# Contents

## II    Biomedical Informatics Applications

## III  Biomedical Informatics in the Years Ahead

### Supplementary Information

# Editors

**Edward H. Shortliffe, MD, PhD, MACP, FACMI** Biomedical Informatics, Columbia University, Arizona State University, and Weill Cornell Medical College, New York, NY, USA

Columbia University, New York, NY, USA

Arizona State University, Phoenix, AZ, USA

Weill Cornell Medical College, New York, NY, USA
ted@shortliffe.net

**James J. Cimino, MD, FACP, FACMI** Informatics Institute, University of Alabama at Birmingham, Birmingham, AL, USA
jamescimino@uabmc.edu

## Associate Editor

**Michael F. Chiang, MD, MA, FACMI** National Eye Institute, National Institutes of Health, Bethesda, MD, USA
michael.chiang@nih.gov

## Contributors

**Russ B. Altman, MD, PhD, FACMI** Departments of Bioengineering, Genetics and Medicine, Stanford University, Stanford, CA, USA
russ.altman@stanford.edu

**Suzanne Bakken, RN, PhD, FAAN, FACMI, FIAHSI** Department of Biomedical Informatics, Vagelos College of Physicians and Surgeons, School of Nursing, and Data Science Institute, Columbia University, New York, NY, USA
sbh22@cumc.columbia.edu

**David W. Bates, MD, MSc, FACMI** Division of General Internal, Medicine and Primary Care, Department of Medicine, Brigham and Women's Hospital, Boston, MA, USA
dbates@partners.org

**David Blumenthal, MD, MPP** Commonwealth Fund, New York, NY, USA
db@cmwf.org

**Patricia Flatley Brennan, RN, PhD, FACMI** National Library of Medicine, National Institutes of Health, Bethesda, MD, USA
patti.brennan@nih.gov

**Eun Kyoung Choe, PhD**    College of Information Studies, University of Maryland, College Park, College Park, MD, USA
choe@umd.edu

**Terry P. Clemmer, MD**    Pulmonary – Critical Care Medicine, Intermountain Healthcare (Retired), Salt Lake City, UT, USA
terry.clemmer@imail.org

**Sarah Collins Rossetti, PhD, RN, FACMI**    Department of Biomedical Informatics, School of Nursing, Columbia University Medical Center, New York, NY, USA
sac2125@cumc.columbia.edu

**Todd Cooper**    Trusted Solutions Foundry, Inc., San Diego, CA, USA

**Robert M. Cronin, MD, MS, MEng**    Department of Biomedical Informatics, Vanderbilt University, Nashville, TN, USA

The Department of Internal Medicine, The Ohio State University, Columbus, OH, USA
robert.cronin@vumc.org

**George Demiris, PhD, FACMI**    Department of Biostatistics, Epidemiology and Informatics, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA
gdemiris@nursing.upenn.edu

**Dina Demner-Fushman, MD, PhD, FACMI**    National Library of Medicine, Lister Hill National Center for Biomedical Communications, Bethesda, MD, USA
ddemner@mail.nih.gov

**Joshua C. Denny, MD, MS, FACMI**    All of Us Research Program, National Institutes of Health, Bethesda, MD, USA
josh.denny@vumc.org

**Parvati Dev, PhD, FACMI**    SimTabs, Los Altos Hills, CA, USA
parvati@parvatidev.org

**Patricia C. Dykes, PhD, MA, RN, FAAN, FACMI**    Center for Patient Safety Research & Practice, Brigham and Women's Hospital, Boston, MA, USA
pdykes@bwh.harvard.edu

**Noémie Elhadad, PhD, FACMI**    Department of Biomedical Informatics, Columbia University, New York, NY, USA
noemie.elhadad@columbia.edu

**Peter J. Embi, MD, MS, FACMI**    Regenstrief Institute and Indiana University School of Medicine, Indianapolis, IN, USA

**Bradley J. Erickson, MD, PhD**    Department of Radiology, Mayo Clinic, Rochester, MN, USA

bje@mayo.edu

**Carol Friedman, PhD, FACMI**  Department of Biomedical Informatics, Columbia University, New York, NY, USA

**Charles P. Friedman, PhD, FACMI, FIAHSI**  Department of Learning Health Sciences, University of Michigan Medical School, Ann Arbor, MI, USA
cpfried@umich.edu

**Mark Frisse, MD, MS, MBA, FACMI**  Biomedical Informatics, Vanderbilt University, Nashville, TN, USA
mark.frisse@vanderbilt.edu

**Jeremy D. Goldhaber-Fiebert, PhD**  Center for Primary Care and Outcomes Research/Center for Health Policy, Stanford University, Stanford, CA, USA
jeremygf@stanford.edu

**Kenneth W. Goodman, PhD, FACMI**  Institute for Bioethics and Health Policy, University of Miami Miller School of Medicine, Miami, FL, USA
kgoodman@med.miami.edu

**Robert A. Greenes, MD, PhD, FACMI**  Department of Biomedical Informatics, Arizona State University, Mayo Clinic, Scottsdale, AZ, USA

**Hayit Greenspan, PhD**  Tel Aviv University, Tel Aviv, Israel

**W. Edward Hammond, PhD, FACMI**  Duke Center for Health Informatics, Duke University Medical Center, Durham, NC, USA

**Vitaly Herasevich, MD, PhD**  Department of Anesthesiology and Perioperative Medicine, Mayo Clinic, Rochester, MN, USA
vitaly@mayo.edu

**William Hersh, MD, FACP, FACMI, FAMIA, FIAHSI**  Department of Medical Informatics & Clinical Epidemiology, School of Medicine, Oregon Health & Science University, Portland, OR, USA
hersh@ohsu.edu

**Assaf Hoogi, PhD**  Computer Science Department, Ariel University, Israel, Ariel, Israel

**Eric Horvitz, MD, PhD, FACMI**  Microsoft, Redmond, WA, USA
horvitz@microsoft.com

**George Hripcsak, MD, MS, FACMI**  Department of Biomedical Informatics, Columbia University Medical Center, New York, NY, USA
hripcsak@columbia.edu

**Charles Jaffe, MD, PhD, FACMI**  Health Level Seven International, Ann Arbor, MI, USA
cjaffe@hl7.org

**Holly Jimison, PhD, FACMI**   Khoury College of Computer Sciences & Bouve College of Health Sciences, Northeastern University, Boston, MA, USA
h.jimison@northeastern.edu

**Kevin B. Johnson, MD, MS, FACMI**   Department of Biomedical Informatics, Vanderbilt University, Nashville, TN, USA
kevin.johnson@vumc.org

**Thomas Kannampallil, PhD**   Institute for Informatics, Washington University School of Medicine, St Louis, MO, USA
thomas.k@wustl.edu

**David R. Kaufman, PhD, FACMI**   Medical Informatics, SUNY Downstate Medical Center, Brooklyn, NY, USA
david.kaufman@downstate.edu

**Kensaku Kawamoto, MD, PhD, MHS, FACMI**   University of Utah, Salt Lake City, UT, USA

**Predrag Klasnja, PhD**   School of Information, University of Michigan, Ann Arbor, MI, USA
klasnja@umich.edu

**Wayne R. Kubick, BA, MBA**   Health Level 7 International, Ann Arbor, MI, USA

**Martin LaVenture, MPH, PhD, FACMI**   Informatics Savvy Advisors, Edina, MN, USA

Institute for Health Informatics (IHI), University of Minnesota, Minneapolis, MN, USA
marty@umn.edu

**Russell B. Leftwich, MD**   InterSystems, Cambridge, MA, USA

Vanderbilt University Medical Center, Department of Biomedical Informatics, Nashville, TN, USA

**Roger G. Mark, MD, PhD**   Department of Electrical Engineering and Computer Science (EECS), Institute of Medical Engineering and Science, Massachusetts Institute of Technology, Cambridge, MA, USA
rgmark@mit.edu

**Clement J. McDonald, MD, MS, FACMI**   Lister Hill National Center for Biomedical Communications, National Library of Medicine, National Institutes of Health, Bethesda, MD, USA
clemmcdonald@mail.nih.gov; CJMcDona@Regenstrief.org

**Genevieve B. Melton, MD, PhD, FACMI**   Department of Surgery and Institute for Health Informatics, University of Minnesota, Minneapolis, MN, USA
gmelton@umn.edu

**Blackford Middleton, MD, MPH, MSc, FACMI**   Apervita, Inc, Chicago, IL, USA

**Matt Might, PhD**   UAB Hugh Kaul Precision Medicine Institute, University of Alabama at Birmingham, Birmingham, AL, USA
might@uab.edu

**Randolph A. Miller, MD, FACMI**   Department of Biomedical Informatics, Vanderbilt University Medical Center, Nashville, TN, USA
randolph.a.miller@vanderbilt.edu

**Sean D. Mooney, PhD, FACMI**   Department of Biomedical Informatics and Medical Education, University of Washington, Seattle, WA, USA
sdmooney@uw.edu

**Judy Murphy, RN, FACMI, LFHIMSS, FAAN**   IBM Global Healthcare, Armonk, NY, USA
judy.murphy29@gmail.com

**Mark A. Musen, MD, PhD, FACMI**   Stanford Center for Biomedical Informatics Research, Stanford University, Stanford, CA, USA
musen@stanford.edu

**Viet Nguyen, MD**   Stratametrics LLC, Salt Lake City, UT, USA

**Douglas K. Owens, MD, MS**   Center for Primary Care and Outcomes Research/Center for Health Policy, Stanford University, Stanford, CA, USA
owens@stanford.edu

**Judy G. Ozbolt, PhD, RN(Ret), FAAN, FACMI**   Department of Organizational Systems and Adult Health, University of Maryland School of Nursing, Baltimore, MD, USA
judy.ozbolt@gmail.com

**Vimla L. Patel, PhD, DSc, FACMI**   Center for Cognitive Studies in Medicine and Public Health, The New York Academy of Medicine, New York, NY, USA
vpatel@nyam.org

**Philip R. O. Payne, PhD, FACMI**   Institute for Informatics, Washington University School of Medicine in St. Louis, St. Louis, MO, USA
prpayne@wustl.edu

**Brian W. Pickering, MB, BCh**   Department of Anesthesiology and Perioperative Medicine, Mayo Clinic, Rochester, MN, USA
pickering.brian@mayo.edu

**Wanda Pratt, PhD, FACMI**   Information School, University of Washington, Seattle, WA, USA
wpratt@uw.edu

**William C. Reed, MS, PhD**    Huntzinger Management Group, Inc, Moosic, PA, USA
wcreed@huntzingergroup.com

**David A. Ross, DSc**    Task Force for Global Health, Decatur, GA, USA
dross@taskforce.org

**Daniel L. Rubin, MD, MS, FSIIM, FACMI**    Departments of Biomedical Data Science, Radiology, and Medicine, Stanford University, Stanford, CA, USA
dlrubin@stanford.edu

**Robert S. Rudin, PhD**    RAND Healthcare, RAND Corporation, Boston, MA, USA
rrudin@rand.org

**Titus Schleyer, DMD, PhD, FAMIA, FACMI**    Department of Medicine, Division of General Internal Medicine and Geriatrics, Indiana University School of Medicine, Indianapolis, IN, USA
schleyer@regenstrief.org

**Nigam H. Shah, MBBS, PhD, FACMI**    Department of Medicine, Stanford University, Stanford, CA, USA
nigam@stanford.edu

**Harold C. Sox, MD, MACP**    Patient-Centered Outcomes Research Institute, Washington, DC, USA
Geisel School of Medicine at Dartmouth, Dartmouth College, Hanover, NH, USA
hsox@comcast.net

**Catherine Staes, PhD, MPH, RN, FACMI**    Nursing Informatics Program, College of Nursing, University of Utah, Lake City, UT, USA
Catherine.Staes@hsc.utah.edu

**Justin B. Starren, MD, PhD**    Division of Health and Biomedical Informatics, Departments of Preventive Medicine and Medical Social Sciences, Northwestern University Feinberg School of Medicine, Chicago, IL, USA
Justin.Starren@northwestern.edu

**Paul C. Tang, MD, MS, FACMI**    Clinical Excellence Research Center, Stanford University, Stanford, CA, USA
paultang@stanford.edu

**Peter Tarczy-Horonch, MD, FACMI**    Biomedical Informatics and Medical Education, University of Washington, Seattle, WA, USA
pth@uw.edu

**Jessica D. Tenenbaum, PhD, FACMI**    Department of Biostatistics & Bioinformatics, Duke University, Durham, NC, USA
jessie.tenenbaum@duke.edu

**David K. Vawdrey, PhD, FACMI**   Geisinger, Danville, PA, USA

**Lynn Harold Vogel, AB, AM, PhD**   LH Vogel Consulting, LLC, Ridgewood, NJ, USA
lynn@lhvogelconsulting.com

**Robert M. Wachter, MD**   Department of Medicine, University of California, San Francisco, San Francisco, CA, USA
Robert.Wachter@ucsf.edu

**Adam B. Wilcox, MD, PhD, FACMI**   University of Washington, Seattle, WA, USA
abwilcox@uw.edu

**Jeremy C. Wyatt, MBBS, FRCP, FACMI, FFCI**   Wessex Institute of Health Research, Faculty of Medicine, University of Southampton, Southampton, UK
j.c.wyatt@soton.ac.uk

**William A. Yasnoff, MD, PhD, FACMI**   National Health Information Infrastructure Advisors, Portland, OR, USA

Division of Health Sciences Informatics, Johns Hopkins University, Portland, OR, USA

National Health Information Infrastructure (NHII) Advisors and Johns Hopkins University, Portland, OR, USA
william.yasnoff@nhiiadvisors.com

# About the Future Perspective Authors (Chapter 30)

### David Blumenthal, MD, MPP

became President and CEO of the Commonwealth Fund, a national health care philanthropy based in New York City, in January, 2013. Previously, he served as Chief Health Information and Innovation Officer at Partners Health System in Boston, MA, and was Samuel O. Thier Professor of Medicine and Professor of Health Care Policy at Massachusetts General Hospital/ Harvard Medical School. From 2009 to 2011, Dr. Blumenthal was the National Coordinator for Health Information Technology under President Barack Obama. In this role he was charged with building an interoperable, private and secure nationwide health information system and supporting the widespread, meaningful use of health IT. Prior to that, Dr. Blumenthal was a practicing primary care physician, director of the Institute for Health Policy, and professor of medicine and health policy at Massachusetts General Hospital/Partners Healthcare System and Harvard Medical School. As a renowned health services researcher and national authority on health IT adoption, Dr. Blumenthal has authored over 300 scholarly publications, including the seminal studies on the adoption and use of health information technology in the United States. Dr. Blumenthal received his undergraduate, medical, and public policy degrees from Harvard University and completed his residency in internal medicine at Massachusetts General Hospital.

### Patricia Flatley Brennan, RN, PhD, FAAN, FACMI

is the Director of the National Library of Medicine (NLM) and Adjunct Investigator in the National Institute of Nursing Research's Advanced Visualization Branch at the National Institutes of Health (NIH). As the world's largest biomedical library, NLM produces digital information resources used by scientists, health professionals, and members of the public. A leader in research in computational health informatics, NLM plays a pivotal role in translating research into practice. NLM's research and information services support scientific discovery, health care, and public health. Prior to joining

NLM, Dr. Brennan was the Lillian L. Moehlman Bascom Professor at the School of Nursing and College of Engineering at the University of Wisconsin–Madison. Dr. Brennan is a pioneer in the development of innovative information systems and services such as ComputerLink, an electronic network designed to reduce isolation and improve self-care among home care patients. She directed HeartCare, a web-based information and communication service that helps home-dwelling cardiac patients recover faster and with fewer symptoms, and also directed Project HealthDesign, an initiative designed to stimulate the next generation of personal health records. Her professional accomplishments reflect her background, which unites engineering, information technology, and clinical care to improve public health and ensure the best possible experience in patient care. A past president of the American Medical Informatics Association, Dr. Brennan was elected to the National Academy of Medicine in 2001. She is a fellow of the American Academy of Nursing, the American College of Medical Informatics, and the New York Academy of Medicine. In 2020, Dr. Brennan was inducted into the American Institute for Medical and Biological Engineering (AIMBE). The AIMBE College of Fellows is among the highest professional distinctions accorded to a medical and biological engineer.

### Mark Frisse, MD, MS, MBA

is an Emeritus Professor in the Department of Biomedical Informatics at Vanderbilt University Medical Center. Until July 2020, he held the Accenture Endowed Chair within the Department. His interests are directed toward the potential contribution to economically sustainable health care through more effective use of informatics and information technology. In addition to his teaching and research responsibilities at the Vanderbilt Medical School, he also directed the Masters of Management in Health Care graduate program at Vanderbilt's Owen Graduate School of Management and led a health information technology course for the executive Masters of Health Care Delivery Science program at Tuck School of Business, Dartmouth College. Previously, Dr. Frisse has held leadership positions at Washington University, Express Scripts, and the First Consulting Group.

At Express Scripts, he was Chief Medical Officer and was responsible for their Practice Patterns Science division and helped found RxHub. At First Consulting, he led engagements in vendor selection, quality governance, physician information technology leadership development, and clinician governance. A board-certified internist with fellowship training in medical oncology, he obtained his bachelor's degree from the University of Notre Dame in 1974 and his MD from Washington University in 1978. He received a master's degree in medical information science from Stanford University in 1987 and an MBA from Washington University in 1997. He is a fellow of the American College of Physicians, the American College of Medical Informatics, and the New York Academy of Medicine. He is an elected member of the National Academy of Medicine.

### Eric Horvitz

is a technical fellow at Microsoft, where he serves as the company's first Chief Scientific Officer. He previously served as director of Microsoft Research Labs. He has pursued principles and applications of AI with contributions in machine learning, perception, natural language understanding, and decision making. His research centers on challenges with uses of AI amidst the complexities of the open world, including uses of probabilistic and decision-theoretic representations for reasoning and action, models of bounded rationality, and human-AI complementarity and coordination. His efforts and collaborations have led to fielded systems in healthcare, transportation, ecommerce, operating systems, and aerospace. He received the Feigenbaum Prize and the Allen Newell Prize for contributions to AI. He was inducted into the CHI Academy for contributions at the intersection of AI and human-computer interaction. He has been elected fellow of the American College of Medical Informatics (ACMI), National Academy of Engineering (NAE), Association of Computing Machinery (ACM), Association for the Advancement of AI (AAAI), the American Association for the Advancement of Science (AAAS), the American Academy of Arts and Sciences, and the American Philosophical Society. He has served as president of the AAAI, and on advisory commit-

tees for the NSF, NIH, and the U.S. Department of Defense. He currently serves on the Board of Regents of the National Library of Medicine and on the scientific advisory board of the Allen Institute for AI. He earned his Bachelors in biophysics at Binghamton University and a PhD in biomedical informatics and his MD at Stanford University.

### Judy Murphy, RN, FACMI, FHIMSS, FAAN

is a nursing executive with a long history in health informatics. She was Chief Nursing Officer for IBM Global Healthcare, where she was strategic advisor regarding provider IT solutions to achieve the quadruple aim. Prior to working at IBM, she was Deputy National Coordinator for Programs and Policy at the ONC in Washington D.C. where she led federal efforts to assist healthcare providers in adopting health IT to improve care and to promote consumers' understanding and use of health IT for their own health. She came to ONC with 25 years of health informatics experience at Aurora Health Care in Wisconsin, a large integrated delivery network. As Vice President-EHR Applications, she led their EHR program since 1995, when Aurora was an early adopter of technology. She publishes and lectures nationally and internationally. She served on the AMIA and HIMSS Board of Directors and is a Fellow in the American Academy of Nursing, the American College of Medical Informatics and HIMSS. She has received numerous awards, including the HIMSS 2018 Most Influential Women in Health IT, the AMIA 2014 Don Eugene Detmer Award for Health Policy Contributions in Informatics, the HIMSS 2014 Federal Health IT Leadership Award, and the HIMSS 2006 Nursing Informatics Leadership Award.

### Peter Tarczy-Hornoch, MD

is Professor and Chair of the Department of Biomedical Informatics and Medical Education at the University of Washington (UW). His background includes computer science, bioengineering, biomedical informatics, medicine (Pediatrics and Neonatology) with undergraduate and medical degrees from Stanford, Residency at the University of Minnesota, Fellowship at the University of Washington. He has played a key role in establishing and growing the biomedical informatics research, teaching and practice activities at UW

for over two decades. The unifying theme of his research has been data integration of electronic biomedical data (clinical and genomic) both for a) knowledge discovery and b) in order to integrate this knowledge with clinical data at the point of care for decision support. His current research focuses on a) secondary use of electronic medical record (EMR) for translational research including outcomes research, learning healthcare systems, patient accrual and biospecimen acquisition based on complex phenotypic eligibility criteria, b) the use of EMR systems for cross institutional comparative effectiveness research, and c) integration of genomic data into the EMR for clinical decision support. Key past research has included data integration and knowledge base creation for genomic testing. He has served in a number of national leadership roles including founding chair of the AMIA Genomics (now Genomics and Translational Bioinformatics) working group.

### Robert M. Wachter, MD

is Professor and Chair of the Department of Medicine at the University of California, San Francisco. He is author of 300 articles and 6 books and is a frequent contributor to the *New York Times* and *Wall Street Journal*. He coined the term "hospitalist" in 1996 and is often considered the "father" of the hospitalist field, the fastest growing specialty in the history of modern medicine. He is past president of the Society of Hospital Medicine and past chair of the American Board of Internal Medicine. In the safety and quality arenas, his book, *Understanding Patient Safety*, is the world's top selling safety primer. In 2004, he received the John M. Eisenberg Award, the nation's top honor in patient safety. Twelve times, *Modern Healthcare* magazine has ranked him as one of the 50 most influential physician-executives in the U.S.; he was #1 on the list in 2015. His 2015 book, *The Digital Doctor: Hope, Hype and Harm at the Dawn of Medicine's Computer Age*, was a *New York Times* science bestseller. In 2016, he chaired a blue-ribbon commission advising England's National Health Service on its digital strategy. He is an elected member of the National Academy of Medicine.

# About the Editors

**Edward H. Shortliffe**

is Chair Emeritus and Adjunct Professor in the Department of Biomedical Informatics at Columbia University's Vagelos College of Physicians and Surgeons. Previously he served as President and CEO of the American Medical Informatics Association. He was Professor of Biomedical Informatics at the University of Texas Health Science Center in Houston and at Arizona State University. A board-certified internist, he was Founding Dean of the University of Arizona College of Medicine – Phoenix and served as Professor of Biomedical Informatics and of Medicine at Columbia University. Before that he was Professor of Medicine and of Computer Science at Stanford University. Honors include his election to membership in the National Academy of Medicine (where he served on the executive council for 6 years and has chaired the membership committee) and in the American Society for Clinical Investigation. He has also been elected to fellowship in the American College of Medical Informatics and the American Association for Artificial Intelligence. A Master of the American College of Physicians (ACP), he held a position for 6 years on that organization's Board of Regents. He is Editor Emeritus of the *Journal of Biomedical Informatics* and has served on the editorial boards for several other biomedical informatics publications. In the early 1980s, he was recipient of a research career development award from the National Library of Medicine. In addition, he received the Grace Murray Hopper Award of the Association for Computing Machinery in 1976, the Morris F. Collen Award of the American College of Medical Informatics in 2006, and was a Henry J. Kaiser Family Foundation Faculty Scholar in General Internal Medicine. He has served on the oversight committee for the Division on Engineering and Physical Sciences (National Academy of Sciences), the National Committee on Vital and Health Statistics (NCVHS), and on the President's Information Technology Advisory Committee (PITAC). Dr. Shortliffe has authored over 350 articles and books in the fields of biomedical computing and artificial intelligence.

**James J. Cimino**

is a board-certified internist who completed a National Library of Medicine informatics fellowship at the Massachusetts General Hospital and Harvard University and then went on to an academic position at Columbia University College of Physicians and Surgeons and the Presbyterian Hospital in New York. He spent 20 years at Columbia, carrying out clinical informatics research, building clinical information systems, teaching medical informatics and medicine, and caring for patients, rising to the rank of full professor in both Biomedical Informatics and Medicine. His principal research areas there included desiderata for controlled terminologies, mobile and Web-based clinical information systems for clinicians and patients, and a context-aware form of clinical decision support called "infobuttons." In 2008, he moved to the National Institutes of Health, where he was the Chief of the Laboratory for Informatics Development and a Tenured Investigator at the NIH Clinical Center and the National Library of Medicine. His principal project involved the development of the Biomedical Translational Research Information System (BTRIS), an NIH-wide clinical research data resource. In 2015, he left the NIH to be the inaugural Director of the Informatics Institute at the University of Alabama at Birmingham. The Institute is charged with improving informatics research, education, and service across the University, supporting the Personalized Medicine Institute, the Center for Genomic Medicine, and the University Health System Foundation, including improvement of and access to electronic health records. He holds the rank of Tenured Professor in Medicine and is the Chief for the Informatics Section in the Division of General Internal Medicine. He continues to conduct research in clinical informatics and clinical research informatics, he was Director of the NLM's weeklong Biomedical Informatics course for 16 years, and teaches at Columbia University and Georgetown University as an Adjunct Professor. He is an Associate Editor of the *Journal of Biomedical Informatics*. His honors include Fellowships of the American College of Physicians, the New York Academy of Medicine and the American College of Medical Informatics (Past President), the Priscilla Mayden Award from the University of Utah, the Donald A.B. Lindberg Award for Innovation in Informatics and the President's Award, both from the American Medical

Informatics Association, the Morris F. Collen Award of the American College of Medical Informatics, the Medal of Honor from New York Medical College, the NIH Clinical Center Director's Award (twice), and induction into the National Academy of Medicine (formerly the Institute of Medicine).

### Michael F. Chiang

is Director of the National Eye Institute, at the National Institutes of Health in Bethesda, Maryland. His clinical practice focuses on pediatric ophthalmology, and he is board-certified in clinical informatics. His research develops and applies biomedical informatics methods to clinical ophthalmology in areas such as retinopathy of prematurity (ROP), telehealth, artificial intelligence, clinical information systems, genotype-phenotype correlation, and data analytics. His group has published over 200 peer-reviewed papers, and has developed an assistive artificial intelligence system for ROP that received breakthrough status from the US Food and Drug Administration. He received a BS in Electrical Engineering and Biology from Stanford University, an MD from the Harvard-MIT Division of Health Sciences and Technology, and an MA in Biomedical Informatics from Columbia University. He completed clinical training at the Johns Hopkins Wilmer Eye Institute. Between 2001 and 2010, he worked at Columbia University, where he was Anne S. Cohen Associate Professor of Ophthalmology & Biomedical Informatics, director of medical student education in ophthalmology, and director of the introductory graduate student course in biomedical informatics. From 2010 to 2020, he was Knowles Professor of Ophthalmology & Medical Informatics and Clinical Epidemiology, and Associate Director of the Casey Eye Institute, at the Oregon Health & Science University (OHSU) Casey Eye Institute. He has served as a member of the American Academy of Ophthalmology (AAO) Board of Trustees, Chair of the AAO IRIS Registry Data Analytics Committee, Chair of the AAO Task Force on Artificial Intelligence, Chair of the AAO Medical Information Technology Committee, and on numerous other national and local committees. He currently serves as an Associate Editor for *JAMIA*, and is on the Editorial Board for *Ophthalmology* and the *Asia-Pacific Journal of Ophthalmology*.