Health Informatics

This series is directed to healthcare professionals leading the transformation of healthcare by using information and knowledge. For over 20 years, Health Informatics has offered a broad range of titles: some address specific professions such as nursing, medicine, and health administration; others cover special areas of practice such as trauma and radiology; still other books in the series focus on interdisciplinary issues, such as the computer based patient record, electronic health records, and networked healthcare systems. Editors and authors, eminent experts in their fields, offer their accounts of innovations in health informatics. Increasingly, these accounts go beyond hardware and software to address the role of information in influencing the transformation of healthcare delivery systems around the world. The series also increasingly focuses on the users of the information and systems: the organizational, behavioral, and societal changes that accompany the diffusion of information technology in health services environments.

Developments in healthcare delivery are constant; in recent years, bioinformatics has emerged as a new field in health informatics to support emerging and ongoing developments in molecular biology. At the same time, further evolution of the field of health informatics is reflected in the introduction of concepts at the macro or health systems delivery level with major national initiatives related to electronic health records (EHR), data standards, and public health informatics.

These changes will continue to shape health services in the twenty-first century. By making full and creative use of the technology to tame data and to transform information, Health Informatics will foster the development and use of new knowledge in healthcare.

More information about this series at http://www.springer.com/series/1114

Amit Acharya • Valerie Powell
Miguel H. Torres-Urquidy
Robert H. Posteraro
Thankam Paul Thyvalikakath

Editors

Integration of Medical and Dental Care and Patient Data

Second Edition

Springer

Editors
Amit Acharya
Marshfield Clinic Research Institute
Center for Oral and Systemic Health
Marshfield, WI
USA

Miguel H. Torres-Urquidy
Centers for Disease Control
and Prevention
Atlanta, GA
USA

Thankam Paul Thyvalikakath
Department of Restorative Dentistry
Indiana University School of Dentistry
Indianapolis, IN
USA

Valerie Powell
Robert Morris University
Moon Township, PA
USA

Robert H. Posteraro
Texas Tech University Health Sciences
Centre - School of Health Professions
Lubbock, TX
USA

Preface

Integration of Medical and Oral Healthcare: Eliminating the Medical Dental Divide

The first edition of this book was introduced by Dr. David Nash's preface entitled Dentistry is Medicine-Oral Medicine. He described the Gies Report of 1926 and its conclusions and recommendations based upon the times he described the 1994 World Health Organization report Oral Health in the Twenty-First Century. He described the Institute of Medicine's report Dental Education at the Crossroads of 1995 and organized dentistry's and dental education response to maintain the status quo. All of these writings suggested that the "status quo for the profession puts it on a path towards stagnation and decline." A recent editorial in the JADA in November 2017 suggested the need for dentistry to respond, faced with the changes already occurring in the twenty-first century and those on the way. The controversies and discussions over healthcare in general designed to improve access, decrease costs, and improve health will eventually impact oral health. Interprofessional education is now entering a phase of interprofessional practice. In 2011, I attended a meeting sponsored by ADEA on interprofessional education. Dr. Don Berwick, head of Institute for Health Improvement (IHI), spoke of meaningful use and triple aim, the subject of a chapter in this new edition. Other than the ADEA leadership and staff, I was the only dentist in attendance. Since then, the Commission on Change and Innovation (CCI) has published its findings, and now a second CCI is underway. The need for changes highlighted by Dr. Nash in his preface and his extraordinary paper entitled "The Band Played On" published in 1993 has only increased. Yet, if the Gies Report was to be released today, it would be as relevant as it was in 1926. In fact, my suggestion for a new Gies Report in 2006 has recently been conducted. Entitled the Gies Report for the Twenty-First Century, a series of papers have been published in the *Journal of Dental Education* in August and September 2017. While erudite, they are hardly provocative in directing dental education toward a more integrative role in healthcare. They point out that almost 70% of dental school curriculum is devoted to restorative dentistry. The potential changes on the way in oral

health delivery of care based upon the economics and potential of dentists to widen their scope of practice and provide some primary care management of their patients' chronic diseases speak to the future possibilities. Dental education produces good clinicians who have a solid understanding of oral health but often a more limited perspective on overall health. Research efforts in most dental schools have decreased, and the practice and delivery of oral health to people is still hampered by lack of access, lack of insurance and integration with general healthcare.

Add to this the Cascada Declaration, calling for oral health to be a branch of medicine, the first ever Surgeon General's Report on Oral Health in 2001, the 2016 update by the surgeon general suggests that oral health integrates with primary care medicine and calls for greater integration of oral health and primary care medicine by physicians and dentists, and we have a moment for adaptive rather than technical change. Heifetz and Linsky point out in their book *Leadership on the Line* that adaptive leadership deals with problems that are not amenable to authoritative expertise or standard operating procedures. Adaptive challenges require experiments, new discoveries, and adjustments from numerous places in the organization, community, and yes, profession. Critically, adaptive change requires moving away from the status quo and loss for someone or some group. Consider the issues surrounding licensure by examination, that includes live patients in the US, experiments such as portfolio exams and OSCE exams exist, but the politics of the examination community is rocked by potential for huge loss in values, in culture, and maybe even in money. The tensions over dental therapists are rocking state legislatures. Ever since the first dental school was founded in the United States in 1840, dentistry and medicine have been taught as—and viewed as—two separate professions. This must change for true integration to occur. Kassebaum and Tedesco in a paper, "The 21st Century Dental Curriculum: A Framework for Understanding Current Models," have pointed out the challenges and opportunity for dental education to deal with changing scientific, social, and economic circumstances in order to move forward.

Advances in oral biology and craniofacial research are poised to produce new diagnostic and therapeutic options that will change the future character of dental and oral health practice. It is happening now. Medical treatments of surgical diseases exist today, and oral health is not immune, as silver diamine fluoride varnishes, and other advances begin to find a place in practice. What will be the tipping point? The establishment of the National Institute of Dental and Craniofacial Research as the third NIH institute was the result of the high percentage of WWII recruits who failed the requirement of seven upper and lower front teeth enabling the pulling of the pin from a hand grenade. Overall health and oral health remain separated by education, practice, and insurance coverage. Lack of integration is even evident in discussions of contemporary scientific advances. Any discussion of the human microbiome usually omits the major potential contribution of the oral microbiome. Gut microflora are highlighted in these discussions but rarely is the oral microbiome mentioned. Oral health is associated with procedures only, not science.

This second edition discusses some attempts to change course. The barriers between oral health and primary care are being chipped away with programs of

integrated medical dental practice at regional healthcare systems like Kaiser Permanente Northwest and Marshfield Clinic Health System. The second editions present a case study on one such integrated care delivery model being focused on Marshfield Clinic Health System. Integrated oral and general health record computer systems are essential for these efforts. Integrated insurance coverage is another way to foster integration. Movement away from solo practice and the evidence that good oral health promotes good general health and reduces overall costs are other factors conducive to change. Our Harvard Initiative to Integrate Oral Health and Primary Care Medicine is based on the economic advantages. The Health Resources Service Administration (HRSA) has highlighted the importance of oral health in primary care by supporting grants to foster integration.

We need more than words now to accomplish integration. Pilots have existed for some time. I would suggest two that have had an impact. The first was the program at Yale Medical School in the 1930s. Dentists were admitted to the medical school to enhance their understanding of overall health and value of research. Although short-lived, due to WWII, this program produced some amazing people like Dr. Lester Burkett, the founder of oral medicine at the University of Pennsylvania, and Dr. Seymour Kreshover, who led the National Institute of Dental Research to prominence. Another such pilot is the oral and maxillofacial surgery-MD-general surgery program instituted at Harvard and the Massachusetts General Hospital in 1971 by Dr. Walter Guralnick. This acknowledged that rotations in medicine and surgery were not as good an education and training as completing the medical degree and doing general surgery at a more appropriate level of responsibility. This enabled expanded scope for many trainees that carried over into practice. What started as one program now is followed by almost 60. Moreover, the American College of Surgeons which originally considered only dual-degree individuals for membership now admits qualified single-degree oral and maxillofacial surgeons. So, the whole specialty has been elevated and acknowledged as well. This could happen to dentistry.

This volume speaks to the relationships between oral health and systemic health and vice versa and presents a handful of chapters that discuss such contact points from an informatics perspective. It is a call for the profession to consider altering its scope of practice, enlarging its interest in overall health, and moving away from procedures only to diagnosis and prevention. This goal is important to the health of the world's populations. This second edition of the book presents the case for integration well.

Walter Guralnick Distinguished   Bruce Donoff
Professor of Oral and Maxillofacial Surgery
Harvard School of Dental Medicine
Boston, MA, USA

Integrating Medical and Dental Care: The Role of Informatics in Solving This Challenge

The intimate relationship between oral and systemic health makes the integration of medical and dental care essential. Epidemiological studies are continually advancing our understanding of this relationship, as evidenced by links between poor oral health and multiple systemic conditions, such as cardiovascular disease, respiratory diseases, and adverse birth outcomes. For instance, periodontal disease contributes to poor metabolic control in diabetics, placing these patients at risk of increased health complications. Diabetes, in turn, exacerbates periodontal infection and inflammation. This bidirectional nature is common to many oral-systemic disease relationships. Further, oral signs and symptoms can also indicate underlying systemic conditions and aid in their early detection. Viral diseases, such as HIV, herpes, and HPV, affect mucosal membranes, and corresponding lesions may first be seen in the mouth. Sjogren's syndrome can cause excessive dry mouth and enlarged parotid glands, signs that could help diagnose this autoimmune disorder. These examples demonstrate the value of integrating dental and medical care to manage oral and systemic health in a holistic manner. As many oral and systemic diseases, such as periodontal disease, cardiovascular disease, and diabetes, rise in prevalence and related healthcare costs increase, adopting an integrated approach becomes even more compelling.

As Dr. Bruce Donoff points out in his preface, many changes are needed to fully integrate dental and medical health systems effectively. Medicine and dentistry have evolved independently of each other, resulting in significant structural and operational differences among the professions. Integrating the two professions involves more than just colocating medical and dental providers. At its heart, integrating medicine and dentistry hinges on successfully merging information relevant to each of the two domains—the core focus of this book.

First, we must understand what information is important to medical and dental care providers, respectively. Such information needs to be structured, presented, and communicated in a way that provides meaning and value to clinicians. Lack of or difficulties in effective cross-communication can result in frustration, ambiguous shared health information, data collection redundancies and errors, and uncoordinated patient care. These communication issues can partially be addressed with a fully integrated and carefully designed electronic health record and communications approach.

How could real-time data access for a joint population of patients benefit both medical and dental providers? Consider, for example, a diabetic patient visiting a dental office for a regular checkup and prophylaxis. The dental hygienist, aware of the patient's health history, would like to know the patient's glycated hemoglobin level (HbA1c). High HbA1c levels signify uncontrolled diabetes and may require the hygienist to adapt the periodontal management and treatment plan. Typically patients have a hard time recalling test results from prior physician appointments. Wouldn't it be wonderful for the dental hygienist to effortlessly locate and review

the patient's most updated medical health information and see the patient's most recent lab results? Consider, too, an obstetrician whose pregnant patient complains of bleeding and sore gums, but is afraid to see a dentist. The practitioner would like to contact a dentist to review and discuss this patient's case. A dental disease risk assessment tool for pregnant patients could be embedded into the electronic health record that would help the obstetrician understand the patient's oral health needs. And, wouldn't it be expedient for the obstetrician to contact a dental provider through the health system's electronic record? The two clinicians could team up to manage the patient's periodontal problems and her concerns with dental treatment during pregnancy. Supported by a seamless information and communication infrastructure, these healthcare providers can collaborate to ensure the mother is as healthy and disease-free as possible in time for the arrival of her newborn child.

With the shift from paper-based to electronic systems in healthcare, the integration of medical and dental data has already received increased awareness and support. Recently, the US Department of Defense (DoD) awarded a $4.3 billion contract to fund the Defense Healthcare Management System Modernization (DHMSM) program. Specifically, the funding supports the development of a new electronic health record (MHS GENESIS) that integrates medical and dental information into a single record. This streamlined electronic record system will give clinicians a complete picture of their patient's health through an interoperable, integrated medical and dental management system and promise to improve clinical decision-making and care outcomes for over nine million military personnel.

Other examples of operational systems that integrate medical and dental information can be found at the Veterans Administration, HealthPartners in Minnesota, and the Marshfield Clinic Health System, one of the largest private group medical practices in Wisconsin. At Marshfield, physicians and dentists can access and share patient medical and dental diagnoses, hospital data, radiographs, and prescription information. In addition, the Marshfield Clinic has implemented clinical decision support systems (CDSS) that use medical and dental data in the electronic health record to generate reminders and alerts. For example, the dental CDSS uses an algorithm that evaluates the patient's risk for diabetes or prediabetes based on selected medical data. If certain criteria are met, the dental CDSS generates an alert that notifies the dental provider to perform a blood glucose test at the dental appointment. This level of integration enables real-time decision support for diabetes management and disease prevention and illustrates the advances that medical and dental data integration can help foster. This book illustrate an integrated care delivery case study which provides a framework for action for others and how it can serve as important practical laboratory for what works and what does not.

Tremendous opportunities exist for the further integration of medical and dental data. However, realizing those opportunities requires that we overcome several challenges. For instance, we need to be able to connect a patient's health information across many clinical domains, care settings, and organizations. In the absence of patient-specific identifiers, this requires sophisticated patient-matching algorithms with high sensitivity and specificity. Second, we need to determine which information is relevant for which type of provider under which circumstances.

Modern digital infrastructures, such as health information exchanges, have been tremendously successful in aggregating patient information. However, for the clinician, accessing this information is akin to drinking from a firehose. The deluge of information needs to be distilled into manageable streams useful to clinicians. Third, standards for communicating information both within and across clinical disciplines need to evolve. While some well-developed and integrated standards exist, more work needs to be done in this area. (For instance, SNOMED now includes a subset of terms for dental diagnoses.) Fourth, new standards, such as Fast Healthcare Interoperability Resources (FHIR), need to be leveraged to effectively and efficiently aggregate patient information. Last, standards on privacy, security, and confidentiality that govern how patient information is shared and managed between the two professions require formulation and support.

If we surmount these challenges to integrating health information across medicine and dentistry, we can advance healthcare delivery significantly—for the betterment of the patient. Without data integration, successful interdisciplinary team approaches for optimal holistic care will continue to be difficult to implement. We owe it to our patients to provide them with high-quality, safe, efficient, and effective total body care. To do this, we must rethink how we care for our patients as a team of healthcare providers, not as individual practitioners. Can we achieve this vision? Read on! This book offers a thorough exploration of the integration of medical and dental data and provides examples and models as to why this work is essential for the future of healthcare.

Titus K. Schleyer
Clem McDonald Professor of Biomedical Informatics
Indiana University School of Medicine
Research Scientist, Regenstrief Institute, Inc.
Indianapolis, USA

Heather L. Taylor
PhD Student, School of Public Health, IUPUI
Indianapolis, USA

Editors' Preface

After the publishing of our first edition, it soon became evident that we would have to revisit our content given the rapidly changing environment and its impact on integrating dental and medical care. It has been 6 years since the publishing of the first edition, and many things have changed. For instance, at the time, the HITECH Act (Title XIII of the American Recovery and Reinvestment Act of 2009) was in full swing. As a result, we witnessed an uptake in the implementation of electronic dental records (EDRs) and electronic medical records (EMRs) as well as renewed interested in interoperability. The Centers for Medicare and Medicaid Services' Meaningful Use initiative drove the adoption through incentives for those offering Medicare/Medicaid services. It also impacted the delivery of care in other ways; for instance, by setting expectations that the general public may have regarding computerization of clinical practice ("would you go to an office that only uses paper?"). This requirement in turn changed the landscape from "if" to "when" we would achieve integration.

From the technological landscape, we can say that, for the most part, the offerings regarding EDRs and EMRs are relatively similar; however, what have evolved significantly are the environments where such technologies operate. App stores, subscription services, and mobile technology are on the rise and are now perfectly cemented mechanisms that further drive innovation. Cloud-based approaches to delivering services continue to evolve, and healthcare systems are getting more comfortable with using services beyond their usual on-premise model. All these changes are transforming the way we use technology. In these chapters, however, we made a conscious effort not to name specific technologies by brand and focused more on the principles behind their services given that, as any good technical writer knows, obsolescence is just around the corner for the written word if not done properly.

Clinically, there is still work that needs to be done, as we will review in the chapters herein. In this edition, we also aimed at bringing attention to informatics elements that are either necessary for integration or are more relevant given the aforementioned changes in the clinical care landscape. We also revisited content based on the readers' responses to the first edition and highlighted points that

warranted further attention, for instance, the clinical contact points is now a whole chapter which summarizes the several connections between the oral and system conditions. This contact point chapter serves as an introduction to Section II chapters which further discuss in depth some of the key contact point areas. We also provide an update on the economic factors that play a role in integration. Optimistically, this can help facilitate discussions among those making decisions whether clinically, technologically, or in policy on why integration is beneficial as a whole. We also touched on aspects we did not work on in the previous version, and we also left elements that remain highly relevant not only clinically but also technically.

To establish continuity with initiatives which have preceded our effort in this edition of the book, the first preface by Dr. Bruce Donoff addresses the importance of integrating medical and oral healthcare and the need to eliminating the existing medical dental divide, while the second preface, by Dr. Titus K. Schleyer and Ms. Heather L. Taylor, highlights the role of biomedical and health informatics discipline in addressing the challenges that persist in the medical and dental data and care integration.

In order to help assure the appropriate interdisciplinary mix of input, we solicited contributions of varying lengths, knowing that being flexible on length would help attract contributors whose practice demands, administrative roles, and research schedules would otherwise not permit them to participate in this volume. Finally, we wanted to make sure that the two versions could be read as a continuation of our efforts. In that sense, the editions are complementary, and the reader of the earlier version will gain a better grasp of the field of dental and medical integration with this second edition. Notwithstanding, those encountering this book for the first time do not need to worry since we made sure it stands on its own and provides well self-contained content necessary to embark in the enterprise of improving dental and medical integration. Brief outlines of the coverage of the chapters are provided below:

- Chapter 1 addresses the rationale for integrating medical and dental care and patient records.
- Chapter 2 focuses on achieving the triple aim in healthcare with oral health in the equation.
- Chapter 3 provides an overview of the relationship between oral and systemic health and disease. It also presents a list of contact points between oral and systemic conditions.
- Chapters 4–10 provide an outline of the prevalence, systemic and oral manifestations, technological implications, existing risk assessment tools, care plans, and few other key topics that can serve as a guide to improve the health of patients with some of the systemic conditions and oral health.
- Chapter 11 addresses the key health information technology considerations of medical and dental data integration.
- Chapter 12 explores possible scenarios/use cases where dentists can use electronic dental record technology to increase the accuracy, coverage, and timeliness of existing public health surveillance efforts.

- Chapter 13 introduces the reader to many of the factors influencing knowledge management and representation as well as gain a better understanding of the technical aspects that can support or impede clinical integration.
- Chapter 14 provides a high-level overview of American national standards for health data integration and the social-technical issues in including oral health in national standards.
- Chapter 15 discusses dental insurance, its coverage, and its relationship to overall health status of the population in the United States and is mostly updated information from the first edition on this topic.
- Chapter 16 focuses on the need for interprofessional medical-dental education and is also an updated topic from the first edition of this book.
- Chapter 17 provides a case study of a large regional healthcare system in the United States on how integrated care delivery was achieved and supported through multifaceted approaches including development and training of integrated medical-dental healthcare delivery teams, interprofessional training, and practice implementation.
- Chapter 18 is the conclusion and focuses on reviewing models of integration in relation to academic, governmental, and private initiatives. The chapter discusses outstanding challenges and how emerging technologies may play a role in fostering dental and medical integration.
- The first two appendices present forms and material from two sources which have explicitly addressed integration of care: the University of Detroit Mercy School of Dentistry (Appendix A) and the Wisconsin Diabetes Mellitus Advisory Group (Appendix B).
- Appendix C provides the professional biography of the editorial team and the contributing authors in this edition.

Marshfield, WI, USA   Amit Acharya
Moon, PA, USA   Valerie Powell
Atlanta, GA, USA   Miguel H. Torres-Urquidy
Lubbock, TX, USA   Robert H. Posteraro
Indianapolis, IN, USA   Thankam Paul Thyvalikakath

Acknowledgments

and Mihira (3 years), for their patience, support, and all the inquisitive questions regarding this book during its development.

> The best scientific thought is agreed that dentistry is a field of medicine. There is no logical right whatever to isolate [the oral cavity] from the rest of the body as if it were made up of ivory pegs in stone sockets." – Dr. Alfred Owre [Dean of Dentistry, University of Minnesota, 1905-27 and Columbia University, 1927-33]

<div align="right">Amit Acharya</div>

I greatly appreciate the efforts of the many individuals that made the publishing of this second edition possible. First, I would like to acknowledge Grant Weston from Springer UK for his infinite patience and wisdom to support our efforts. Second, I want to thank my colleagues at CDC for supporting and allowing me to continue with this work. I especially would like to thank Barbara Nichols, Mark Berndt, Mark Frank, Emory Meeks, and Dr. Paula Yoon. I also want to thank the members of my team, Marian Dougherty, Benjamin Erickson, Guy Faler, Kathryn Harper, Emil Hristov, Susan Hughes, Marcus Kubota, and Caroline Westnedge. Additionally, I wish to thank Toby Crafton and Enrique Nieves who have always shared their wisdom, time, and, most of all, insightful conversations. Third, I want to thank all of the co-authors and co-editors whose dedication and insights made not only one but two editions of this book a reality. Especially I want to mention Valerie Powell for her unquestionable passion for this topic. It goes without saying that without her commitment, this edition would not have come to fruition. Finally, I want to thank and dedicate this book to my family, my wife Cristina, Alice, and Eva, for being so patient and letting daddy take time away to make this happen. I hope this book will serve as future inspiration when the time arrives.

<div align="right">Miguel H. Torres-Urquidy</div>

First, I would like to thank my late father, Anthony F. Posteraro, AB, DDS, FACD, who instilled in me the truism that physicians and dentists are professional equals, and my late mother, Lygia P. Posteraro, for instilling in me a love of language and an understanding of grammar, punctuation, syntax, and spelling, which I only came to appreciate later in life. Next, I wish to especially acknowledge Valerie Powell for her intellectual curiosity, profound insight, and zeal in taking the lead in the struggle to integrate medical and dental healthcare records and for gathering us co-editors under her wing to help bring the message to a wider audience. She is truly one who asks not "Why?", but "Why not?". Grant Weston, from Springer UK, has been extremely patient as the second edition took shape and has also been a prime mover in getting us to bring it to fruition. Thank you, Grant! I wish to thank my fellow co-editors, Valerie Powell, who initiated the project; Amit Acharya, who stepped up to the plate when Valerie had more pressing issues to attend to and who set us on the course to completion; Miguel H. Torres-Urquidy, whose insights and suggestions were very helpful to me; and Thankam Thyvalikakath, who also offered well-appreciated insights and suggestions and was my co-reviewer and co-proofreader. Other than Valerie, I have not had the pleasure of meeting my other co-editors, face-to-face, but I feel that I have come to know them "virtually" and I hold them all

Abbreviations

3D	3 Dimensional
AAMC	Association of American Medical Colleges
AAP	Aspiration-associated pneumonia
ACA	Affordable Care Act
ACC	American College of Cardiology
ACEI	Angiotensin converting enzyme inhibitor
ACGT	Advancing Clinico-Genomic Trial
ACO	Accountable Care Organization
AD	Autoimmune disease
ADA	American Dental Association
ADA	American Diabetes Association
ADEA	American Dental Education Association
AGE	Advanced glycosylation end products
AEGD	Advanced education general dentistry
AHA	American Heart Association
AHRQ	Agency for Healthcare Research and Quality
AI	Artificial intelligence
AIDS	Acquired immunodeficiency syndrome
AMI	Acute myocardial infarction
AMP	Anterior mandibular positioning
ANSI	American National Standards Institute
AP	Antibiotic prophylaxis
APACHE II	Acute physiology and chronic health evaluation II
ARRA	American Recovery and Reinvestment Act
ASCP	American Society of Clinical Pathologists
ASTHO	Association of State and Territorial Health Officials
ATS	American Thoracic Society
BBS	Bardet-Biedl syndrome
BDS	Bachelor of Dental Surgery
BMI	Body Mass Index
BON	Bisphosphonate-associated osteonecrosis

BTH   Brown tumor of hyperparathyroidism
CAD   Coronary artery disease
CAHPS   Consumer assessment of healthcare providers and systems
CAMBRA   Caries management by risk assessment
CAP   College of American Pathologists
CAP   Community acquired pneumonia
CBP   Complete blood picture
CBT   Computer based testing
CBT   Computer based training
CCHIT   Certification Commission for Health Information Technology
CDA   California Dental Association
CDA   Canadian Dental Association
CDC   Centers for Disease Control and Prevention
CDS   Clinical decision support
CDT   Current dental terminology
CE   Continuing education
CeVD   Cerebrovascular disease
cGVHD   Chronic graft-versus-host disease
CHC   Community Health Center
CHD   Coronary heart disease
CIED   Cardiovascular implantable electronic device
CKD   Chronic kidney disease
CKD-MBD   Chronic kidney disease—mineral and bone disorder
CMS   Centers for Medicare and Medicaid Services
CMS   Clinical Management System
CODA   Commission on Dental Accreditation
COHR   Computer-Based Oral Health Record
COSH   Center for Oral and Systemic Health
COTS   Commercial off-the-shelf
COPD   Chronic obstructive pulmonary disease
CPOE   Computerized physician order entry
CRP   C-Reactive protein
CSA   Cross-subspace analysis
CT   Computed tomography
CTSC   Cathepsin C gene
CVDs   Cardiovascular diseases
DART   Diagnostic Aid Resource Tool
DDS   Dental Diagnostic System
DDS   Doctor of Dental Surgery
DICOM   Digital imaging and communications in medicine
DKA   Diabetic ketoacidosis
DL   Description logics
DM   Diabetes mellitus
DMD   Doctor of Dental Medicine
DNM   Descending necrotizing mediastinitis

DOQ	Doctor's office quality
E&M	Evaluation and management
EBICP	Evidence-based integrated care plan
EDR	Electronic Dental Record
eGFR	Estimated glomerular filtration rate
EHR	Electronic Health Record
EHT	Electronic health technologies
EMR	Electronic Medical Record
ENT	Ear, nose and throat
EP	Eligible professional
ER	Emergency room
ESC	European Society of Cardiology
ESRD	End stage renal disease
FFS	Fee for service
FHC	Family Health Center
FQHC	Federally Qualified Health Center
GCF	Gingival crevicular fluid
GDP	Gross domestic product
GFR	Glomerular filtration rate
GH	Group health
GMP	General medical practitioner
GO	Gene ontology
GPRO	Group practice reporting option
GVHD	Graft-versus-host disease
GWAS	Genome Wide Association studies
HAART	Highly active anti-retroviral therapy
HAP	Hospital-acquired pneumonia
HCAP	Health care acquired pneumonia
HCP	Healthcare provider
HCT	Hematocrit
HCT	Hematologic stem cell transplant
HDL-C	High density lipoprotein-cholesterol
HHS	Health & Human Services
HIE	Health Information Exchange
HIO	Health Information Organization
HIPAA	Health Insurance Portability and Accountability Act
HIT	Health Information Technology
HITECH	Health Information Technology for Economic and Clinical Health
HIV	Human immunodeficiency virus
HMO	Health Maintenance Organization
HONK	Hyperosmolar hyperglycemic non-ketotic
HPO	Human phenotype ontology
HPT	Hyperthyroidism
HRSA	Health Resources and Services Administration
hsCRP	High sensitivity C-reactive protein

HSDM	Harvard School of Dental Medicine
HTC	Hemophilia Treatment Centre
Hx	History
ICD	Implantable cardioverter-defibrillator
ICD	International Classification of Diseases
ICD-10	International Classification of Diseases, Tenth Revision
ICD-10 CM	International Classification of Diseases, Tenth Revision, Clinical Modification
ICD-9	International Classification of Diseases, Ninth Revision
ICD-9 CM	International Classification of Diseases, Ninth Revision, Clinical Modification
ICU	Intensive care unit
IDSA	Infectious Diseases Society of America
IE	Infective endocarditis
iEHR	Integrated Electronic Health Record
iEDW	Integrated Enterprise Data Warehouse
IHI	Institute of Healthcare Improvement
INR	International Normalized Ratio
IOM	Institute of Medicine
IOTF	International Obesity Task Force
IT	Information Technology
JNC	Joint National Committee
KBTA	Knowledge based temporal abstraction
KDIGO	Kidney disease: improving global outcomes
LBW	Low birth weight
LDL	Low density lipoprotein
LIS	Laboratory Information System
LOP	Late onset pneumonia
LPS	Lipopolysaccharide
MA	Moving average
mBTS	Modified British Thoracic Society
MC	Marshfield clinic
MCEF	Marshfield Clinic Education Foundation
MCHS	Marshfield Clinic Health System
MCRI	Marshfield Clinic Research Institute
MCIS	Marshfield Clinic Information system
MD	Doctor of Medicine
MDPP	Medicare Diabetes Prevention Program
MEF	Mean etiologic fraction
MESA	Marshfield Epidemiologic Study Area
MetS	Metabolic syndrome
MGED	Microarray Gene Expression Data
MHD	Medical History for Dentists
MI	Myocardial infarction
MLR	Minimum loss rate

MOL	Maximum owed losses
MRI	Magnetic resonance imaging
MRSA	Methicillin-resistant *Staphylococcus aureus*
MSR	Minimum Savings Rate
MSS	Maximum Shared Savings
MSSP	Medicare Shared Savings Program
MU	Meaningful use
MVP	Mitral valve prolapse
NADP	National Association of Dental Plans
NCQA	National Committee for Quality Assurance
NHANES	National Health and Nutrition Examination Survey
NHE	National Health Expenditure
NHLBI	National Heart, Lung and Blood Institute
NIDDK	National Institute of Diabetes and Digestive and Kidney Diseases
NIH	National Institutes of Health
NIS	Nationwide inpatient sample
NJDOH	New Jersey Department of Health
NJDDCS	New Jersey Discharge Data Collection System
NK	Natural killer
NLP	Natural language processing
NPC	Nasopharyngeal carcinoma
NSACO	National Survey of Accountable Care Organizations
OF-RO	Osteitis fibrosa/renal osteodystrophy
OMS	Odontogenic maxillary sinusitis
ONCHIT	Office of the National Coordinator for Health Information Technology
OPG	Orthopantomogram
ORN	Osteoradionecrosis
OWL	Ontology Web Language
PCI	Percutaneous Coronary Intervention
PCMH	Patient Centered Medical Home
PD	Periodontitis
PD	Periodontal disease
PDQ	Physician Data Query
PGP	Physician group practice
PHI	Protected Health Information
PHR	Personal Health Record
PLS	Papillon-Lefèvre syndrome
PQRI	Physician quality reporting initiative
PPM	Permanent pacemaker
PSF	Privacy and Security Framework
PSI	Pneumonia Severity Index
PVD	Peripheral vascular disease
PY	Performance year
RDW	Research Data Warehouse

RECIN	Registry for Effectively Communicating Immunization Needs
RMED	Rural Medical Education
RODS	Real-Time Outbreak and Disease Surveillance Laboratory
RSV	Respiratory syncytial virus
SAPS	Simplified Acute Physiology Score
SARS	Severe acute respiratory syndrome
SCORE	Systematic coronary risk evaluation
SDOs	Standards Development Organizations
SHEA	Society for Healthcare Epidemiology of America
SLE	Systemic lupus erythematosus
SNODENT	Systematized Nomenclature of Dentistry
SNOMED CT	Systematized Nomenclature of Medicine—Clinical Terms
SS	Sjögren syndrome
SSN	Social Security Number
TNFα	Tumor necrosis factor-alpha
UAE	Urinary albumin excretion
UI	User interface
US	United States
USA	United States of America
USDHHS	US Department of Health & Human Services
USAMRIID	US Army Medical Research Institute of Infectious Disease
USRDS	United States Renal Data System
UWSMPH	University of Wisconsin School of Medicine and Public Health
VA	Veterans Administration
VATS	Video-assisted thoracoscopic surgery
VAP	Ventilator acquired pneumonia
VSD	Vaccine Safety Datalink
WARM	Wisconsin Academy for Rural Medicine
WBC	White blood cell
WDS	Washington Dental Service
ZIP	Zone Improvement Plan

Contents

Contributors

Amit Acharya, B.D.S., M.S., Ph.D. Center for Oral and Systemic Health, Marshfield Clinic Research Institute, Marshfield, WI, USA

Mureen Allen, M.D., M.S., M.A., F.A.C.P. UnitedHealth Group, New York City, NY, USA

Jordan L. Ashton, D.O. Marshfield Clinic-Stettin Medical Center, Stettin, WI, USA

Valerie Bertaud-Gounot, D.M.D., Ph.D. Psychiatric Hospital of Rennes, Rennes, France

Kelly Boggs, M.B.A. Network Engagement, Aspirus Network Inc., Wausau, WI, USA

Monica Chaudhari, Dr.P.H. Cancer Research and Biostatisticians, Seattle, WA, USA

Louay O. Danial, M.D. Marshfield Clinic-Park Falls Medical Center, Park Falls, WI, USA

Richard Dart, M.D. Center for Human Genetics, Marshfield Clinic Research Institute, Marshfield, WI, USA

Mark Diehl, D.D.S., M.A., M.P.H. Health Informatics Program, Misericordia University, Dallas, TX, USA

Franklin Din, D.M.D., M.A. FraudLens Inc., Arlington, VA, USA

Bruce Donoff, D.M.D., M.D. Harvard School of Dental Medicine, Boston, MA, USA

Stephen Foreman, J.D., Ph.D., M.P.A. Health Economics, Robert Morris University, Pittsburgh, PA, USA

Shin-Mey Rose Yin Geist, D.D.S., M.S. Departments of Biomedical and Diagnostic Sciences and Patient Management, University of Detroit Mercy School of Dentistry, Detroit, MI, USA

Ingrid Glurich, Ph.D. Center for Oral and Systemic Health, Marshfield Clinic Research Institute, Marshfield, WI, USA

Casey Hein, B.S.D.H., R.D.H., M.B.A. International Center for Oral-Systemic Health, College of Dentistry, University of Manitoba, Winnipeg, MB, Canada

Rady Faculty of Health Sciences, University of Manitoba, Winnipeg, MB, Canada

Mark Jurkovich, D.D.S., M.H.A. HealthPartners Institute, Minneapolis, MN, USA

Joseph Kilsdonk, Au.D. Office of Medical Education, Aspirus Healthcare Systems, Wausau, WI, USA

Ted Klein, M.S. Klein Consulting Informatics, LLC, Star Valley Ranch, WY, USA

Kori Krueger, M.D., M.B.A. Institute for Quality Innovation and Patient Safety, Marshfield Clinic, Marshfield, WI, USA

Jayanth Kumar Medam, B.D.S. Dental Informatics Core, Department of Cariology, Operative Dentistry and Dental Public Health, Indiana University School of Dentistry, IUPUI, Indianapolis, IN, USA

School of Informatics and Computing, IUPUI, Indianapolis, IN, USA

William Melms, M.D. Marshfield Clinic-Minocqua Medical Center, Minocqua, WI, USA

Sushma Mishra, Ph.D. Robert Morris University, Pittsburgh, PA, USA

John O'Brien, D.D.S. Family Health Center Inc., Marshfield, WI, USA

Aloksagar Panny, B.D.S., M.S. Center for Oral and Systemic Health, Marshfield Clinic Research Institute, Marshfield, WI, USA

Ram Pathak, M.D., F.A.C.P., F.A.C.E. Department of Endocrinology, Marshfield Clinic, Marshfield, WI, USA

Robert H. Posteraro, M.D., M.B.I. Department of Healthcare Management and Leadership, Texas Tech University Health Sciences Center School of Health Professions, Lubbock, TX, USA

Valerie Powell, Ph.D., M.S., R.T.(R). Robert Morris University, Moon Township, PA, USA

Frank Scannapieco, D.M.D., Ph.D. Department of Oral Biology, School of Dental Medicine, State University of New York at Buffalo, Buffalo, NY, USA

Titus K. Schleyer, D.M.D., Ph.D. Center for Biomedical Informatics, Research Scientist, Regenstrief Institute, Inc., Indianapolis, IN, USA

Department of Medicine, Indiana University School of Medicine, Indianapolis, IN, USA

Neel Shimpi, B.D.S., M.M., Ph.D. Center for Oral and Systemic Health, Marshfield Clinic Research Institute, Marshfield, WI, USA

Cynthia A. Sorenson, F.N.P. Marshfield Clinic Stettin Medical Center, Stettin, WI, USA

Heather L. Taylor, M.P.H., L.D.H. PhD Student, IUPUI School of Public Health, Indianapolis, IN, USA

Thankam Paul Thyvalikakath, D.M.D., Ph.D. Dental Informatics Core, Department of Cariology, Operative Dentistry and Dental Public Health, Indiana University School of Dentistry, IUPUI, Indianapolis, IN, USA

School of Informatics and Computing, IUPUI, Indianapolis, IN, USA

Centre for Biomedical Informatics, Regenstrief Institute, Indianapolis, IN, USA

Miguel H. Torres-Urquidy, D.D.S., M.S., Ph.D. (candidate) Centers for Disease Control and Prevention, Atlanta, GA, USA

Peter Umukoro, M.D., M.P.H., Sc.D. Department of Internal Medicine, Marshfield Clinic, Marshfield, WI, USA

Jayanth Vedre, MD, M.P.H. Medical Intensive Care Unit, Marshfield Clinic, Marshfield, WI, USA

About the Editors

Amit Acharya B.D.S., M.S., Ph.D., is the executive director of the Marshfield Clinic Research Institute (MCRI) at Marshfield Clinic Health System (MCHS) in Wisconsin, USA. Dr. Acharya provides leadership and direction to support the mission and vision of the Institute, and he is responsible for the oversight of the research operations. He subsequently serves as the chief dental informatics officer (CDIO) of the Family Health Center (FHC) at MCHS. FHC provides care to low-income, Medicaid, and uninsured populations at 19 medical and 10 dental FQHC sites (44 general dentists, 2 oral surgeons, and 44 hygienists) in partnership with Marshfield Clinic. As the CDIO, Dr. Acharya is responsible for developing strategic road map and advising specific implementation groups of key informatics and information technology best practices to support patient care, research, and educational activities. He is actively involved in development and implementation of effective clinical systems and applications that brings the practice of medicine and dentistry at MCHS closer, contributing to cost reduction and helping streamline the process of delivering healthcare.

Dr. Acharya is also a tenured research scientist at the Center for Oral and Systemic Health at MCRI. Dr. Acharya has been a leading researcher and is well-regarded throughout the United States on his expertise in biomedical and dental informatics. As a general dental surgeon and a computer scientist with expertise in the field of biomedical informatics, Dr. Acharya's research focus has been in the area of applied clinical informatics focusing on integration of medical and dental data, clinical and research information systems, and design and architecture of electronic health records; developing clinical decision supports; and investigating the oral-systemic relationship between periodontal and systemic disease, such as diabetes, and cardiovascular and respiratory diseases. Dr. Acharya's desire to pursue the field of health information technology and informatics developed due to a desire to bridge the gap between medical and dental care.

Dr. Acharya has been instrumental in the founding of the Center for Oral and Systemic Health (COSH) (formerly known as the Institute for Oral and Systemic Health) which is one of the six research centers at MCRI, the integration of

Marshfield Clinic's electronic dental record with its propriety electronic medical record, and the establishment of one of the very few oral health informatics postdoctoral fellowship programs in the nation. Dr. Acharya places a strong emphasis on education and the development of the future research workforce. He served as the program director of this NLM-/NIDCR-funded Oral Health Informatics postdoctoral fellowship program at MCRF (in collaboration with the University of Wisconsin-Madison) from 2012 to 2017. He also served on the management committee of UW-Madison's Computational and Informatics in Biology and Medicine program and has mentored several graduate students and postdoctoral fellows as part of this program. Marshfield Clinic along with UW-Madison is one of the only three institutions in the nation to offer postdoctoral training in dental informatics training.

Dr. Acharya completed his Bachelor of Dental Surgery from Bangalore University, India, in 2000 after which he practiced clinical dentistry as a house surgeon and a dental officer for few years. He then completed his master's in computer science from Western Kentucky University, KY, in 2004 moving on to completing his doctoral in biomedical informatics from University of Medicine and Dentistry in New Jersey, NJ, in 2010. He also pursued additional training in leadership strategies for information technology in healthcare from Harvard School of Public Health, Boston. Before moving to Marshfield Clinic in 2010, Dr. Acharya served as a visiting scholar at the Center of Dental Informatics, University of Pittsburgh.

Dr. Acharya has published over 100 scientific abstracts and manuscripts in national and international peer-reviewed journals. He was also one of the original editors on the first edition of this book, *Integration of Medical and Dental Care and Patient Data* which was published by Springer. He was invited to serve on the 2012 American Medical Informatics Association (AMIA) Scientific Programming Committee (SPC). He has received multiple grant funding dedicated to bridging the medical and dental divide throughout the course of his career.

Dr. Acharya has held several national leadership roles including secretary, chair-elect, and chair of the American Dental Education Association's Dental Informatics Section and co-chair-elect and co-chair of the American Medical Informatics Association's Dental Informatics Work Group. He had served as the chairman of the clinical informatics subcommittee of the American Dental Associations' (ADA) Standards Committee for Dental Informatics and the ADA representative to the Health Level Seven (HL7) in the past. He has also served on national HIT expert panels coordinated by entities like Agency for Healthcare Research and Quality (AHRQ), Office of the National Coordinator (ONC) for Health Information Technology, and National Quality Forum (NQF). Dr. Acharya currently serves as a member on the advisory board of the National Center for Community Health Research and ADA Dental Quality Alliance's Implementation and Evaluation Committee.

He is a strong advocate for child health and volunteers with the Children International Organization, which is dedicated to fighting poverty and supporting children in need in poor and developing countries.

Valerie Powell Ph.D., M.S., R.T.(R)., a native of Racine, Wisconsin, USA, first studied humanities, with a focus on languages, philosophy, and linguistics, then computer science and information systems, and finally radiologic technology. Her undergraduate studies in German and philosophy at Wabash College in Indiana included a year of studies of philosophy and linguistics at the Albert-Ludwigs-Universität, Freiburg im Breisgau, Germany. She then earned a master's degree and a PhD at the University of Texas at Austin. Her postdoctoral master's degree in computer science was completed at Texas A&M University in Commerce, Texas. She started teaching at the University of Texas at Austin in the fall of 1959 and has been teaching for over 50 years. She spent a sabbatical semester as a visiting scientist in dynamic systems at the Software Engineering Institute of Carnegie Mellon University, where the focus of her work was formal modeling of resectorization in the FAA Air Traffic Control System. Dr. Powell's studies in philosophy sensitized her to the properties of classification systems. She feels this foundation helped her question the routine sense of medical care that omitted attention to the stomatognathic system in certain critical respects.

When she began to work with and teach MUMPS (Massachusetts General Hospital Utility Multi-Programming System) in computer science in the early 1980s, she was soon invited to work with the US Department of Veterans Affairs (VA). Her first publications in the field of hospital information systems appeared in the mid-1980s. She taught databases, including clinical databases, for a number of decades (both relational SQL technology and the MUMPS-based VA FileMan database technology of the US Department of Veterans Affairs. She was admitted to the Sigma Xi science research honor society for research leading to a paper presented in Nagoya, Japan, in 1988: "Implications of Non-1NF Extensions to the Relational Database Model for the MUMPS Standard and MUMPS Databases." From 1988 through 1996, she served as a consulting scholar in medical computing for IBM Corporation. Dr. Powell carried out a number of projects for the VA (and also for the Indian Health Service (IHS)) over the years through 1999. From 1988 through 1992, she worked with Trident Technical College in Charleston, SC, to add an electronic dental record for patients served by their oral health education programs (dental hygiene and dental assisting).

During this period, she also served on software standards committees: X3/DBSSG (Database Systems Study Group), X11 (MUMPS Users Group), NCITS/T3 (OSI Telecommunications), and as chair of NCITS/J21 (model-based formal specification systems), a committee with US technical advisory group (TAG) responsibilities for the Z and VDM international standards. Dr. Powell learned health informatics through collaboration with Dr. Charles J. Austin, author of textbooks on hospital information systems, and Dr. med. Wolfgang Giere, Director, Zentrum für medizinische Informatik, Goethe University, Frankfurt am Main, Germany, and through almost 20 years of experience assisting the US Veterans Health Administration and working with its DHCP (later VistA) electronic health record (EHR) technology. In 1999, she gave invited lectures on health informatics and Year 2000 concerns at the Zentrum für Medizinische Informatik, Goethe University, Frankfurt am Main, Germany. She also lectured on Year 2000 issues at

the Brandenburg Technische Hochschule in Cottbus. These lectures were sponsored by the US Embassy in Berlin.

In 2000, she felt she needed clinical experience to do the kind of work in healthcare informatics she wished to do and completed the prerequisites for a degree in radiologic technology and then the degree itself, passing the ARRT registry exam in 2002. She found this clinical experience valuable in her informatics work. She chose imaging as it would (and did) give her contact with many subspecialties of medical care as well as first-hand experience in the emergency department and with a variety of surgical procedures in the operating room environment. It gave her experience with the workflow of the care setting and the necessary sense of delivering care to an individual patient for which one is responsible and not just for patient data. Since 1999, Dr. Powell has worked with WorldVistA, a nonprofit organization making open-source VA VistA EHR technology available domestically and internationally. In 2007, she was invited by the Mexican government agency Instituto Mexicano del Seguro Social (IMSS) to provide technical advice on health information technology (HIT) in Mexico City. She taught healthcare informatics at Robert Morris University.

In 2007, Pennsylvania Gov. Ed Rendell appointed Dr. Powell to the Governor's Commission on Chronic Care Management, Reimbursement, and Cost Reduction, because of her extensive work with health information technology. With this assignment and facing the question as to whether performance measures proposed for the Commission's strategic plan were adequate, she noticed the omission of "dental referral" from the set of diabetes performance measures. She sought advice from the American Academy of Periodontology research staff in Chicago to learn what she needed to know to evaluate diabetes performance measures. She set about bringing her evaluation to the attention of the American Diabetes Association (ADA) and encouraged the ADA to add "dental referral" to its standards of care (SoC) for diabetes. This was done in 2007–2008. In 2008, she started giving lectures on and writing on the need to integrate medical and dental care and patient data. In 2018, Dr. Powell was named to the Board of Directors, Metro Community Health Center, South Braddock Ave., Pittsburgh, PA. She holds an appointment as university professor of computer and information systems emerita at Robert Morris University, Moon Township, Pennsylvania, where she has taught for 20 years.

Miguel H. Torres-Urquidy D.D.S., M.S., Ph.D. (candidate), is a Senior Service Fellow with the Division of Health Informatics and Surveillance of US Centers for Disease Control and Prevention. Because of his clinical and informatics expertise, he has served in multiple roles and projects within CDC. He currently supports the Medical Countermeasure Tracking System (CTS). Elements of CTS are used to distribute medications and medical supplies to the general population during national and regional public health emergencies. Previously he managed the public web release of information for the National Notifiable Disease Surveillance System (NNDSS) used by all US public health departments to report notifiable conditions. He served as lead for the Public Health Informatics Fellowship Program and also as former acting program manager for BioSense (now the National Syndromic Surveillance Program).

As part of the National Syndromic Surveillance Program, he oversaw the Influenza-Like Illness, Hepatitis and Opioid-Overdose Pilot Projects. As Ebola responder, he served as senior informatics advisor for the CDC's Domestic Clinical Inquiries Team supporting US hospitals and clinics, as well as public health departments when handling confirmed and suspected Ebola cases in the United States.

He first joined CDC as informatics fellow for CDC's Influenza Division. During his tenure, he worked on facilitating access to CDC data to the general public by creating several visualization systems of influenza information (FluView Interactive). In addition, he developed two iPhone/iPad applications, one that provides data on national influenza activity and another that assists triaging patients with flu-like symptoms. He also supported the Idaho Department of Health and Welfare in improving the matching of Vehicle Accident Data with other information sources. Internationally, he aided the Influenza Division in assessing influenza surveillance capabilities in Central America. His work earned him the Best Poster Award at the International Society for Disease Surveillance Conference in 2010. He and his colleagues also received the 2013 National Center for Immunization and Respiratory Diseases (NCIRD) Honor Award for "Excellence in Domestic Epidemiology" for their work in FluView.

Before joining CDC, he worked as postdoctoral associate at the Center for Dental Informatics at the University of Pittsburgh where he conducted NIH-funded research focused on diagnostic terminologies. Dr. Torres-Urquidy was trained as a dentist at the National Autonomous University of Mexico and continued his education with a master's degree in biomedical informatics from the School of Medicine at the University of Pittsburgh where he also pursued his doctoral studies. He also rotated with the NIH's National Library of Medicine in the summer of 2004. During his rotation, he conducted analyses on US public policy related to the establishment of the National Health Information Infrastructure. Previously, in 1996 and 1999, he collaborated with the Department of Dental Informatics at Temple University conducting and publishing studies in the adoption of information technology and use of Internet by clinicians.

He is past chair of the Dental Informatics Working Group at the American Medical Informatics Association. He has published and currently serves as reviewer in several grant and contract review panels, scientific journals, and conferences.

Robert H. Posteraro M.D., M.B.I., F.A.C.R., is a professor and assistant program director in the Master of Science in Healthcare Administration (MSHA) program at Texas Tech University Health Sciences Center—School of Health Professions. Dr. Posteraro graduated Phi Beta Kappa, magna cum laude, in cursu honorum, with a Bachelor of Science degree from Fordham College and earned his MD degree from Yale University School of Medicine. He did a fellowship in chest radiology at Yale and a fellowship in magnetic resonance imaging at Duke. He earned his Master of Biomedical Informatics degree from Oregon Health & Science University. Prior to joining the MSHA faculty, Dr. Posteraro practiced radiology in both academic and private practice settings. He was chairman of the Department of Radiology at Texas Tech University HSC School of Medicine. He continues to stay current in

radiology and teaches radiation biology, radiation protection, and digital imaging, on a voluntary basis, at the Covenant School of Radiography, in Lubbock, TX.

Dr. Posteraro has numerous publications, presentations, and guest lectures to his credit. He has been named Outstanding Faculty Member seven times, by the students in the MSHA program. He is a peer reviewer for three journals and is a member of the American Medical Informatics Association and the Society for Imaging Informatics in Medicine. His current work is on the use and effects of informatics in distance education and the development of critical thinking skills in students.

Thankam Paul Thyvalikakath D.M.D., M.D.S., Ph.D., is the director of dental informatics core at the Indiana University School of Dentistry as well as a research scientist at the Center for Biomedical Informatics, Regenstrief Institute, Indianapolis, IN. As core director, she has established a program to enhance patient care through improved data capture and retrieval to assess treatment outcomes. Dr. Thyvalikakath earned her PhD degree in biomedical informatics in 2012 from the University of Pittsburgh School of Medicine. She also holds a dental degree and certificate in clinical research from the University of Pittsburgh as well as a dental degree from the University of Kerala, India, and a master's degree in oral and maxillofacial surgery from the University of Calicut, India.

Dr. Thyvalikakath has served as principal investigator, co-investigator, or consultant on numerous National Institute of Health grants. Her research established foundational knowledge on applying user-centered design and cognitive engineering methods to design and evaluate clinical systems in dentistry. Currently, she is leading a study supported through the National Dental Practice-based Research Network of the NIDCR to explore the feasibility of mining electronic dental record data from network practices to assess treatment outcomes. In addition, she is co-investigator on a recent NIDCR-funded study to implement clinical decision support for tobacco cessation in dental practices. Dr. Thyvalikakath also participates in clinical teaching and practice at the IU School of Dentistry. She has several publications, presentations, and guest lectures to her credit and is a peer reviewer for five journals. She was a member of the American Medical Informatics Association (AMIA) Task Force to develop eligibility requirements for the Advance Health Informatics Certification (AHIC). She is also a past chair of the Dental Informatics Work Group at AMIA and Dental Informatics Section at American Dental Educators Association (ADEA).

About the Authors

Mureen Allen M.D., M.S., M.A., F.A.C.P., has held several positions involving health information technology (IT) and data analytics. She has worked on a variety of initiatives involving the acquisition and aggregation of clinical data with administrative data to identify signals that drive variation in clinical care. Dr. Allen is committed to the development of solutions that improve the delivery of healthcare. Her interests include clinical decision support, quality measurement, systems interoperability, usability, and the patient-centered medical home. Dr. Allen was the senior associate for informatics and practice improvement at the American College of Physicians (ACP), providing support for health IT public policy initiatives. Dr. Allen served as a co-chair of the Health Information Technology Standards Panel. As a co-chair, she was active in identifying the appropriate standards to support consumer empowerment while using a personal health record, and she supported the identification of standards for consumers to express their preferences for sharing data. Dr. Allen is board-certified in internal medicine. Beyond her recognition as a fellow of the American College of Physicians, she is a member of the American Medical Association and the American Medical Informatics Association. Dr. Allen holds master's degrees in biomedical informatics and in technology management.

Jordan Ashton D.O., practices family medicine in a holistic manner, which incorporates all aspects of medicine, including oral health. As a clinical oral health champion, she has been engaged in a pilot study incorporating oral healthcare for her diabetic patients. Her passion for the integration of oral-systemic health has led to national recognition of her efforts, including speaking on behalf of Marshfield Clinic at the National Interprofessional Initiative on Oral Health (NIIOH) Symposium and creating a webinar for the American Diabetic Association (ADA). She received her Bachelor of Science from the University of Wisconsin-Madison and attended medical school at Michigan State University College of Osteopathic Medicine. Dr. Ashton completed her family medicine residency at Botsford Hospital in Farmington Hills, Michigan. Now in her fifth year of practice with Marshfield Clinic, she is putting her values of integrated healthcare into fruition. As a Wisconsin native, Dr. Ashton understands the importance of giving back to her community, as she is also actively engaged in medical education for students.

Valerie Bertaud-Gounot Ph.D., is full professor and hospital practitioner at the Health Big Data Department of the University of Rennes, France. She obtained her bachelor's degree in computer engineering and subsequently her dental degree. She later obtained a PhD in biomedical informatics followed by a master's in statistics. She teaches preventive medicine, biostatistics, evidence-based medicine, and dental informatics. In addition, she continues her clinical activities providing care for patients at the dental emergency facility of the University Hospital and the Dental Office of the Psychiatric Hospital of Rennes.

Kelly A. Boggs B.S., M.B.A., achieved her undergraduate degree in political science and public administration from UW-Stevens Point in 2001. After college, Kelly spent 7 years in the mortgage industry before going back to school for an MBA with a healthcare focus in 2006 and graduating in 2008. Kelly completed a 2-year Academic Administrative Fellowship at Marshfield Clinic. Her capstone project of her fellowship involved of the completion of an application to the Commission on Dental Accreditation for a dental residency program, which was ultimately approved. In 2012, Kelly joined Ministry Health Care as an account executive working on dual programs for cardiology and oncology with Marshfield Clinic. In the next 5 years, she progressed from an account executive to the director of physician relations. Kelly completed a Leadership Development Program with American College of Healthcare Executives and has been a member of the Medical College of Wisconsin's Regional Advisory Admissions Committee (RAAC) since the inaugural class in 2015. In 2018, she accepted a director of network engagement position with Aspirus Network, Inc., a clinically integrated network. Kelly lives in Stevens Point, WI, with her husband, Dan, and sons, Harrison and Griffin.

Monica Chaudhari Dr.P.H., is a doctoral biostatistician providing methodological, analytical, and statistical support in the field of healthcare research. She began her career at WDS (2006–2011) after attaining a master's degree in biostatistics from the University of Washington. Her functional areas at WDS included facilitation of medical-dental collaborative research, multicenter provider profiling, dental utilization and cost analysis, and dental treatments and outcomes assessment. During her tenure, Dr. Chaudhari and Group Health investigators examined association between diabetes mellitus and periodontal disease in health outcomes and medical costs. They also looked at implications of diabetes in use of dental services and costs.

Since then, she has had experience in multiple therapeutic areas (clinical phase-II/phase-III or observational studies) including immunology, diabetes type-I/type-II, post-traumatic stress disorder (PTSD), gynecology, and oncology. Her statistical work has focused on methodologies for precision medicine and other modeling techniques including, but not limited to, stochastic/mixed effect, survival/longitudinal, Bayesian, skewed/overdispersed/missing data, causal inference, multistate disease progression, and high-dimensional supervised and unsupervised learning. She has contributed significant independent scientific insights and has demonstrated the ability to develop and apply new methods to studies of a relatively new field of inquiry.

Dr. Chaudhari serves as a journal referee and belongs to professional organizations including the International Biometric Society and the American Statistical Association (ASA).

Louay Danial M.D., is a family medicine practitioner at the Marshfield Clinic Park Falls Center and Marshfield Clinic Phillips Center. He has more than 20 years of clinical experience. He completed his residency in family medicine from Swedish Covenant Hospital, Chicago, in 2005. His interests include primary care including OB/GYN, pediatric medicine, and geriatric medicine.

Richard Dart M.D., M.A.C.P., F.C.C.P., F.A.H.A., F.A.S.N., F.A.S.H., is a Marshfield Clinic Emeritus Research Clinician. Dr. Dart has been actively engaged in the research process to varying degrees throughout his nearly 50-year career as a physician. During special fellowship training in the research division of the Cleveland Clinic Foundation, he was engaged in a study of total body sodium under the tutelage of Harriet P. Dustan, MD. Upon entering clinical practice in the Department of Hypertension and Nephrology at Marshfield Clinic in 1973, he participated in clinical studies as well as collaborative research with basic scientist Duane Tewksbury, PhD, in the Marshfield Clinic Research Foundation on a study exploring high molecular weight angiotensinogen in pregnancy-induced hypertension. Later collaborative work resulted in characterization of the placental location of an angiotensinogen receptor in the human placenta.

In addition to this collaborative work, he has also participated in numerous clinical trials, including a phase three trial of Capoten, one of the first oral angiotensin-converting enzyme inhibitors, and the membranous glomerulonephritis/nephrotic syndrome Prednisone trial. In addition, Dr. Dart served as site PI for a number of multi-institutional initiatives, including the IgA Nephropathy/Fish Oil trial, the National Heart, Lung, and Blood Institute's Antihypertensive, Lipid Lowering, Heart Attack Prevention Trial (ALLHAT), and the Focal Sclerosing Glomerulonephritis Genetics Trial. More recently, Dr. Dart's efforts have been focused on genetic-based studies, including an investigation of the genetic variation in 25-hydroxyvitamin D 1 alpha hydroxylase (CYP27B1) in congestive heart failure patients with hypertension and additional studies related to the relationship between single nucleotide polymorphisms and high-sensitivity C-reactive protein and other covariables (1–3).

Outside the clinical research environment, he has also been involved in several educational and bioethical projects serving as a contributing member and co-author for several writing committees.

Mark Diehl D.D.S., was the director of the Health Informatics Program at Misericordia University, Dallas, PA, where he built a comprehensive undergraduate, graduate, and continuing education program. His research interests included data architecture and modeling, information governance, and the human-system interaction.

Dr. Diehl was member of the US Technical Advisory Group of the International Standards Organization Technical Committee 215 on Health Informatics, chair of the American Dental Association Standards Committee on Dental Informatics Subcommittee 11 on Clinical Informatics, and co-chair of the ASTM subcommittee E31.25 on Healthcare Data Management, Security, Confidentiality, and Privacy. He is the principal author of several health informatics standards such as the ANSI/ADA Specifications 1000, 1027, and 1039 and ASTM standards E2145 and E2436.

He also contributed to standards work in Health Level Seven, serving as the HL7 liaison to the American Dental Association, and worked on standards activities in the ANSI Health Information Technology Standards Panel and the National Council for Prescription Drug Programs.

Among his degrees, Dr. Diehl received a DDS from Temple University, an MA in computer data management and health systems management from Webster University and an MPH in Health Services Administration from the Uniformed Services University.

Franklin M. Din D.M.D., M.A., is currently the chief medical information officer for FraudLens Inc. Previously he was a solution architect for Transactions, Code Sets & Informatics, HP Enterprise Services, Global Healthcare, and is responsible for providing medical informatics, terminology, and other healthcare data standards expertise improve healthcare delivery, costs, outcomes, and future trends. Standardization of data is essential to the informatics goal of turning massive amounts of data into useful and actionable knowledge.

Frank worked at HP from 2009 until 2012. In July 2009, he led the Medical Informatics Center of Excellence (MICOE) team successfully partnered with a Title XIX Account to seamlessly in-source business analytic work that was previously outsourced at a cost of millions of dollars. In March 2010, he led the MICOE team that successfully delivered an HP proprietary, Medicaid-specific predictive model for diabetes. In November of 2010, Frank successfully designed, prototyped, and demonstrated an approach to perform medical term standardization, natural language processing, and ontology development, all in Mandarin, for a Nationwide Medical Records Project in China.

Before joining HP, Frank was a senior informatics consultant for Apelon, Inc. He was involved with data standardization for two rounds of the National Health Information Network (NHIN); he led the team that produced a strategy to cross map discrete medication data streams which resulted in simplified analytics for an academic medical center; he devised a plan to bring SNODENT terminology into compliance with SNOMED CT; he worked on the improvement to the National Cancer Institute's NCI Thesaurus that resulted in the new BioMed GT terminology while simultaneously creating the prototype of a collaborative semantic media wiki that permits remote collaboration on BioMed GT. While working for the VHA in the Salt Lake City Office of Information, Frank created a tool to map concepts in VistA with SNOMED CT for the LDSI (Lab Data Sharing Initiative) which links the VHA and the Department of Defense lab systems; he created an MS Excel mapping tool to convert the Kaiser Permanente ICD-9-based problem list into a SNOMED CT-based list. This work became the basis of the FDA's SPL problem list.

Prior to his specialization in biomedical informatics, Frank was a practicing dentist, assistant clinical professor of dentistry at NYU Dental School, and course director for forensics dentistry at Columbia University School of Dental and Oral Surgery. He currently serves as a member of DMORT (Disaster Mortuary Operational Response Team) to perform forensic dental services at mass disaster sites, with previous deployments to the World Trade Center and Hurricane Katrina.

Frank has active memberships in AMIA (American Medical Informatics Association) and HIMSS (Healthcare Information Management Systems Society). He was a member of HITSP and co-chaired the subcommittee on planning and internal communications for HITSP's Education, Communication, and Outreach (ECO) Committee.

Frank received a BS in biology from Lehigh University and a DMD from Fairleigh Dickinson University and completed an NLM (National Library of Medicine) postdoctoral fellowship in Biomedical Informatics with an MA from Columbia University.

Stephen Foreman J.D., Ph.D., M.P.A., is professor of health economics at Robert Morris University, Pittsburgh, PA, where he teaches health economics, health policy, statistics, and health law and ethics in the University's graduate programs. Steve has been a Fulbright scholar at the Crimea State Medical University, Simferopol, Crimea, where he lectured and conducted research in comparative international health policy. Dr. Foreman's research focuses on structure, performance, and strategy in health insurance, hospital and physician markets, and health insurance data. His work includes the international economics of aging, economic mechanisms as they relate to corruption, and the economics of human trafficking. Professor Foreman holds a PhD in health economics from the University of California, Berkeley, a JD with honors from the University of North Carolina and a Master in Public Administration from Harvard's Kennedy School of Government where he was a Littauer fellow.

Shin-Mey Rose Yin Geist D.D.S., M.S., is an associate professor in the Departments of Biomedical and Diagnostic Sciences and Patient Management at the University of Detroit Mercy School of Dentistry. Born and raised in Taiwan, Republic of China, Dr. Geist graduated from Dental School in Taiwan in 1974. She specialized in oral surgery and was teaching in the University Hospital when she found her passion for oral medicine. She completed her master's degree in oral diagnosis/oral medicine at the Indiana University School of Dentistry in 1985 and then studied and worked in molecular biology and DNA cloning research at the medical schools at Indiana University and Wayne State University. Dr. Geist received her DDS degree in 1990 from the University of Detroit and has been teaching oral diagnosis and oral medicine at UDM since that time. She has been course director of the advanced oral medicine course for graduate students in periodontics and advanced general dentistry. Dr. Geist served as chair of the oral diagnosis and oral medicine section of the American Dental Education Association (ADEA) and is presently serving on the editorial review board of the *Journal of Dental Education*, the official journal of ADEA. She was recently appointed as a member of the content analysis working group of MedEdPORTAL Oral Health in Medicine Model Curriculum. *MedEdPORTAL* is a peer-reviewed online publication of the Association of American Medical Colleges (AAMC), partnered with ADEA.

Dr. Geist has held a diplomate of the American Board of Oral Medicine since 1992 and has special interest in medically complex dental patient management. She is committed to improving the interface between medical and oral healthcare. Her

research interests include the efficiency in teaching and service in providing comprehensive coordinated care.

Casey Hein In July 2018, Casey Hein, B.S.D.H., R.D.H., M.B.A., retired from her decade-long appointments at the University of Manitoba, where she was an assistant clinical professor in the Department of Periodontics, director of education of the International Centre for Oral-Systemic Health in the College of Dentistry, and the director of continuing professional development for dentistry and dental hygiene in the Rady Faculty of Health Sciences at the University of Manitoba (Canada). One of her responsibilities at the University of Manitoba was to lead a team in the development of her vision for the first comprehensive curriculum about oral health for physicians, nurses, and other non-dental healthcare providers (Oral-Systemic Health Education for Non-Dental Healthcare Providers), which won for the University of Manitoba the prestigious William J. Gies Award for Outstanding Innovation in 2015. She maintains a faculty appointment as an assistant professor in the University's School of Dental Hygiene and writes and lectures on the topic of dental-medical collaboration in caring for people at risk for oral-systemic diseases and conditions. She has developed two educational websites that provide resources for implementation of periodontal-systemic science (www.caseyhein.com) and online courses related to oral-systemic health for both the dental and medical communities (www.oralhealthed.com).

Glurich Ingrid Ph.D., earned her degree in microbiology and microbial pathogenesis with a special emphasis on autoimmunity and immunopathology from the State University of New York at Buffalo. Dr. Glurich has been involved in research for over 30 years and is currently a project scientist in the Center for Oral and Systemic Health at Marshfield Clinic Research Institute in Marshfield, Wisconsin. Her basic and clinical research has focused on oral-systemic health connections and has included studies surrounding immune and inflammatory mechanisms and the role of host response to microbial pathogens. Her current research activities include advancing integrated care delivery models for oral and medical management of patients with diabetes, defining a potential role for immune and inflammatory response to oral pathogens in exacerbation of renal disease, characterizing the role of oral health status in patients with emergent pneumonia, and translating precision medicine into the oral healthcare delivery arena. To date, Dr. Glurich has authored/co-authored over 60 manuscripts and book chapters.

Mark W. Jurkovich D.D.S., M.B.A., M.H.I., is a senior fellow at the HealthPartners Institute in Bloomington, MN, and is a graduate of the University of Minnesota School of Dentistry, the Carlson School of Business, and the Institute of Health Informatics at the University of Minnesota. He provided direct patient care in a variety of private practice formats for 38 years. He currently works in the areas of research, terminology development, and data analytics, with a focus on the dental field. He currently serves on the American Dental Association's (ADA) oversight committee of the Standards Committee on Dental Informatics, on the State of Minnesota e-Health Advisory Committee, and on the Information Exchange oversight committee. He is chair of the

ANSI SNODENT Maintenance Committee and lead for the SNOMED International Dental CRG. He has provided numerous presentations throughout the country on dental topics involving electronic dental record systems and terminologies.

Joseph Kilsdonk Au.D., has served as the administrator for Marshfield Clinic's Education Division since 2004. The Division oversees the largest community health center-based training programs in the State of Wisconsin. Prior to that, he served as an associate dean overseeing health careers for a public college, served as an executive for a national ancillary healthcare service corporation, served on the management team of a multispecialty physician group practice and a community hospital, taught as an assistant professor, and founded and managed hospital and community-based outreach practices.

Dr. Kilsdonk was the lead author on the Clinic's dental education feasibility study leading to its current efforts in dental education resulting in a public-private partnership for rural dental education expansion. He has presented locally, regionally, and nationally on a number of healthcare and practice management topics. Most recently, he has presented to the "National Health Policy Forum on Oral Health; 10 Years after the Surgeons General's Report" in Washington, DC. He has served on Wisconsin's Dental Education Feasibility Study Advisory Committee and presently serves on the Advisory Committee for the Wisconsin Academy for Rural Medicine, the Committee for the Wisconsin Rural Physician Residency Assistance Program, and the Chancellor's Advisory Committee for University of Wisconsin at Stevens Point. He has been a manuscript reviewer for the *Journal of Dental Education* since 2009.

Dr. Kilsdonk received his doctorate in audiology for the Arizona School of Health Sciences, a master's degree from the University of Wisconsin, Oshkosh, and his undergraduate degree in communicative disorders from the University of Wisconsin, Stevens Point.

Ted Klein M.S., Klein Consulting, Inc. Vocabulary Co-chair, HL7 International.

Kori Krueger M.D., M.B.A., is the medical director of the Institute of Quality, Innovation, and Patient Safety at Marshfield Clinic, Marshfield, Wisconsin. Dr. Krueger attended medical school at the University of Wisconsin Medical School in Madison and completed his residency at Marshfield Clinic in Marshfield, Wisconsin. He is board-certified in internal medicine and pediatrics. He is involved in medical education and works as a primary care provider in pediatrics and internal medicine at Marshfield Clinic, Stratford Center. Dr. Krueger completed his medical MBA degree at the University of St. Thomas in Minneapolis, Minnesota, in 2013. Dr. Krueger is also the medical director of the Marshfield Clinic ACO.

Jayanth Kumar Medam B.D.S., is currently pursuing MS in health informatics at the School of Informatics and Computing, Indiana University. He holds a bachelor's in dental surgery from Dr. NTR University of Health Sciences, India. Following dental residency in India, Jayanth Kumar worked with multiple IT organizations and served in different roles such as medical content developer, subject matter

expert in revenue cycle, and clinical analyst. This experiential learning inspired him to pursue a career focused in the application of information technology in healthcare to improve healthcare outcomes. This eventually stimulated him to pursue an advanced degree in health informatics.

Jayanth Kumar Medam is a graduate research assistant at the Dental Informatics Core directed by Dr. Thankam Paul Thyvalikakath, Indiana University School of Dentistry. He is presently working on his master's thesis under her valuable guidance. This explorative study would address some of the existing communication gaps between medical and dental providers. His ultimate goal is to be a clinical informatics professional and contribute significantly to this domain.

William Melms M.D., is the Northeast Regional Primary Care Medical Director at Minocqua Center of Marshfield Clinic. Dr. Melms has more than 20 years of clinical experience in urgent care and family medicine. He has authored/co-authored research papers. He pursued his MD from the University of Wisconsin School of Medicine and Public Health in 1986 and completed his residency in family medicine from Medical College of Wisconsin Affiliated Hospitals in 1989. Dr. Melms interests include general family medicine.

Sushma Mishra M.B.A., Ph.D., is an associate professor of computer information systems at Robert Morris University. She is the director of doctor of science (DSc) program at RMU. She has an MBA degree from India and a PhD in information systems from Virginia Commonwealth University. Dr. Mishra's research interests include information security, information assurance issues in healthcare information systems, systems auditing, and systems development methodologies. Dr. Mishra has published in several conference proceedings, book chapters, and journal articles on these topics. She teaches information security and decision support systems.

John O'Brien D.D.S., is the clinical dental director of the Family Health Center Dental Clinics and is a practicing dentist. He pursued his DDS from the State University of New York at Buffalo School of Dental Medicine. He has been involved in various research studies.

Aloksagar Panny B.D.S., M.S., is the research specialist at the Center for Oral and Systemic Health, Marshfield Clinic, Marshfield, Wisconsin. In March 2013, he obtained his Bachelor of Dental Surgery (BDS) from Dr. NTR University of Health Sciences, India. In May 2016, he earned a Master of Science in medical informatics and a graduate certificate in healthcare data analytics—both from George Mason University, Fairfax, VA. He is also a SAS-certified programmer. Mr. Panny was an intern at the National Institutes of Health where his work was focused on using a range of informatics and natural language processing (NLP) techniques to analyze clinical research documents of both active and terminated clinical trials. Mr. Panny has a strong clinical background. His research interests include oral-systemic connections, clinical decision support systems, and dental informatics.

Ram Pathak M.D., F.A.C.P., is a consultant in the Department of Endocrinology at Marshfield Clinic in Wisconsin. He also serves as the director of Diabetes Education Program across the Marshfield Clinic Health System. He has more than two decades of experience caring for patients with diabetes and formerly served as the chair of the Department of Endocrinology.

Dr. Pathak has been a principal investigator for various studies in the diabetes field and has published more than two dozen manuscripts in national and international journals. He served as a member of the research committee for 6 years and as a trustee for the Marshfield Clinic Research Foundation from 2011 to 2014. Currently, Dr. Pathak is active in patient care, medical teaching, and clinical research.

Frank Scannapieco D.M.D., Ph.D., professor and chair of the Department of Oral Biology and associate dean for faculty and professional development, School of Dental Medicine, State University of New York at Buffalo, is a periodontist and investigator with over 25 years of research experience. He studies oral microbiology, molecular mechanisms of bacterial colonization, and the interface between oral and systemic health, especially the role of oral conditions in the process of respiratory infection. He received the DMD from the University of Connecticut and the PhD in oral biology and certificate in periodontology from the University at Buffalo.

Dr. Scannapieco is a past associate editor of the *Journal of Periodontology*, has edited an issue of *Dental Clinics of North America*, has served on the editorial board of the *Journal of Dental Research*, and as a referee for over 40 medical, dental, and scientific journals. He has received substantial funding from NIH to support his research and has authored or co-authored over 150 peer-reviewed papers and abstracts.

Neel Shimpi B.D.S., M.M., Ph.D., is currently working as a tenure-track associate research scientist at the Center for Oral and Systemic Health at Marshfield Clinic Research Institute at Marshfield, Wisconsin, USA. Dr. Shimpi was trained as a general dental surgeon and received her PhD in the field of biomedical and health informatics. Additionally she has master's degree in healthcare management from Cambridge, Massachusetts, and diplomas and certificates in hospital administration and clinical research. Dr. Shimpi has been involved in research for over 5 years, applying her expertise to research focused on applying informatics to projects involving artificial intelligence, educational curriculum development, natural language processing, and clinical and oral-systemic health research, among other applications. She has published in many national journals and presented at national and international conferences. Her work on assessment of oral cancer knowledgeability among healthcare providers was highlighted by the Oral Cancer Foundation in 2016. She has also been involved in conducting quantitative studies surrounding oral cancer, mixed methods approaches for conducting oral-systemic health research, and data-driven and exploratory analysis of quantitative health informatics data to develop and evaluate various clinical decision support tools at point of care. She has co-mentored and mentored many summer interns and dental residents in the conduct of research studies. Dr. Shimpi's research interests include medical and dental informatics, developing clinical decision supports and expert systems, educational toolkits for healthcare providers, ontologies and terminologies,

principles of evidence-based practices, and investigating the oral-systemic relation-ships with high potential for translation into clinical practice.

Cindy Sorenson F.N.P., graduated from Viterbo University in 1983 with bache-lor's in nursing. Her nursing career started in the intensive care unit and the emer-gency department at Marshfield Clinic. Due to her keen interest in family practice, she went back to school and pursued a master's degree in nursing with an emphasis in family practice in 1955. She has been working for 22 years at the Marshfield Clinic Stettin Center. She played a key role in a pilot study surrounding integration of oral healthcare in diabetic patients.

Peter Umukoro M.D., M.P.H., Sc.D., is a physician and researcher with extensive cardiovascular experience. While at Harvard, his research focused on elucidating the determinants of ischemic heart disease and autonomic cardiac disease among occupational groups with peculiar exposures at work such as nurses, construction workers, and welders.

His research work spans cardiac autonomic function, physical activity determi-nants of nurses and construction workers, ergonomic intervention assessments among construction workers, and key determinants of ischemic heart disease risk in welders. His research with the Harvard Center for Work, Health, and Well-being has publications that have linked trunk bending to physical activity of nurses and described associations between occupational and leisure time physical activity. He has authored/co-authored original publications from his work with Harvard includ-ing a landmark publication in the *British Medical Journal* which describes associa-tions between particulate exposure and decreases in cardiac acceleration and deceleration capacities.

He is currently a resident physician at the Marshfield Medical Center, an investi-gator with the Marshfield Clinic Research Foundation, and a member of the American Public Health Association, American College of Physicians, and American College of Cardiology.

Jayanth Vedre M.D., M.P.H., is a pulmonologist and intensivist licensed in Wisconsin and Minnesota, with board certification in critical care medicine, neurocritical care med-icine, and internal medicine with over 12 years of experience in medical practice. Dr. Vedre is currently the director of the medical intensive care unit and intensivist at Marshfield Clinic Health Systems in Marshfield Wisconsin. Dr. Vedre was engaged in research in the critical care medicine during his tenure as a research fellow in the Mayo Clinic Epidemiology and Translational Research in Intensive Care (METRIC) at Mayo Clinic in Rochester, MN. His research interests include intensive care quality improve-ment projects, pneumonia management, critical care bedside ultrasound development, and extracorporeal membrane oxygenation. Dr. Vedre has 4 published abstracts and has authored/co-authored 17 additional abstracts/posters to date at national/state confer-ences. Dr. Vedre also holds an MPH in public health education from Western Kentucky University in Bowling Green, KY, and proactively engages in medical education of resi-dents. He has received two excellence-in-teaching awards.