# Health Informatics Research Lab

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### Our Vision

**Our vision is to empower individuals and healthcare providers with the technology-based solutions they need to deliver the best possible care and achieve the best possible outcomes.**

We are committed to developing and employing solutions that incorporate IoT technology, real-world data, and contemporary social science research, in order to enhance healthcare delivery and improve health outcomes.

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### Our People

**We are a team of diverse thinkers and practitioners, all working together to advance healthcare research.**

Our team is a collaborative involving academic researchers from various fields, healthcare professionals, industry partners, policymakers, and the wider community, in an effort to drive progress in healthcare research.

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### Our Work

We aim to develop health-information systems that leverage the technological advancements in Internet of Things (IOT) to improve the delivery of safe, high-quality healthcare services.

Our initiatives are designed to address the various needs and challenges that individuals may encounter throughout their health journey, including wellness, disease management, cognitive decline prevention, and institutional and home care.

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### Grants and Awards

National Health Innovation Challenge Programme Office Grant (2019 – 2022)

University of Sydney-NUS Partnership Collaboration Awards (PCA) (2019 – 2020)

Dean’s Start-up Strategic Initiative Fund) (2017 – 2019)

## Vision [Page]

Our research vision is to empower individuals and healthcare providers with the technology-based solutions they need to deliver the best possible care and achieve the best possible outcomes.

The healthcare journey for an individual encompasses a broad range of areas from managing wellness in our daily lives to receiving care in homes or dedicated healthcare facilities. While healthcare systems endeavour to provide reliable and effective care for all, they face constraints on resources like time, manpower, and funding. Technology-based solutions offer a way to overcome such limitations through the enhancement of healthcare delivery for the individual. Through these solutions, we strive towards our vision of empowering the individual in their healthcare journey.

Our research mission is to develop and employ solutions that incorporate Internet-of-Things (IoT) devices and platforms, real-world empirical evidence, and contemporary social science research. We have built IoT technology-based solutions such as EMPOWER, a mobile app-based platform that enhances chronic disease management through greater accessibility and personalisation; iMovin’, a technology-based intervention comprising a wireless activity tracker and a multi-feature mobile app that delivers personalised and persuasive health messages to encourage exercise; and Wellness Buddy, a platform to measure and model workplace fatigue to enhance employee well-being while maintaining high operational capabilities.

**Our Research Areas**

Our current initiatives in HIRL embody the individual’s health journey.

* Wellness
* Disease Management
* Cognitive Decline
* Institutional / Home Care

## Projects [Page]

Current Projects (grouped in chronological order)

### 1. EMPOWER

Lifestyle change is key to managing chronic diseases such as diabetes, hypertension and hyperlipidaemia. However, constraints on resources and time within Singapore's healthcare systems often lead to suboptimal support for patients in their efforts to improve lifestyle habits.

To address this, we partner with the Singapore General Hospital (SGH) and Duke-NUS Medical School to develop EMPOWER—a mobile app-based platform for the efficient and effective management of chronic diseases. By using a dedicated mobile app, patients can log a comprehensive range of activities and receive intelligent nudges based on these logs. They can also review their logs as reports, play games, or share them with healthcare workers. Users benefit from personalized healthcare services, while healthcare professionals can utilise technology to streamline and enhance care delivery.

Preliminary results from an ongoing longitudinal field study revealed that participants who used EMPOWER fared better in diabetes management than those from the control group.

Empower is currently available via invitation for Android and iOS users. Future planned features for Empower include an updated food database, integration with more advanced wearables such as Apple devices and glucometers, facilitation for health coach-patient interactions, and AI-assisted smart nudges based on the latest research in machine learning. Our innovative approach to care, featuring multi-component intervention, has the potential to improve outcomes in the management of chronic diseases.

People: Low Liang Leng (Dr.), Ong Zhi Quan (Alfred), Ong Zhi Peng (Leon), Ma Pengfei, Poh Yi Long (Lawrence), Fu Yisi, Xu Ping, Le Van Minh

Publications (if any): Kwan, Y. H., Ong, Z. Q., Choo, D. Y. X., Phang, J. K., Yoon, S., & Low, L. L. (2022). A Mobile Application to Improve Diabetes Self-Management Using Rapid Prototyping: Iterative Co-Design Approach in Asian Settings. Patient Preference and Adherence, 1-11.

### 2. Wellness Buddy

Due to the shift work and irregular working hours that pilots and airline crew may face, working on long-haul flights is associated with multiple health problems. One widely investigated health issue is pilot fatigue. According to Caldwell (2005), approximately 4% to 8% of aviation incidents and accidents can be attributed to fatigued pilots. With the prevalence of long-haul and ultra-haul flights in recent years, it is critical to consider how air crew's levels of fatigue and alertness adapt to the more demanding flight duties. While airline companies have made great efforts to monitor and evaluate air crew fatigue, it still meets severe challenges in monitoring and evaluating air crew fatigue.

To address this, we partner with the SIA-NUS Digital Aviation Corporate Lab (SIA-NUS) to develop Wellness Buddy – a platform to measure and model stages of occupational fatigue. Featuring questionnaires and measurement tools from state-of-the-art research, Wellness Buddy is designed to model the effects of consecutive flight duties when predicting air crew fatigue and well-being. Data from this platform will be used to develop a novel fatigue modelling and prediction model that considers individual heterogeneity and complex interactions that exist among fatigue factors. This model can provide more accurate fatigue predictions hence enhancing air crew safety and well-being while maintaining professional standards of work performance.

People: Captain Nilesh Patil, Joshua J Gooley, Ong Zhi Quan (Alfred), Zhang Zhiyao, Yin Jiamin, Luo Jihao, Liu Xiaohui

Publications: Luo, Jihao; Yin, Jiamin; and Teo, Hock-Hai, "The Effects of Gamification Rewards in E-Learning: A Longitudinal Field Study on Motivation and Mental Fatigue" (2022). *ICIS 2022 Proceedings*. 5. <https://aisel.aisnet.org/icis2022/learning_iscurricula/learning_iscurricula/5>

### 3. VR Therapy for Patients in Rehabilitation

Given the rise in patients with cognitive decline in Singapore, enhancing the therapy process for patients in rehabilitation can lead to benefits for the individual both in addressing their cognitive decline and improving their well-being. Working towards this objective, we have developed Virtual Reality (VR)-assisted therapy for patients in rehabilitation. Our solution aims to validate psychosocial intervention for rehabilitation / dementia patients through solutions such as reminiscence therapy, music therapy and occupational therapy. VR-assisted reminiscence therapy involves encouraging patients to revisit memories from the past, for instance through recreating a museum scene for them to identify important people. Music therapy focuses on creative outlets such as listening to calming sounds of nature while occupational theory could involve VR-created scenes of a beach for patients to walk around. Ultimately, these VR-assisted therapeutic solutions aim to enhance emotional well-being, reduce behavioural symptoms, and promote everyday functioning.

People: Munirah Binte Bashil, Liu Rui

Publications:

### 4. MindPRO

Cognitive decline prevention can be achieved through early detection of cognitive impairment. However, the cost of cognitive screening is prohibitively high, and hospitals face constraints on manpower, space, and cost. To address the lack of early detection of cognitive impairment, we are developing a digital solution, the MindPRO Super App, that can provide a quick assessment of brain functions to detect any impairment of cognitive functions even at the slightest range. MindPRO focuses on the testing of the user’s frontal lobe capabilities in order to efficiently assess all the functions more commonly associated with head injuries, dementia and chronic diseases and provide quick follow-up if required. Initial results from an ongoing validation study that tests MindPRO against conventional hospital pen-and-paper screening tests have been promising.

People:

Publications (if any):

### 5. Cognify

Conventional contact sensor-based health measurement systems may cause discomfort and inconvenience to the patient especially with the pandemic situation where non-contact solutions are preferred. Some conventional health measurement systems also do not support long-term monitoring of elderly patients who experience difficulties accessing healthcare due to immobility. Our team has designed an AI-assisted non-contact health measurement systems that monitors vital signs through a series of remote sensors. Wireless vital signal monitoring enables healthcare practitioners to accurately monitor and assess the patient’s vital signs remotely, ensuring that quality healthcare can reach all those who need it. With Cognify having achieved high accuracy (88.2% - 94.6%) for tests of vital signs such as respiration rate, blood pressure, and heart rate, our next aim is to reach 95% accuracy through machine learning with more data.

People:

Publications (if any):

### 6. $WEAT

Maintaining physiological and mental wellness can be challenging in today’s world, as people are exposed to numerous stresses in their daily lives that can lead to a raft of health and social issues. $WEAT creates an integrated digital wellness platform that cultivates physiological and mental wellness through habit formation, motivation activation and social interaction. $WEAT combines a mobile application with wearable technology to provide interactive and customised user experiences that employ digital reminders and nudges, quantified self, social connection, and social comparison. A prior research study involving a prototype of $WEAT showed that using the solution was correlated with a greater chance of improved physical activity motivation over time, particularly for those with low initial motivation. $WEAT is currently in development and due to launch in phases within 2023.

People: Ong Zhi Quan, Ma Pengfei, Poh Yi Long (Lawrence), Fu Yisi, Xu Ping

Publications (if any):

### 7. iMovin’

Although the benefits of physical activity on individual well-being have been well-documented, many individuals continue to have insufficient levels of exercise. To address this issue, technology is increasingly used in interventions aimed at promoting physical activity. With the advent of new information and communications technologies (ICT) and capabilities, personalized interventions are emerging as a new wave of technology-based solutions to communicate health messages more persuasively to a diverse audience.

In response, we developed iMovin’—a personalized technology-based intervention that uses a mobile-based platform (mobile app) to promote physical activity. iMovin’ consists of a self-developed, multi-feature mobile app paired with a wireless activity tracker. The features in iMovin’ are personalized based on the participants’ current motivations and goals for exercise.

A research trial involving 100 participants between 2020 and 2021 has found that the use of iMovin’ is associated with improvements in exercise outcomes and motivation for physical activity. Moreover, the trial outcomes indicated that individuals with lower levels of pre-intervention motivation for physical activity reaped even more benefits from the app.

People: Ong Zhi Quan, Wang Chen, Ma Pengfei, Yin Jiamin

Publications: Ong, Z. Q., Yin, J. (2023). The Potential of Salient Nudging in Physical Activity Promotion: Evidence from A Longitudinal Field Experiment. Manuscript in preparation.

## People [Page]

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Principal Investigator

Teo Hock Hai

Hock-Hai Teo is Provost’s Chair Professor in the Department of Information Systems and Analytics, School of Computing at National University of Singapore. He is currently very passionate and focused on implementing three of his pet projects: 1) improving the healthcare service delivery models and outcomes through process improvement using healthcare Internet of Things (IoT); 2) shaping the innovation capabilities of Singapore’s Small Medium Enterprises in today’s digital economy; and 3) enhancing the learning outcomes of pupils through better delivery of pedagogical content and building of competences via an adaptive, customizable learning platform.

Hock-Hai has previously served as the Vice-Dean (Corporate Communications), School of Computing and as Head of the Department of Information Systems. During his tenure as Head of Department, he was instrumental in raising its profile and reputation both locally and internationally. Today, the department is recognized as one of the most productive research departments in Information Systems and Analytics globally. With strong support from the local government agencies, he helped the school set up the Strategic Technology Management Institute and the Center for Health Informatics as vehicles for industry engagement and executive education, and launched one of the world’s pioneering undergraduate Business Analytics Degree Programs to meet the industry needs for data science professionals. In recognition of his outstanding contributions to the information systems discipline in terms of research, teaching and service, the Association of Information Systems honored him with an AIS Fellow award.

Hock-Hai received his PhD (Information Systems), MSc. (Computer and Information Sciences) and BSc. (Computer and Information Sciences) from the National University of Singapore and was a visiting scholar (post-doc) at The Wharton School, University of Pennsylvania. He is grateful for the education, the opportunities and the support he has received from his alma mater.

### Current Team

Ong Zhi Quan (Alfred)

Ong Zhi Quan (Alfred) is a Research Fellow in the Department of Information Systems and Analytics under the NUS Institute of Operations Research and Analytics. His current research stream focuses on the development and employment of technology-based interventions in promoting health-related behavior. This stream translates to the conceptualization and testing of theories to explain: (i) how technology-based platforms and wearables (such as Fitbit) are employed to promote health-based behavior such as exercise, diabetes management and workplace fatigue, and (ii) the best possible ways to design the platforms to maximize their efficacy. Outside of work, Alfred participates in volunteer work and is a gourmet enthusiast.

Ong Zhi Peng (Leon)

Ong Zhi Peng (Leon) is a Research Fellow in the Department of Information Systems and Analytics. His current research stream focuses on: (i) application of machine learning in technology-based interventions, which involves conceptualization of smart AI notifications for promoting health-related behavior, and (ii) statistical analysis on cognitive tests for diagnosis of patients' diseases such as dementia and Mild Cognitive Impairment. Outside of work, Leon enjoys solving logic puzzles.

Luo Jihao

Luo Jihao is a Ph.D. candidate in the Department of Information Systems and Analytics. With a focus on fatigue modeling and intervention, his research combines machine learning techniques to create multivariate models that accurately measure fatigue levels. In addition, Jihao is also dedicated to finding technology-based solutions to alleviate fatigue and improve overall well-being. Outside of work, Jihao is also an enthusiastic traveler, reader, and gourmet.

Liu Xiaohui

Xiaohui Liu is a Ph.D. candidate in the Department of Information Systems and Analytics. Her research interest focuses on AI-advised human decision-making, AI bias, and the social impact of AI.

Liu Rui

Liu Rui is a Research Assistant in the Department of Information Systems and Analytics. His current research interests include anomaly detection in multi-aspect and image data. Anomaly detection on multi-aspect data focuses on the detection of sudden bursts and outliers in a streaming manner, which is common in traditional tabular-based data and network attack analysis. The goal is to build a framework that performs online learning and scoring, and at the same time, be robust to potential concept drifts. The detection on image data works with photos of industry photos. It aims at the classification of normal and defective industry products, as well as image alignment and defect localization. Aside from those, Rui is also a VR game developer, familiar with Unity and Unreal Engine.

Yang Meixia

Meixia Yang is a Full-Stack developer in the Department of Information Systems under the National University of Singapore. She has experience working with both front-end and back-end technologies to create dynamic and responsive web and mobile applications. Her research experience is comprehensive and includes the development and integration of hardware sensors, signal processing, and machine learning algorithms to analyse radio signals. Meixia’s current interest is to explore the healthcare domain using information and communication technologies.

Poh Yi Long (Lawrence)

<write-up>

Yisi

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Pengfei

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Xu Ping

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Munirah

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Le Van Minh

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Hu Jiajun

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Zhang Zhiyao

Zhang Ziyao is a Research Assistant in the NUS-SIA Corp-Lab. Advised by Prof. Teo Hock Hai and Prof. Jussi Keppo, he works as a joint software engineer. Prior to joining the lab, he graduated with Computer Science & Second major in Statistics from the National University of Singapore (NUS). His focus areas and interests include software engineering, machine learning, blockchain, web3 areas, and so on. He enjoys coding and always gain knowledge as his passion.

Yang Mei Xia

Meixia Yang is a Full-Stack developer in the Department of Information Systems under the National University of Singapore. She has experience working with both front-end and back-end technologies to create dynamic and responsive web/(mobile) applications. Her research experience involved a comprehensive approach that included the development and integration of hardware sensors, signal processing, and machine learning algorithms to analyse radio signals. And her current interest is to explore healthcare domain using information and communication technologies.

### Collaborators

Low Liang Leng (Dr.)

Assoc Prof Low Lian Leng is currently a Consultant at the Department of Family Medicine and Continuing Care at the Singapore General Hospital, and Medical Director at Outram Community Hospital. Concurrently, he is also Director of the Population Health and Integrated Care Office in SGH, Director, SingHealth Office of Regional Health System for SGH campus, and Director of Health Services and Outcomes Research for the SingHealth Duke-NUS Family Medicine Academic Clinical Programme. He is also faculty at the SingHealth Family Medicine Residency program and Duke-NUS Family Medicine clerkship.

Assoc Prof Low completed his Master of Clinical Investigation at the National University of Singapore and has a deep interest in health services research, especially in the areas of population health, innovative integrated care delivery models, value-based care and data analytics. He is currently the Co-Director of the Centre for Population health research and Implementation in SingHealth, and is theme lead and core lead of the Complex needs and data analytics core respectively in the SingHealth Regional Health System Population Health centre grant. The SingHealth population health research database tracks critical population health indicators and outcomes in the Regional Health System (RHS) based on the Quadruple Aim. As core lead of the Data Analytics platform in the SingHealth PULSES centre grant, Assoc Prof Low is supervising data analysts, research associates in their professional work. Concurrently, he is mentoring third year Duke-NUS medical students, family medicine residents and fellows for their research projects.

Joshua J Gooley (Asst. Prof.)

Dr Joshua Gooley is an Associate Professor in the Neuroscience & Behavioural Disorders Programme at Duke-NUS Medical School in Singapore. He is Principal Investigator of the Chronobiology and Sleep Laboratory and Director of Research of the SingHealth Duke-NUS Sleep Center. He is the current president of the Singapore Sleep Society and is Neuroscience Theme Lead of the Institute for Applied Learning Sciences and Educational Technology at the National University of Singapore. He received his PhD in Neurobiology from Harvard Medical School, where he studied neural pathways that regulate sleep and circadian rhythms. His research program at Duke-NUS focuses on understanding the role of sleep and circadian rhythms in regulating human performance and health outcomes.

Captain Nilesh Patil

Nilesh is a Management pilot with Singapore Airlines involved with Flight Operations Safety, Security and Quality. He is currently a Captain on the Boeing 787, having recently transitioned from the Boeing 777, a fleet he has been on for over 20 years. His journey in management has allowed him to explore and participate in the inner workings of flight operations. Within the management role, he has had the opportunity to work in Fatigue Risk Management. Airline crew work round the clock in a unique setting. Their quality of work and their quality of life is closely tied with their quality of sleep. This is what interested him in WP3 which centres around Crew Wellness.

Outside of work, he likes to spend time reading. He is always reading something and tries to read at least 2-3 books every month. He also spends a little time each day doing some yoga and meditation.

### Alumni

Wang Chen

Yin Jiamin

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