

Digital Health Care

Perspectives, Applications, and Cases

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We hereby dedicate this book to our immediate family members.

For Phillip Olla, they would be Yazmin, Joelle, Gabriel, and Zayne, his wise and enthusiastic wife Venus, and his mother for their constant prayers and encouragement; for Joseph Tan, his son, Joshia as well as his wife, Leonie, have always been understanding, encouraging, and supportive for everything in his *wish* list.

–Phillip Olla and Joseph Tan

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Preface

Digital Health Care: Perspectives, Applications, and Cases explores the applications of health information technology (IT) and informatics in multifaceted perspectives that are transforming how health care is being delivered around the world. It provides a comprehensive series of chapters to unveil how digital health is being deployed to revolutionize all aspects of the administrative and clinical workflows that are typically encountered in an evolving health learning system. In addition to the general themes such as historical evolution, current state-of-the-art reviews, and emerging eHealth, telemedicine, mobile health and identifying future trends, this text also provides unique insight into digital health transformation in real-life practices via short case studies as well as real-world examples.

This digital health informatics text essentially covers theory along three distinct viewpoints: technological, business, and clinical, while providing insight into the intersection of these spheres. The multiple contributors explore and detail the innovative adoption of core and supplementary digital tools in administrative and clinical settings with specific examples of how these innovations affect real-world practices. Moreover, some authors emphasize techniques for evaluating clinical outcomes with the use of these tools or devices, such as improved care, performance improvement, and cost reduction in clinical settings. Other authors worked on topics that are pertinent to comprehend because of the rapid digitization of health care, including privacy, interoperability, risk analysis and regulatory standards, and policies. The reader will also discover how the clinical setting is being transformed and understand the role healthcare professionals must undertake to assess, develop, and use health IT

and informatics to work more efficiently, allocate resources more effectively, and improve patient care and safety.

This book is written for undergraduate health-care professionals from multiple disciplines such as allied health, nursing, dietetics, health administration, public health, and health informatics, to name just a few. The overarching objective is to provide an understanding of how the digitization of health care is transforming all aspects of how health care is being provided. The content is presented in a way that makes it accessible to students at various skill levels, independent of any prior technology knowledge.

The text is designed to be used also by all healthcare professionals, not just medical or clinical practitioners. Students with a background in information and communication technology will also find the book an important summary of the diverse digital health applications, as well as presenting the unique challenges emerging from this domain. Beyond this, the book emphasizes strongly what concepts and technology are emerging, and the cases help the readers understand why some solutions appear to work so much better than others. Notably, each chapter and case study in this book concludes with questions to test the reader's comprehension of the concepts covered and to stimulate discussion. Altogether, these chapters with the cases have been created and organized to be extensive but applicable for a 14- to 16-week semester and focus as much as possible on fundamental concepts and principles rather than simple descriptions of the basic topics.

Digital health has undergone considerable transformations over the last decade. New approaches have emerged, and new techniques and technologies have been adopted. Previous ideas have fallen

by the wayside, obsolete because of improved computer processing power and artificial intelligence. It would be an unwise undertaking for a single author to write a comprehensive textbook on digital health informatics. We have therefore invited experts from diverse disciplines to collaborate to develop a textbook that will include information that will have a long shelf life. The research and practical aspects of digital health develop rapidly, and it is very easy to create materials that date quickly. Hence, it is a tough bal-

ance between creating an introductory textbook that explores the core digital health informatics concepts required to understand our discipline with a unified voice or an encyclopedic multi-authored textbook that aims to do everything but may have too many voices that can easily overwhelm the readers. For this reason, we have struck an equilibrium and managed to keep a unified voice.

Phillip Olla and Joseph Tan



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Contributors

Mustafa Abumeeiz

Mustafa Abumeeiz recently graduated with a bachelor of science from the Behaviour, Cognition and Neuroscience program at the University of Windsor. He is currently employed as a research associate at Audacia Bioscience in Windsor, Ontario. His research interests include applications of blockchain and cryptocurrency, COVID-19 testing, and breathonomics.

Biola Adeniyi

A trained dentist, Biola is a dental public health professional and researcher with 14+ years of experience in population oral health research and specialized expertise in integrated oral health and maternal and child oral health. Biola has technical experience in community-based oral health interventions and is a committed and dynamic professional, trainer, and mentor with the ability to convey scientific concepts to diverse audiences.

Joshua Armstrong

Joshua J. Armstrong, PhD, is an assistant professor in the Department of Health Sciences at Lakehead University. He has taught courses across three departments at Lakehead (Health Sciences, Psychology, Computer Science) and has research interests in gerontology, epidemiology, cognitive sciences, health measurement, and data analytics.

Aya Abu-Libdeh

Aya I. Abu-Libdeh is currently pursuing a bachelor of applied science degree in electrical and computer engineering, with minors in mathematics and business administration at the University of Windsor. From 2019 to 2021, she was a research assistant with the e-MINDS Research Center, Windsor. Her research interests include BioMEMS sensors.

Mahnaz Bayat

Mahnaz Bayat is a master's candidate in the e-health program at McMaster University. She is also working as a nurse in the St. Joseph Hospital in Hamilton. She is currently a registered practical nurse (RPN) and in the final stages of becoming a registered nurse (RN) in the province of Ontario. Before joining McMaster University, Mahnaz completed her master's in health informatics and management program from the University of Massachusetts, Lowell. She later worked in the Cerner Corporation as a clinical consultant. Through employment in Cerner, she gained invaluable knowledge about the hospital information system and learned to characterize, evaluate, and refine clinical processes, as well as develop, implement, and refine clinical decision support systems. Parallel to her studies in the United States, she pursued the nursing program in the state of Massachusetts and became an RN. Working as a nurse for over 10 years, Mahnaz has in-depth knowledge of hospital operations in the operating room and cardiac care units. She has hands-on clinical experience in hospital settings in the United States, Canada, and Iran.

Rajib Biswas

Dr. Rajib Biswas received his master of science degree in physics from Dibrugarh University, India and received his PhD from North East Institute of Science & Technology, India. Since 2010, he has been serving as a faculty member in the Department of Physics, Tezpur University. He has been an editorial board member of several peer-reviewed journals and has published more than 90 papers in reputed peer-reviewed journals. His current research interests include optoelectronics, fiber optics and instrumentation,

nano materials, heavy metal ion detection, contamination, and big data analytics.

Jingyu Cao

Jingyu Cao received her master's degree in management sciences from the University of Waterloo in 2018. Her research interests include operations research, decision support systems, and data science with applications on business analytics and health informatics.

Ileana Carillo

Dr. Ileana M. Carillo-Crane is an assistant professor in the Health Services Administration program at Lehman College of the City University of New York (CUNY). She teaches content in healthcare management, health information technology, reimbursement methodologies, strategic management, informatics, human resources, finance, and others. She also teaches health information technology at State University of New York (SUNY), Nassau Community College. Dr. Carillo's expertise in workforce development has contributed to improving the regional workforce and establishing long-lasting industry and academic partnerships. Her research contributes to exploring motivation and succession planning to ensure an adequate pipeline of healthcare workers in the future.

Nicole Chestnut

Nicole Chestnut is in the process of becoming a registered dietitian nutritionist (RDN). She was born and raised in New Zealand, moving to the United States at age 17 to pursue a volleyball scholarship at Madonna University. After graduating with a bachelor of science in dietetics, she completed a master's degree in nutrition and wellness (May 2021). Nicole is currently an intern for the University of Michigan in preparation to take the RDN exam early next year. As a future dietitian her goals lie within policy and research. There is a need to both create and revise certain systems and policies surrounding nutrition, to ensure all members of the community are equipped with the tools they need to thrive as healthy individuals.

Turna Chowdhury

Turna Chowdhury grew up in Chittagong, Bangladesh. The existence of superstitious belief, the double burden of disease, and other mental health problems motivated her to pursue studies in the field of public health. At a very early stage in life, she became aware of the many ways in which inequality affected people in her country. One of the ways in which this disparity can be seen is in the access to affordable and high-quality health care. She volunteered and worked in many governmental and nongovernmental organizations that led her to understand how much good one can do by addressing these health issues at a community level. She completed her undergraduate degree in public health from Asian University for Women, Bangladesh and received her master's degree in public health at McMaster University. She is currently working as a community organizer. She likes reading books, traveling, and spending time with her loved ones.

Katelyn Colling

Katelyn Colling attended Marygrove College in Detroit, where she majored in dance performance. She graduated summa cum laude in December 2017 with a bachelor of arts. She has enjoyed many years of professional dancing, teaching, and choreographing. Katelyn is a certified Zumba instructor, as well as a certified group fitness instructor through Athletics and Fitness Association of America. She started her own business, Your Time Fitness LLC, in 2020. To further her career in the health and fitness area, she obtained a master of science in nutrition and dietetics from Madonna University in May 2021. Katelyn was accepted as an intern by Priority Nutrition Care Distance Dietetic Internship. She is looking forward to a fulfilling career as a registered dietitian nutritionist.

Michael Dohan

Michael S. Dohan, PhD, is the director of the Center for Innovation and Entrepreneurship Research and associate professor in the Faculty of Business Administration at Lakehead University. He teaches several topics related to information systems, such as systems analysis and design.

His research focuses on issues related to digital transformation in healthcare and has published his work in the *Communications of the Association for Information Systems*, and *Healthcare Management Review*.

Eman El-Masri

Eman El-Masri completed her bachelor of applied science in electrical and computing engineering at the University of Windsor. She studied micro and nanodevices at e-Minds Research Centre as an Outstanding Scholars student. In recognition of Eman's academic excellence, she received multiple awards from within and outside the University of Windsor. She has a passion for both engineering and biology and plans to pursue further education in biomedical engineering.

Lauren Elliott

Lauren Elliott recently graduated with a bachelor of science from the Behaviour, Cognition and Neuroscience program at the University of Windsor. She is currently employed as a research associate at Audacia Bioscience in Windsor, Ontario. Her research interests include data management solutions for health care, breath analysis, and COVID-19 vaccine efficacy.

Arezoo Emadi

Dr. Emadi is an associate professor in the Department of Electrical and Computer Engineering. She joined the University of Windsor in July 2017. Dr. Emadi received her PhD from the Department of Electrical and Computer Engineering at the University of Manitoba and her licentiate degree from the Department of Microtechnology and Nanoscience at the Chalmers University of Technology in Sweden. She is a senior member of the Institute of Electrical and Electronics Engineers (IEEE) and a professional engineer. Dr. Emadi's research activities revolve around the area of Micro Electromechanical Systems (MEMS), medical MEMS sensors and transducers, biosensors and chemical sensors, advanced diagnosis sensor technologies, micro and nano electronic devices, and fabrication and medical imaging systems. She has focused her effort on advanced micromachining techniques to create opportunities for the development of revolutionary new sensors that

are small enough for integration into microelectronic systems and instrumentation, more easily deployable in a multitude of sensing applications, and capable of sensing unique aspects of the environment more accurately, safely, and reliably than ever before. Dr. Emadi has led academic and industry cross-functional projects to introduce and implement next-generation micromachined smart sensor systems in a wide range of fields that make abundant use of sensors and transducers such as medical, environmental sciences, agriculture, and personal electronics to deliver the benefits of these technologies to a wider segment of the world's population.

Leah Sue Evans

Leah is recently retired from University of Pittsburgh Medical Center where she worked as an informatics nurse. She was a nurse for 45 years before retirement. During that time, she worked with healthcare professionals in a medical setting supporting them in the clinical arena. Her role included extensive teaching and mentoring not only to new employees but also to support current employees. Leah is currently an adjunct professor in the Healthcare Informatics program at Chatham University and has developed several courses for that program as well. Leah is also a retired United States Army Reserve Major, having retired after 20 years as a reservist. Leah currently lives in Gibsonia, Pennsylvania, and enjoys traveling, camping, and spending time with family.

Michael Hall

Dr. Michael L. Hall is an associate professor of public administration and the master of science in leadership at Roger Williams University in Providence and Bristol, Rhode Island. He served as director of both programs from 2006 to 2018. Before joining the faculty of Roger Williams University, he was program director of the master of public administration (MPA) and health administration master's degree programs at the Sage Colleges in Troy and Albany, New York. He has also taught public administration at The University of Oklahoma, The University of Texas at Dallas, The Pennsylvania State University, the State University of New York at Delhi, and the Rensselaer Polytechnic Institute. He holds

a master's and a PhD from The University of Oklahoma. Dr. Hall has published in numerous peer-reviewed journals including *Teaching Public Administration*, *Public Administration Quarterly*, *The Official Journal of the European Association of Hospital Managers*, and *Health Marketing Quarterly* among others. He is the president of the Rhode Island Chapter of the American Society for Public Administration and has served on the American Society for Public Administration National Council. He also served as principal representative to the National Network of Schools of Public Administration/Affairs from the Roger Williams University MPA.

Hai Huynh

Hai Huynh (HBComm) is a master of science (management) student at Lakehead University.

Mountasser Kadrie

Dr. Mountasser Kadrie has over 25 years of healthcare executive experience, including holding executive leadership appointments at world-renowned health systems, academic medical centers, and higher education institutions. Dr. Kadrie now serves as associate professor and programs director of Clinical Operations Healthcare Management and the Healthcare-MBA at the School of Medicine and Health Sciences and the School of Business at George Washington University. His expertise has been focused on promoting strategies for maximizing healthcare performance and creating transformational change. Dr. Kadrie's professional, academic, and research interests are concentrated on promoting healthcare innovation and digital health transformation. Dr. Kadrie is a double Fulbright awardee, a Fellow of the American College of Healthcare Executives (FACHE), and a Fellow of the American College of Medical Practice Executives (FACMPE), and a Certified Professional in Healthcare Information Management Systems (CPHIMS). He has served as a board examiner for the Baldrige Performance Award Program at the National Institutes of Standards and Technology (NIST) and council member at the *New England Journal of Medicine* (NEJM) Catalyst Insights Council and other national and international organizations. Dr. Kadrie engages in

consulting opportunities with national and international healthcare organizations and academic institutions to promote healthcare improvement and transformation.

Joanne Kearon

Joanne Kearon is a public health and preventive medicine resident at McMaster University. She completed a master of science in neuroscience at Queen's University, before attending medical school at the Michael G. DeGroote School of Medicine at McMaster University, graduating in 2017. Since then, she has completed a residency in family medicine and a master of public health. She now works part time clinically as a family doctor, while completing her public health residency.

Jiban Khuntia

Dr. Jiban Khuntia is an associate professor of information systems at the Business School of the University of Colorado Denver. He is also a faculty member in the health administration program. He directs the Health Administration Research Consortium and CSIS (Computer Science and Information Systems) Business PhD program. He received his PhD from the Robert H. Smith School of Business, University of Maryland. Dr. Khuntia's research is in the areas of health information technology and service innovation. His work has appeared in top journals, including *Journal of Medical Internet Research*, *Information Systems Research*, *Production and Operations Management*, *Journal of Management Information Systems*, *Decision Science*, *Decision Support Systems*, and *Communications of the Association for Information Systems*. Previously, he had a decade of professional and consulting experience in supercomputing, the IT industry, and government.

Emily Marron

Ms. Emily Marron is a registered dietetic technician working in the Milk Room at C.S. Mott Children's Hospital and Von Voigtlander Women's Hospital in Ann Arbor. She is currently finishing her master's degree in nutrition and wellness at Madonna University and plans on becoming a registered dietitian. She lives in Westland, Michigan, with her 13-year-old son and her fiancé.

Deanna McClellan

Deanna is a graduate student at Madonna University studying for her master's in nutrition and dietetics. She received her bachelor's degree in health science from Grand Valley State University in 2012. She works closely with Madonna University's Nutrition Network as the vice president where she helps organize volunteer efforts and nutritional events around campus and surrounding communities. Deanna has worked in the medical field as a nursing assistant providing hands-on patient care for 13 years and plans to continue working closely with patients as a registered dietitian nutritionist, specializing in diabetes education, once she completes her dietetic education.

Matilda Mustapha

Dr. Mustapha is an assistant professor of quantitative systems, management, and marketing in the School of Business at Madonna University. She also brings 9 years of corporate experience in quality management to the academic setting. She received her bachelor's degree in science, a master of science in business administration (quality management), and a PhD in technology management. Dr. Mustapha focuses on developing research and analytical skills for both graduate and undergraduate students. She has taught a variety of courses ranging from business statistics, strategic management, leadership and ethics, research methodology, computer science, management information systems, and operations management. She has also taught business management courses for Madonna University programs in Mainland China. Dr. Mustapha is involved in several research projects including The Symbolic Interactionist View on Transnational Education, Managing Virtual Teams, Ethical Organizational Climate, Transformational Leadership and Emotional Intelligence and Examining the Paradoxical Relation between Socio-Technology Optimization and Marxist Theory of Alienation. She has coauthored articles in highly referenced scientific and business journals and has presented in both domestic and international conferences. Dr. Mustapha is a professional chair member of International Economics Development and Research Center, a member of Decision Sciences Institute, and a member of the Society for

Collegiate Leadership and Achievement-Honor Society. She is also an honorary faculty member of Delta Mu Delta.

Haleh Nazemi

Haleh Nazemi is a PhD student in the Department of Electrical and Computer Engineering at the University of Windsor, Ontario. She received her master of applied science degree in electrical engineering at the University of Windsor with a background in physics. Her current research interests include microelectromechanical systems (MEMS) sensors and transducers, integrable sensors and transducers, chemical sensors, BioMEMS, and design and development of environmental monitoring systems. She is the lab manager of e-Minds Research Centre at the University of Windsor, IEEE member, and the Women in Engineering co-chair at IEEE, Windsor section.

Nancy Pham

Nancy Pham is a project lead at a two-site hospital: Mackenzie Health Hospital and Cortellucci Vaughan Hospital. Nancy has a bachelor of science degree and is working toward a master of science in eHealth at McMaster University. She is managing IT-related projects for the hospitals as well as managing ongoing operational initiatives that improves clinical workflows for staff and patient care. Mackenzie Health is the first hospital in Canada that implemented the full suite of the Epic electronic medical record. Other innovative projects that she has implemented include an integrated bedside solution for patients, giving them access to entertainment, meal ordering digitally as well as other supplementary patient education materials to help improve their stay, and a mobile application solution that helps improve communication between healthcare providers. She is passionate for innovative technologies and solutions that will continue to improve and benefit the healthcare industry.

Parveen Razvi

Parveen Razvi was born in London, Ontario, and raised in Michigan and Ontario. Parveen graduated from the University of Windsor in Windsor, Ontario, where she obtained a bachelor of science in nursing. She is now practicing as an RN at the Detroit Medical Center in Detroit, Michigan.

Haley Walter

Haley Walter is a business analyst for a physician organization in Southfield, Michigan, serving as a liaison between the clinical and information technology team and leading a variety of business initiatives. She holds a bachelor of science in health sciences degree from Madonna University and is currently pursuing a master of public health degree from Madonna University.

Debra Wolf

Dr. Debra Wolf is a professor of healthcare informatics and nursing at Chatham University in Pittsburgh, Pennsylvania. Dr. Wolf is the founding director of the Healthcare Informatics graduate program at Chatham and an independent healthcare informatics consultant supporting higher education, healthcare institutions, and IT vendors in integrating IT-related concepts, theory, and new technology. Dr. Wolf has over 40 years of experience within the healthcare arena. Dr. Wolf serves as an accreditation evaluator for the Commission on Collegiate Nursing Education and is on the advisory board for several health-related organizations. Dr. Wolf has published numerous articles and book chapters and coauthored books titled *Social Media for Nurses: Educating Practitioners and Patients in a Networked World* and *Introduction to Computers for Healthcare Professionals* (seventh edition). She has presented at international, national, and local conferences. Dr. Wolf is a member of various organizations such as the Healthcare Information and Management Systems Society and Sigma (an International Nursing Honor Society).

ShiKui Wu

ShiKui Wu, PhD, is an assistant professor in the Faculty of Business Administration at Lakehead University. He teaches business modeling and decision analytics, project management, operations management, enterprise systems and architecture. His research interests include e-com-

merce, analytics, and supply chain management. His research has been published in journals such as *Journal of Strategic Information Systems*, *Journal of Business Research*, *Journal of Organizational Computing and Electronic Commerce*, and *Journal of Information Technology Cases and Applications* and has also been presented at prominent conferences such as International Conference on Information Systems, Hawaii International Conference on System Sciences.

David Wyant

David K. Wyant, PhD, is an assistant professor of management in the Jack C. Massey College of Business, Belmont University. He holds a PhD in health services research policy and administration (finance) from the University of Minnesota and a master of business administration (finance) and master of arts in economics (international trade) from the Ohio State University. His healthcare career began in 1977 as staff economist for the Ohio Nursing Home Commission of the Ohio Legislature. He has held positions with healthcare providers, in healthcare policy, and on university faculty. He coauthored research published in *Medical Care*, *Journal of the American Board of Family Medicine*, *Archives of Physical Medicine and Rehabilitation*, *Journal of Health Care for the Poor and Underserved*, *Journal of Medical Systems*, *Digital Health*, *Journal of Healthcare Information Management*, *Community Mental Health Journal*, and other journals. He is active in the Healthcare Management and Information Systems Society and the Healthcare Financial Management Association.

Yazmin Olla

Yazmin Olla is a graduate of Ottawa University where she completed her French immersion Biomedical Science degree. She has worked with Health Canada as a project assistant. She works as a Veterinary Assistant at a local Animal Hospital.



Foreword

There is no denying the tremendous impact digital health is having on transforming global health systems. As the world deals with the aftermath of the COVID-19 pandemic, digital health technologies deployed during the pandemic are now being adapted to traditional healthcare delivery models to create new models of care. The end goals are to educate healthcare consumers so they can be better informed and self-managed when and where necessary, to enlighten care providers so they can better coordinate the delivery of connected care as envisioned, and to empower policymakers so they can better reallocate limited resources available to meet competing needs and wants for prioritizing and safeguarding public safety, health, and well-being.

Although digital health systems existed in a mature state before the onset of the global pandemic in 2020, healthcare organizations were resistant to change because of the status quo, billing models, and healthcare policies that favored more traditional face-to-face care. This is changing, and we can now expect to see increasing use of telemedicine for diagnostics, treatments, and round-the-clock monitoring in enhancing the safety and efficiency of health care. Digital health is also being deployed to improve supply chains and logistics and reduce the cost of delivering care. Data sciences and data analytics are now central to health learning systems, either as a scheme to managing Big Data or as a foundation

for artificial intelligence tools to support surveillance, planning, and care management as well as personalized treatment protocols.

Over the past decade there has been a distinctive and gradual transference in the power dynamics between medical practitioners and the patient, transforming the health systems toward a more personalized, patient-centered, and intelligent system. Unfortunately, as with any disruptive technology, the evolution of digital health is also manifesting unforeseen health data challenges such as data ownership, control, management, and monetization. A more immediate critical challenge is how to maintain privacy, security, and confidentiality in a world where all data repositories are now even more vulnerable to cyber hackers.

In this comprehensive work, Drs. Phillip Olla and Joseph Tan offer broad and deep insights to the key concepts, multifaceted approaches, and noted challenges in digital health, emphasizing core and emerging digital health technologies that today's health practitioners and practicing students must learn to adopt in the coming era of post-pandemic healthcare. The book is certainly going to be more valued by practitioners, for the mini case studies in its final part, connecting theoretical understanding with real world practices and problem-solving.

Stephen Bartol, MD, MBA, FRCSC