countries between January 2020 and April 2021. It has enabled the rapid development of diagnostic tests and vaccines, and the tracking of new variants.

of generating 3D images of tumours. This will allow surgeons to examine tumours virtually so that they can perform precise, personalised surgery. The second is atopic dermatitis, a common condition in Singapore. SRIS is involved in two new drug development projects with C&C Research Laboratories based in South Korea, as well as ASLAN Pharmaceuticals based in Singapore. A/Prof Thng is optimistic that both projects will result in novel therapeutics for atopic dermatitis, which for a long time received little innovation in treatment.

Better treatment options will go a long way towards improving the quality of life and self-esteem of people suffering from skin problems, in addition to saving them money they would otherwise spend (in vain) to manage their condition. However, benefits go further. “The new knowledge generated will be crucial in capturing value for the Singapore economy, in terms of attracting investment from MNCs and creating jobs,” says A/Prof Thng. He adds that a big reason Procter & Gamble



“While research is time-consuming, stressful, and frustrating at times, the joy of making a new discovery or innovation **that advances the care of patients – even by a little bit – more than compensates for the sacrifices we make.**”

Associate Professor Steven Thng
Chief Dermatologist, Skin Research Institute of Singapore

(P&G) has set up its regional lab in Singapore is because the company recognises the country’s ventures into skin research, results of which might influence P&G’s development of consumer care products such as soaps and facial cleansers.

NOT LOST IN TRANSLATION
A/Prof Thng also pulls double duty as the Director of NHG’s Translational Research Office (TRO). “TRO was established to chart the direction and strategy of NHG’s research activities and align them with our translational research foci, namely skin, infectious diseases, mental health, ageing, and population health,” he explains. “I work with the various translational research project leads to unlock internal funds to seed those initiatives, as well as obtain extramural grants such as from the National Medical Research Council (NMRC).”

TRO facilitated the establishment of the Wounds iCare Collaborative (WiCC) Research and Clinical Workgroup. It brings together representatives from various NHG institutions to consolidate efforts and resources in wound care management, and also serves

SRIS runs clinical research trials at the P.H. Feng Research Centre, located at NCID.



Photo: Skin Research Institute of Singapore (SRIS)

➔ **BESIDES SRIS, OTHER COLLABORATIONS FACILITATED BY TRO IN RECENT YEARS INCLUDE:**

- ➔ **Rehabilitation Research Institute of Singapore (RRIS), jointly established by NTU, A*STAR, and NHG**
- ➔ **Health for Life in Singapore (HELIOS) Study, a population cohort study led by LKCmedicine, in partnership with NHG and Imperial College London**
- ➔ **gAmes for heaLth InnoVations cEntre (ALIVE), launched by LKCmedicine and NHG**
- ➔ **Palliative Care Centre for Excellence in Research and Education (PaIC), set up by Dover Park Hospice, LKCmedicine, and NHG**
- ➔ **Brain Bank Singapore (BBS), initiated by LKCmedicine, the National Neuroscience Institute (NNI), and NHG**



as a coordinating platform for collaborations with academia and industry. “One important area to look at is Diabetic Foot Ulcers (DFUs), given the high prevalence of diabetes in our population. DFUs contribute to Singapore having one of the highest rates of lower-extremity amputation in the world,” says A/Prof Thng.

He adds, “Over the years, we have established many partnerships with the aim of translating research outcomes into evidence-based disease management, especially in areas with high disease burden in Singapore that collectively coincide with NHG’s and partners’ strengths.”

WHAT THE FUTURE HOLDS
Healthcare collaborations look set to gather pace. “As science and technology continue to deepen, the need for multi-faceted interdisciplinary collaborations will become greater. This calls for an accelerated pace at which we develop solutions to ideas,” says A/Prof Tan. Not even a pandemic can slow things down, he notes. “Technology provides opportunities for us to increase productivity and enhance care beyond the hospital and into the community through remote means and patient activation. Virtual cross-boundary discussions also allow us to engage global partners for research and innovation.”

One imagines that digital technologies will stretch the possibilities of what can be achieved in the future. For example, with the ability to analyse big datasets and machine learning, doctors can radically improve their understanding of health and diseases and make better treatment decisions with patients. “The way ahead is to stratify populations such that we can target early interventions in the groups which will benefit most, and where it makes economic sense at the systems level,” says Prof Seet.

For this to happen, close partnerships between scientists, clinicians, administrators, and patients – across primary, institutional, and community

care – are essential. “We need to develop a new level of partnership with patients. It is critical to elevate medical literacy in Singapore, and equip patients with the right knowledge and tools to better manage their medical conditions,” adds Prof Seet.

With the COVID-19 crisis still disrupting the global ecosystem, Prof Seet says collaborations now and into the future should be, “Targeted, Multiplier, Outcomes-driven.” Wise words indeed, as all sectors, including healthcare, will have to be dynamic and strategic to keep pace with the rapidly evolving changes in a post-COVID-19 endemic world.

➤ **THE CASE FOR CLINICIAN-SCIENTISTS**

To grow translational research activities, not only must NHG collaborate with multiple partners; it also needs clinician-scientists to helm such projects. Many clinicians may feel apprehensive about performing this dual role, due to the demanding training requirements and significant time commitment. But A/Prof Thng appeals to their altruistic nature. “Most of the time, medicine as it is practised today just alleviates symptoms, and is not curative. The only way to do better for our patients is through research,” he stresses. “While it is time-consuming, stressful, and frustrating at times, the joy of making a new discovery or innovation that advances the care of patients – even by a little bit – more than compensates for the sacrifices we make.”

