2022 WITSA Global Innovation and Tech Excellence Awards
Nomination Form

The 2022 WITSA Global Innovation and Tech Excellence Awards *(*formerly known as *the Global ICT Excellence Awards*) will be presented to select individuals, academic institutions, corporations, NGOs or governments whose use and applications of digital technologies exhibit exceptional achievement within the following broad categories:

Private Sector/NGO	Public Sector
Digital Opportunity/Inclusion Award	Digital Opportunity/Inclusion Award
Smart Cities Award	Smart Cities Award
Sustainable Growth/Circular Economy Award	Sustainable Growth/Circular Economy Award
Innovative eHealth Solutions Award	Innovative eHealth Solutions Award
Public/Private Partnership Award	Public/Private Partnership Award
E-Education & Learning Award	E-Education & Learning Award
Emerging Digital Solutions Award	Startup Ecosystem Award

In addition, a *Chairman's Award* will be presented to a nominee selected from the entire pool of candidates from all award categories.

Candidates for these Awards are nominated by ICT experts from around the world who span over 80 countries/economies. The 2022 *WITSA Global ICT Excellence Awards* will take place in conjunction with the September 13-15, 2022 World Congress on IT in Penang, Malaysia (**https://wcit2022.com/https://wcit2021.org.bd/**).

Innovative eHealth Solutions Award

Award #1: Individuals, academic institutions, corporations, or NGOs
Award #2: Government authorities

Award Criteria- This Award recognizes Individuals, healthcare institutions, academic institutions, corporations, NGOs or governments that have made remarkable and successful efforts at utilizing ICTs as a tool to promote health and health care such as telehealth, mHealth (mobile health), eHealth or through eLearning, electronic health records, big data, legal frameworks, or social media. Solutions utilized may range from provision of information to keep citizens healthy, to support for public health in communities, care and support systems in health facilities, and from all the above the data needed to inform management and policymakers.

This award also recognizes any companies, individuals, NGOs or other entities who successfully develop or utilize information and communications technology, artificial intelligence, big data or other innovative technologies in the fight against COVID-19. Examples of solutions include vaccine distribution/logistics, vaccine digital certification or other telehealth apps, as well as technologies and solutions which enable productive and safe workspace in the “new normal”.

YOUR NOMINEES (limit three nominations per award category). *Please specify whether the nominee(s) are for the private or public sector category*.

Private/Public Sector: Public Sector

Project Name: Digitalisation of Customised Orthoses and Prostheses

REASONS FOR NOMINATION (NOTE: It is important that you make a detailed description of the nominee and why you think the nomination is justified. The absence of a detailed summary of qualifications as they *relate* to the above-mentioned award description will make it difficult for the awards committee to make an appropriate assessment of the candidate):

SUPPORTING INFORMATION: Please send any supporting information to the address above, including information from candidate (i.e. excerpt from program description, web site print-out, press release, etc.)

[Please insert below the Product or Solution Synopsis, Impact, Case Studies etc.]

Organisation Profile

Tan Tock Seng Hospital (TTSH) is the flagship hospital of the National Healthcare Group and part of Singapore's Public Healthcare System. As a pioneering hospital with strong roots in the community for over 177 years, TTSH is recognised as the People's Hospital, serving a resident population of 1.4 Million living in Central Singapore.

Together, with 70 community partners and 80 community health posts, it brings care beyond the hospital into the community as an integrated care organisation – Central Health.

As one of the largest multi-disciplinary hospitals in Singapore, TTSH operates more than 1700 beds with centres of excellence including the National Centre for Infectious Diseases (NCID), Institute for Geriatrics & Active Ageing (IGA), NHG Eye Institute (NHGEI) and TTSH Rehabilitation Centre.

TTSH's 600-bed Integrated Care Hub will be ready in 2023 to provide for subacute care and rehabilitation. As a healthcare leader in population health, systems innovation, health technologies and workforce transformation, TTSH hosts Singapore's largest purpose-built innovation centre for healthcare - the Ng Teng Fong Centre for Healthcare Innovation (CHI) and its Co-Learning Network of 37 local and international partners.

Product / Solution Synopsis:

The Foot Care & Limb Design Centre at Tan Tock Seng Hospital (TTSH) has successfully innovated and digitalised their clinical practice and manufacturing methods for customised orthoses and prostheses. This was through the adoption of available technology such as 3D-scanners, Computer-aided Design, Computer-aided Manufacture, and 3D-printing. The successful digital transformation has brought better value to patients in terms of design and quality

of their customised devices. The product streams that have been introduced to patients through the digitised methods include ankle foot orthoses, knee ankle foot orthoses, scoliosis braces, custom shoes, offloading insoles, prosthetic arm, prosthetic sockets, waterproof prosthetic covers and silicone hands/feet.

The digital transformation included a business and care model collaboration with other public-sector hospitals in Singapore. This was through the set-up of a “Hub & Spoke” model to deliver national prosthetic and orthotic services. Through this model, patients had greater and earlier access to care, care remains integrated and patients are right-sited. Costs of the customised devices have remained affordable as there is a pooling and utilisation of available national resources, and manpower productivity savings from use of digital solutions.

Adoption and innovating with different forms of digital solutions spanning across Engineering, Design & Technology and Additive Manufacturing industries has increased the connectivity of mainstream Healthcare services to the larger local and global ecosystem. This has allowed for cross-pollination and the application of industry best practices and advancements in technology to help address key challenges faced in healthcare, which are – a growing, ageing population, a shrinking specialised workforce, and costly infrastructure.

Adopting the Innovation

As the only Prosthetics & Orthotics (P&O) Service in Singapore, the Centre was faced with limited resources to manage an increasing workload from an ageing population and a higher incidence of diabetes leading to complications such as limb amputations. Singapore has one of the lowest number of Prosthetist/Orthotists (P&O)s to population ratios in the world which posed a manpower challenge. In addition, infrastructure to build and expand more workshops for scaling up manufacturing demands was costly. With these challenges, patient care was affected with long wait times, thus impacting rehabilitation outcomes.

The Centre’s strategic plan was to transform their business model and care delivery in order to meet the national challenges. They used emerging technologies such as 3D-scanning, Computer-aided design (CAD) and additive manufacturing (3D-printing) as part of their innovative solutions to disrupt and transform their clinical practice and manufacturing process for customised devices. Between August 2016 to February 2018, they went through the different stages of Value Proposition, Proof-of-Concept (PoC), Bench-Testing and Proof-of-Value (PoV) Clinical Trials. During PoC, they tested various hand-held 3D-scanners that would meet their functional and technical specifications. They used available tools in their CAD software to perform the 3D-rectification work on the scanned image. Using Fused Deposition Modelling method their first prototype of an orthoses was successfully 3D-printed.

The Centre’s bench-testing phase was to compare the mechanical properties of the 3D-printed Nylon-12 and conventionally-made polypropylene orthoses. Together with A*SIMTech and Forefront Additive Manufacturing (FAM), they invented a bench-testing apparatus and methods to measure the material properties and fatigue resistance throughout a 500,000 gait cycle. Their PoV clinical trials found that 3D-printed orthoses were comparable to conventionally-made, with user satisfaction domains for comfort and effectiveness scoring better in 3D-printed orthoses.

Since 2018, 3D-printed orthoses have been introduced as part of the standard customised product streams to patients. This has expanded to other product streams benefitting from the digitalisation. They include scoliosis brace moulds, custom shoe lasts, knee ankle foot orthoses, offloading insoles, prosthetic arm, prosthetic sockets, waterproof prosthetic covers and silicone

hands/feet. The adoption and implementation was made easy with the alignment to TTSH's digital transformation strategy towards a "Hospital Without Walls".

Innovativeness of Solution

Customised jobs to create orthoses and prostheses require large amount of man hours by the P&Os and Technicians. The jobs require the use of raw materials and workshop space for various machineries. The conventional method of shape capture involves taking a cast impression of the patient's limb through a manual process using plaster-of-paris bandage. It then goes through a lengthy subtractive manufacturing process of manual plaster filling, cast rectification, vacuum moulding, grinding, polishing and finishing. It takes 8 man hours over 4 days to fabricate a single, standard orthosis.

In additive manufacturing, the materials are added or printed layer-by-layer. The process is shorter, requires minimal manual fabrication time and there is less material wastage. In order to do this, the manual process of shape capturing needs to be first digitalised. The innovative idea was to capture this through readily available 3D-scanners and import the STL image to a CAD software. Features of the orthosis such as the foot plate and calf shell were added to this 3D-image before it was further optimised and 3D-printed.

Digitisation process with 3D-manipulation brings better value to patients as the design can be further augmented with complex architecture and geometry for greater comfort, and/or varying thickness at different parts of the devices to improve strength and durability. This was not possible with conventional methods. The user experience for patients are greater as they are not exposed to messy plaster-of-paris during conventional casting; and 3D-scanning takes less than a minute to perform. Unlike plaster moulds, the digital image saved can be used repeatedly. Patients do not have to return physically to be re-casted for a device replacement. There is also no need to repeat the lengthy manufacturing process.

The process of manual shape capture and cast rectification requires a highly specialised skill sets of the P&O clinician. Less experienced P&Os require more repetition and reiteration to achieve successful fitting outcomes. This contributes to long wait times for patients to receive their orthoses/prostheses, as well as variability in the quality of supplied devices. 3D-scanning of the exact anatomical structure and use of CAD library has reduced these variabilities.

Impact and Value

From this pioneering project the Centre has transformed their business model to better deliver national prosthetic and orthotic services. There were large barriers for public hospitals in Singapore to setup their own services. These included high costs of infrastructure and recruitment of a specialised workforce. Through learning from other industries on the disruptive benefits of Industrial Transformation 4.0 where there is a convergence of both the cyber and physical systems in manufacturing; the Centre proceeded to adopt this concept and innovate it into their own business and care models.

The "Hub & Spoke" model was implemented in 2018 in response to a growing need for P&O services nationally. Between 2018 to 2019, TTSH successfully helped three other hospitals set up their prosthetic/orthotic services as the "Spokes". This has allowed them to manage their own patients within their own care teams ("Spokes"). Foot Care & Limb Design Centre at TTSH as the

"Hub", supports them by manufacturing the devices and collaborating with companies to outsource fabrication work such as 3D-printing. This ensures the delivery of care remains integrated and patients are right-sited.

The decentralisation of front-end clinical services to "Spoke" units has enabled patients to receive more timely and right-sited care. Its estimated more than 800 new additional patients (annually) now have access to P&O services in Singapore. Even with the increased workload, wait times for first visits has improved from 9-12 weeks to as short as 1-4 weeks. Costs have remained affordable as there is a pooling and utilisation of available national resources, and manpower productivity savings from use of digital solutions. Manufacturing output has significantly increased by 117% with 25% less Technician manpower.

With digitalisation, the COVID-19 pandemic did not disrupt the Centre's services when there were restrictions in cross-institution movement of healthcare workers and patients. For example, KK Women's and Children's Hospital (KKH) could still continue delivering timely orthotic services to their paediatric patients as they could remotely 3D-scan their patients and electronically send their 3D-scanned images for TTSH to perform 3D-design rendering and carving of their 3D-moulds. These moulds were then delivered to KKH. In another example, patients known to the Centre requested for a new pair of custom insoles to be delivered to them overseas. This was due to the travel restrictions during the pandemic and they were unable to return to Singapore for their review consultations. Through tele-consult with the patient, use of previously stored digital scans and digital design prescription; TTSH managed to get their outsourced partner to fabricate the custom insoles and deliver them across the globe to these patients.

Further Spread of Value and Impact

Foot Care & Limb Design Centre has worked closely with local Small Medium Enterprises (SME)s and overseas companies to deliver their digitalised service in Singapore. These include local SMEs such as, FAM who they outsource their 3D-printing jobs; Admiralty Int Pte Ltd which provides their custom foam blocks for CAM 3D-carving, and Shonan Design (S) Pte Ltd which supports their 3D-scanning and CADCAM software/hardware. These SMEs do not traditionally serve the Healthcare market. By working closely with them, the Centre has kept their costs affordable, have better access to technical assistance, and at the same time tap on the SME's industry network to source for future cost-effective solutions. Digitalisation has opened up Healthcare's connectivity to the larger, multi-layered ecosystem in Engineering, Design & Technology and Manufacturing industries.

The introduction of digital solutions has brought potential cybersecurity risk. In 2020, the Centre collaborated with Secure 3DP+, a local start-up arm of Intellectual Ventures, to create an encrypted, blockchain-enabled system. This digital platform was to allow additive manufacturing activities to be performed in a secure and traceable environment. The PoC project was in anticipation of an increasing interest in adoption and application of 3D-printed parts in clinical healthcare. Support was needed for standards in file processing, data security, encryption/de-encryption, database management and the handling of end-to-end integrated workflows to connect customers (clinical users), designers/intellectual property owners and additive manufacturing companies on one platform. The PoC has successfully completed with the build of an integrated workflow, marketplace catalogue system (library/database), quality management system and an artificial intelligence module. Further PoVs will be done through usability tests on a wider pool of clinicians. The final goal of this platform is to scale-up and function as a

marketplace for customisation of medical parts and devices, to be widely used by clinicians in both public and private healthcare systems.

The digitalisation experience by Foot Care & Limb Design Centre at TTSH has given them the ability to make key decisions for long-term plans in national prosthetic and orthotic care delivery. It has assisted the Ministry of Health and upcoming new public hospitals such as Woodlands Health Campus to plan for a "digital-ready" and connected care model to save on costly infrastructure. Manpower challenges has also been addressed by upskilling both the P&Os and Technicians in new digital competencies, hence being digital-ready. The Centre have also guided several other medical and allied health professions as they embark on their own digitalisation journey of innovating their clinical practice.

Regional/National/Local Awards:

OpenGov Asia Recognition of Excellence 2022 for "Digitalisation of Customised Orthoses and Prostheses."

Techblazer Awards 2021 Best Public Adoption (Special Mention) for "Digitalisation of Customised Orthoses and Prostheses"

National Healthcare Innovation and Productivity Award (NHIP) 2019: Best Practice Medal for Automation, IT and Robotics Innovation for the project "Disruption through Digitisation and 3D-Printing".

National Healthcare Group (NHG) Quality Day Quality Improvement Awards 2019: Best Project in Innovation in Healthcare Category for the project "Digitising the Process of Customised Insoles for Diabetic Foot Ulcers".

Tan Tock Seng Hospital Value Festival 2019: Outstanding Award in Improvement and Innovation Competition for the project "Digitising the Process of Customised Offloading Insoles for Diabetic Patients with Active Plantar Foot Ulcers".

Awards/Grants

National Healthcare Group Centre for Medical Technologies & Innovations (NHG CMTi) and National Healthcare Innovation Centre (NHIC) MedTech Grant 2022 for "3D-knitted prosthetic socket with integrated liner".

Centre for Allied Health & Pharmacy Excellence (CAPE) Grant 2022 for "Evaluating user satisfaction and feasibility of a remote-digital model for 3D scanning and printing of prosthetic sockets for patients with transtibial amputation: A preliminary clinical trial".

Ng Teng Fong Healthcare Innovation Programme Project Grant 2022 for "Feasibility of 3D printed ankle-foot orthosis with Multi Jet Fusion Technology for management of patients with foot and ankle dysfunction".

Centre for Allied Health & Pharmacy Excellence (CAPE) Grant 2021 for "Protective Headgear for Neurosurgical Patients".

National Additive Manufacturing Innovation Cluster (NAMIC) Project Grant 2020 for "Design AFO for Manufacturing on HP Multi-Jet Fusion 3D Printer".

Ng Teng Fong Healthcare Innovation Programme Seed Funding 2018 for "Protective Headgear for Neurosurgical Patients".

National Additive Manufacturing Innovation Cluster (NAMIC) Project Grant 2017 for “Project Design and Development of a Novel 3D-Printed Non-Metallic Self-Locking Prosthetic Arm for a Forequarter Amputation”.

National Health Innovation Centre (NHIC) Innovation to Protect (I2P) Grant Award, Stage 3 - National-level, 2020 for “A Method of Bench Testing an Additive Manufactured Ankle Foot Orthosis”.

National Health Innovation Centre (NHIC) Innovation to Protect (I2P) Grant Award, Stage 2 - PCT Filing, 2018 for “A Method of Bench Testing an Additive Manufactured Ankle Foot Orthosis”.

National Health Innovation Centre (NHIC) Innovation to Protect (I2P) Grant Award, Stage 1 - First Filing, 2017 for “A Method of Bench Testing an Additive Manufactured Ankle Foot Orthosis”.

Media Coverage:

Mediacorp Channel 8 Morning Express, 15th February 2022 “3D-printing of customised orthotic device”. https://bit.ly/3LsxUJE

Mediacorp Vasantham News, 19th December 2021 for “Embracing New Technologies”. https://www.facebook.com/198272663537331/posts/4932520260112524/?vh=e&extid= 0&d=n

Mediacorp Channel 5 “Mind & Body” Season 8 23rd December 2020 on “Prosthetics & Orthotics in Rehabilitation”.

Mediacorp Channel 8 News & Vasantham News, 4th November 2020 for “3D Arm project”

Mediacorp Channel 8 News, 13th December 2019, “3D-printing”.

The Straits Times, 21st May 2019 for “3D Printing Shortens Wait for Orthotic Devices at Tan Tock Seng Hospital”. https://www.straitstimes.com/singapore/health/3d-printing-shortens-wait-for-orthotic-devices-at-tan-tock-seng-hospital

Mediacorp Channel 8 News & Current Affairs, 9th September 2018 for “3D Printing Technology to Produce Orthoses for Patients”. http://bit.ly/2CDlteE (from the 00:35 mark)

Local & International Sharing/Presentations:

SingHealth Allied Health Innovation Day - Ignite, Inspire, Innovate 2022 “Digitalisation of Customised Orthoses and Prostheses”.

Australian Orthotic Prosthetic Association (AOPA) Congress 2020 “Remotely Connected, Virtually Together”, 8th October 2020, “The thoughtful use of digital technology in prosthetics and orthotics”.

Singapore University of Technology & Design (SUTD) Research News, 26th Oct 2020 Technical Release “Low cost, customised prosthesis using 3D printing”

Singapore Health & Biomedical Congress 2019, Allied Health Workforce Transformation & Innovation Track: “Disruption through Digitisation & 3D-Printing”.

Enabling Singapore’s Digital Manufacturing Future 2019. Senior Minister Teo Chee Hean visit to NTU Innovation Centre. Showcased “Biomedical: Prosthetic Applications - 3D Printed Prosthetic Arm”.

3D HEALS - NAMIC Healthcare 3D Bioprinting Seminar 2019. Presented on “Prosthetics & Wearables – Advancing Patient Care using 3D Printed Prosthetics”.

Sharing with Sirindhorn School of Prosthetics & Orthotics (SSPO) in August 2019 for Visit to Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand.

Singapore Design Week 2019. Invited to showcase “Design with Care - 3D Printed Prosthetics and Orthotics”.

CaREhab 2019. Expert panel for “3D Printing Enabled Affordable Rehabilitation Techniques - Key Considerations and Potential Implications in Asia”.

National Healthcare Group (NHG) Centre for Medical Technology & Innovation (CMTi) Retreat 2018. Presented on “Staying Ahead of the Technology Curve: Our Journey in Additive Manufacturing” and Expert panel for “Innovation in Singapore and Israel, a Comparison”.

TechInnovation 2018 organised by Intellectual Property Intermediary (IPI) Singapore: Poster presentation on “Methods and Apparatus for Testing Material Properties of an Orthosis”.

NAMIC Global AM Summit, Industrial Transformation Asia-Pacific 2018. Expert panel for “The Clinician’s Perspective for the Advancement and Adoption of 3D Printing in Healthcare”.

Singapore Health & Biomedical Congress 2017. Poster presentation on “Evaluating the Mechanical Properties of Ankle-foot Orthoses generated by Additive Manufacturing against that generated by Conventional Subtractive Manufacturing through a Robust BenchTesting Procedure”.

American Orthotic & Prosthetic Association (AOPA) World Congress 2017. Poster presentation on “Development of a Bench Testing Procedure in Quantifying the Mechanical Properties of Ankle-Foot Orthoses in Additive Manufacturing”.

5th Singapore Rehabilitation Conference 2017. Presented on “Revolutionizing Healthcare: How 3D Printing Will Transform Future Prosthetics & Orthotics Industry”.

Scientific Publications / Book Chapters:

Binedell T, Subburaj K (2022): Design for Additive Manufacturing of Prosthetic and Orthotic Devices. In: Subburaj K, Sandhu K, Cukovic S (eds) Revolutions in Product Design for Healthcare. Design Science and Innovation. Springer, Singapore. https://doi.org/10.1007/978-981-16-9455-4_5

Binedell T, Subburaj K, Wong Y, Blessing L (2020): Leveraging digital technology to overcome barriers in the prosthetic and orthotic industry: an evaluation of its applicability and use during COVID-19 pandemic. JMIR Rehabil Assist Technol, 7(2): e23827 https://doi.org/10.2196/preprints.23827

Binedell T, Meng E, Subburaj K (2020): Design and development of a novel 3D-printed non-metallic self-locking prosthetic arm for a forequarter amputation. Prosthetics and Orthotics International, https://doi.org/10.1177/0309364620948290

NOMINEE CONTACT INFORMATION (for award follow up and coordination)
Name: Darilyn Yap
Job title: Senior Executive
Email: Darilyn_Hx_YAP@ttsh.com.sg
Phone/Mobile: 63578409
