

Health Informatics

Connie W. Delaney
Charlotte A. Weaver
Judith J. Warren
Thomas R. Clancy
Roy L. Simpson *Editors*

Big Data- Enabled Nursing

Education, Research and Practice

 Springer

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>

Connie W. Delaney • Charlotte A. Weaver
Judith J. Warren • Thomas R. Clancy
Roy L. Simpson
Editors

Big Data-Enabled Nursing

Education, Research and Practice

 Springer

Editors

Connie W. Delaney
School of Nursing
University of Minnesota School of Nursing
Minneapolis
Minnesota
USA

Charlotte A. Weaver
Issaquah
Washington
USA

Judith J. Warren
School of Nursing
University of Kansas School of Nursing
Plattsmouth
Nebraska
USA

Thomas R. Clancy
School of Nursing
University of Minnesota
Minneapolis
Minnesota
USA

Roy L. Simpson
Nell Hodgson Woodruff School of Nursing
Emory University
Atlanta
Georgia
USA

ISSN 1431-1917

ISSN 2197-3741 (electronic)

Health Informatics

ISBN 978-3-319-53299-8

ISBN 978-3-319-53300-1 (eBook)

DOI 10.1007/978-3-319-53300-1

Library of Congress Control Number: 2017945758

© Springer International Publishing AG 2017

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by Springer Nature

The registered company is Springer International Publishing AG

The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

To my family; and nursing's honor of the bold authentic voices of the patients, families and communities.

Connie W. Delaney

In memory of Betty R. Weaver, a mother who supported her daughter to follow her dream.

Charlotte A. Weaver

To Edward, my loving husband, who supported, listened, critiqued, and edited.

Judith J. Warren

To my father, John Clancy, who convinced me to become a nurse 40 years ago and it has been a wonderful journey ever since.

Thomas R. Clancy

To the patients and caregivers whose frustration with technology creates opportunities for big data visualization to enhance the effectiveness and efficiency of healthcare quality, including its processes, structures and outcomes.

Roy L. Simpson

Foreword 1

The idea of big data brings up the old saying “water, water, everywhere and not a drop to drink”. It may be wise to add that “drowning in data” is also of concern. The sheer volume and velocity of data has exploded with electronic information systems, the global internet, software and hardware technology, the cloud and use by almost everyone. The idea of big data has grown rapidly. Even with the advances in methods of collection, analysis, and reporting, the usefulness of data has not grown as rapidly. The vision of how data will add to knowledge and wisdom has initiated high interest and dreams of answering major questions to guide multiple current issues, challenges and decisions. Most professional and general public publications include discussions of big data addressed from perspectives of clinical care, science, business, education, travel, finance, marketing, and quality determinants.

In this important book pioneering authors address several important considerations and hopes for the creation, generation and use of big data particularly from the perspectives of the science and delivery of health care. The book is written as basic information for those who are becoming interested and for those who already have an interest in how big data can add to information and knowledge of importance to them. More specifically the authors describe how each individual, group, or nation might conquer, contribute to, and use big data to inform their own questions about science, practice, education, policy, organization, resources, and quality.

Researchers have and will continue to generate large amounts of data in many formats, at all levels and in every corner of the world. There is an increasing and urgent need to better understand how to capture, store, manage, analyze and share data to further knowledge and foster new discovery. Likewise, those who deliver and pay for care continue to generate large amounts of clinical, administrative, policy, and cost data to inform the decisions made by each individual or group. And the recipients of the decisions made by these groups have keen interest as buyers, patients, funders, and policy makers. Thus both those seeking the big picture and those seeking more specific targets can easily be blurred by the thousands of data elements.

Big data is of importance to many types of stakeholders. Biomedical, clinical, health services, economics, and population are examples of researchers. Serious

expectations are proposed for precision medicine with the aim to cure major diseases like cancer, Alzheimer's, AIDS and genetic disorders. Physicians, nurses, physical therapists, dentists, psychologists and other health professionals have need for specific data of importance to their practice. This need for specific data only increases when specialty areas are considered. Further stakeholders are hospitals, home care, long-term care, mental health, public health and hospice organizations. Patients and consumers are major stakeholders with needs for data tailored to specific conditions and situations. Ownership, governance, payers, and policy makers increase the complexity of essential data. Recently, community social determinants data have been identified.

A few years ago I was invited to present at the First International Interdisciplinary Conference on Big Data held in Singapore. I proposed that big data was not big enough especially from the perspective of nursing practice and nursing science and from the perspective of patients, families and communities. Our experience with data for decades has been focused on classifications of diseases and medical procedures. Data about the assessment, problems, interventions, and outcomes of nursing care are invisible. It was and still is a challenge to find essential patient data from the perspective of nurses in electronic information systems, data warehouses, repositories and the cloud. There was surprise and agreement from engineers and computer scientists at the conference. Unfortunately, this state exists even with extensive work on a Nursing Minimum Data Set and a Nursing Minimum Management Data Set as well as work on international and national development of nursing terminologies and vocabularies. This is a serious limitation and challenge to meeting the goal of advancing nursing science and nursing practice. It is also a serious limitation for all interdisciplinary efforts to generate and use data.

The potential value of big data has created intense interest from the creators and users to be sure that what is of importance to each is included in big data. A current challenge is the desire to have a longitudinal plan of care for each patient. Each stakeholder wants to include a very specific type of data important to a specific practice. Data of importance to another is often considered clutter and makes the information/decision support system time consuming and of little use. Also a challenge and of keen interest is that each piece of data is clearly defined, and is valid and reliable. Highly reliable evidence-based care to ensure quality, safety, and value in health care clinical decisions needs to be supported by accurate, timely and up to date clinical information. Missing data on care not delivered or care data not delivered is of great importance as part of the search for best care. All stakeholders need to accelerate the integration of best knowledge into a care decision.

SNOMED CT and LOINC represent international and nationwide work on reference and clinical terminology that are helping achieve the goal of having standardized interoperable data. This should help the goal that each stakeholder uses the same data element with the same concept. Researchers and clinicians often use different terminology. This quest is no small challenge because of the many areas of science, technology, clinical care, administration, policy development, and the broad variety of health delivery systems and the populations who are the participants in health care.

Each part and chapter of this book has comprehensive descriptions of the evolution of data and knowledge discovery methods that span qualitative as well as quantitative data mining and other methods. Multiple examples are included. There are opportunities and challenges as the data grows in scale, complexity, volume, variety and velocity. Opportunities also expand with the rapid growth of new approaches to data management, analysis, and sharing and with further development of technology (hardware and software).

When all is said and done, the value of big data to patients will depend on how well their care can be delivered and received. A most important question may be precision medical diagnosis and treatment using a wide range of data. Or it may be that cost or community safety is a top question. On the other hand, important concerns may include questions regarding their immediate and long-term care. Big data will not be of much interest to patients having such very personal problems as unmanaged pain, pressure ulcers, lack of information to inform self- management, nausea, vomiting, falls with injury, hospital acquired infections, and uncoordinated care if not included in big data sets.

There is still much to learn about what really contributes to outcomes of value to stakeholders. Use of big data holds promise for advancing health care, research methods, education and policy. This book is a major contribution to that learning.

Norma M. Lang, RN, PhD, FAAN, FRCN
School of Nursing
University of Pennsylvania
Philadelphia, PA, USA
University of Wisconsin–Milwaukee
Milwaukee, WI, USA

Foreword 2

Big data science has to be the concern of all nurses. The 21st-century question for every health professional is: How do you promote transformational change in which the emphasis is not on transitory, isolated performance improvements by individuals, but on sustained, integrated, comprehensive advancement of the whole? The turn-of-the-century focus on bridging the quality divide, with its emphasis on re-engineered care processes and effective use of information technology, has been replaced by the wish to create the continuously learning healthcare systems (LHS) described by the Institute of Medicine. The LHS can analyze all aspects of the care experience for real-time decision-making by patients and clinicians alike. In the space of a dozen years, the stress has moved from simply establishing and using the electronic health record to analyzing all aspects of the care experience for new insights which might involve mining a host of previously unconnected data bases (e.g., quality-safety benchmarks, cost accounting, environmental hazards, admission-discharge records, and so forth).

Big data is not only of importance to nurse informaticians and health services researchers, but to all who aspire to leadership positions in practice, education, research, and policy. Nursing leaders have highlighted the need for nurses to know enough about big data that they can appreciate its relevance to care coordination. Nurses need to be cognizant of technologic developments if they are educators or deans so they can be futuristic about program planning and faculty recruitment. Nurses need to understand enough about how big data can give them insights into health risk differences. Consider, for example, the challenge of designing population-based care for urban and rural women in a particular country. Nurses need to recognize the promise and potential perils of big data if their research is concerned with advancing symptom management.

As we know, leadership isn't just what you can do yourself, but encompasses what you can get done. Do you know enough about trends and the changing nature of health care to hire people with the right skills sets and ask pithy questions of experts who are telling you that your organization should be moving in a particular direction? Do you know how technology-mediated interventions might increase patient engagement and adherence in your clinical setting, so that you can start to

move your setting in that direction? Nurse leaders in all settings and at all levels need to be familiar with big data science, and big data needs to be shaped so it asks the questions of concern to care giving. This major volume on big data science can, therefore, be of use to those nurses already concerned with these matters, and I believe it can also be valuable as an immersion in futures thinking for those who don't know enough currently about how to address the informatics revolution underway. If you are trying to get your head around how to handle the tidal wave of data, the increasing concern about figuring out the social determinants of health, or the transformation taking place in how we think and work, then this book is must reading.

Angela Barron McBride, PhD, RN
School of Nursing, Indiana University
Bloomington, IN, USA

Preface

This book's purpose is to engage all of nursing in the potential that big data analytics holds for advancing our profession and the discipline of nursing spanning practice, operations, research, academics, industry, and policy. The book includes big data state-of-the-art-and-science reviews, as well as applied chapters and case study exemplars in nursing using big data analytic methods and technology. In this book, we celebrate the early adopters and the transformative initiatives in play at health-care organizations, vendors, payers and academia. We also aim to present the opportunities for nursing's impact in this new, emerging knowledge-driven world.

Nursing research historically adopted qualitative methodologies with purposive sampling and quantitative methodologies with small sample sizes because access to patients or large study populations was constrained. Clinical trials, bench research, epidemiology studies and large data methods were in the medical domain and used traditional biostatistical analyses. However, the digitization of medical records and payers' claims data has redefined population studies and made large databases available to all disciplines. In the United States, large payer data has been amassed and organizations have been created to welcome scientists to explore these data to advance knowledge discovery. Health systems' electronic health records (EHRs) have now matured to generate massive databases with longitudinal trending. The learning health system infrastructure is maturing, and being advanced by health information exchanges (HIEs) with multiple organizations blending their data, or enabling distributed computing. The evolution of knowledge discovery methods that use quantitative data mining and new analytic methods, including the development of complex data visualization, are enabling sophisticated discovery not previously possible. These developments present new opportunities for nursing, and call for skills in research methodologies that can best be further enabled by forging partnerships with data science expertise spanning all sectors. Recognizing that these new opportunities also call for reassessment of all levels of academic preparation of nursing professionals from pre-licensure through post-doctoral training, parts of this book are dedicated to nursing education and competencies needed at all levels.

This book represents the first big data/data science book in nursing to be published worldwide. It succinctly captures the state of big data and societal context,

provides exemplars to establish a foundation for nursing's response to the big data science frontier and provides multiple pathways for driving nursing's future. Accordingly, we organized the book into five parts with the goal of introducing the core concepts of big data and data science in Part I with examples that relate to nursing as well as other industries. Part II brings in the new and emerging technologies that make big data analytics possible, and illustrates through case studies and references to initiatives currently happening. These two foundational parts also provide state-of-the-art/science reviews that are written by fellow nurses with an eye to demystifying and removing any intimidation that might surround this field.

Introduced throughout all five parts is the important principle of using partnerships and building teams that include big data analytics experts and data scientists in order to have the clinical and technical skill mix needed. The days of the single researcher, analyst, or single domain team are being called into question for their relevancy and efficiency. Recognizing that all missions—academic, research, practice, policy—are transformed by big data, Part III focuses on research. Specifically, this part dives into the complexity of disease, advancement of networks to increase access to large data capacity, and actual application of data analytics to drive transformation of the healthcare system. Taken together, Part III's chapters show the potential of nursing's engagement in big data science to transform the science by the new knowledge generated and its application in practice, education and policy.

The last two parts attend to applied current state exemplars for nurse executives to have reference roadmaps, competencies needed at all levels, and a look at the near future impact for healthcare delivery, education and research. Throughout Part IV and V, "readiness" is directed at those who own change across the sectors: those who teach our next generation of nurses; the health policymakers who support change through regulations, guidance and funding; and nurse executives who define care strategies within their healthcare organizations. Front and center to all these sectors within the near future big data world is the critical state of the nursing workforce. Part V includes a description of quantity, emergent roles, education and appropriate certification and credentialing that "readiness" for the changes afoot will require.

A theme throughout the book is the goal of having "sharable and comparable" nursing data, and the need for standards to make this possible. While nursing is making progress on having adequately matured, codified terminologies to represent nursing concepts, actions and outcomes across all care domains, we are not there yet. The tactics used to compensate for this current state are reflected in the chapters and case studies presented in Part IV and V. Interoperability and data standards are the key challenge of our times and will continue to have intense focus. Standards that work for all are not just U.S. challenges, but rather extend worldwide; and thus, the significance of a global world permeates these invitations for engagement, transformation and empowered nursing.

In summary, this book is applicable to all nurses and interprofessional colleagues in all roles. We deliberately constructed the content and selected the applied

examples and case studies so that the book can serve as a technology reference, or a “101 Intro” to big data for all nurses, and most importantly, a “how to” guide for planning your own big data initiatives. We hope that you will use the book broadly for continuing education purposes as well as for educational curricula; but above all, we hope that you read and enjoy the book!

Connie W. Delaney
Charlotte A. Weaver
Judith J. Warren
Thomas R. Clancy
Roy L. Simpson

Acknowledgments

The idea for this book grew out of many nursing and interprofessional dialogues about big data and data science’s growing presence throughout the healthcare industry including research, education and policy. The need for a “big data and nursing” book emerged from multiple conversations that happened in the context of the University of Minnesota School of Nursing’s annual Big Data and Nursing conferences that started in June 2013. From these rich interchanges, we recognized a pressing urgency to bring the potential of big data analytics into all the domains of nursing—practice, operations, research, academics, industry, and policy. More sobering was the discovery that there were no books in the marketplace in 2016 that specifically focused on nursing and big data. So our biggest “thank you” goes to all the authors and co-authors of the many chapters and case studies that make up this book. As early contributors in this first nursing publication on the topic worldwide, these authors bravely stepped forward to share their work and to lay out candidly how they are bringing big data applications into their respective domains.

In addition, we owe thanks to many others for helping us bring this body of work to you. To start at the beginning, we want to acknowledge the debt we have to the annual Big Data and Nursing Knowledge Conference Steering Committee Members who have worked diligently to ensure that we had this annual gathering without which the ideas, content and contributors for this book would not have happened. Bonnie Westra and Lisiane Pruinelli served as the organizing principals, aided by Susan Matney, Joyce Sensmeier, Daniel Pesut, Nancy Ulvestad and four of the book editors. A number of organizations also contributed by sponsoring representatives to the annual conferences and those include: American Nurses Association, American Association of Colleges of Nursing, American Medical Informatics Association, National Institute of Nursing Research, Trinity Health, Hospital Corporation of America, and University of Minnesota Medical Center. Cerner Corporation and OptumLabs’™ Scott Regenstein, Greta Bagshaw and William Crown were instrumental partners as fellow researchers, book contributors and data science experts who willingly shared knowledge and guidance.

We give our greatest thanks to Dixie Berg, consulting editor, for helping us track all the details, keeping all the editors organized and on task, and for doing the final

book manuscript preparation. Behind the scenes, we have Toni Bennett from Cerner Corporation and Dana Hurley from the University of Minnesota School of Nursing who gave immeasurable assistance with planning and organization for conference calls across time zones and difficult schedules. Many of our colleagues behind the scenes encouraged us and contributed their ideas, time and creativity. We are indebted to Melanie Dreher, Nancy Dunton, Catherine Ivory, Tess Settergren, Russ McDonough, and Jeannine Rivet. A special note of appreciation goes to Grant Weston, who as our Springer editor was a strong supporter of this book and a constant source of guidance throughout this exciting journey.

Connie W. Delaney
Charlotte A. Weaver
Judith J. Warren
Thomas R. Clancy
Roy L. Simpson

Contents

Part I The New and Exciting World of “Big Data”

1 Why Big Data?: Why Nursing?	3
Connie W. Delaney and Roy L. Simpson	
1.1 Why Big Data?	4
1.2 Why Big Data in Nursing?	6
1.3 Summary	8
References.	8
2 Big Data in Healthcare: A Wide Look at a Broad Subject	11
Marisa L. Wilson, Charlotte A. Weaver, Paula M. Procter, and Murielle S. Beene	
2.1 Reaching the Tipping Point: Big Data and Healthcare	12
2.2 Big Data and Analytics Enabling Innovation in Population Health	14
2.2.1 Blending in the Social Determinants	17
2.3 Big Data in Action	18
2.3.1 The Department of Veterans Affairs	18
2.3.2 A View from Home Health	23
2.3.3 The Spine: A United Kingdom Big Data Endeavor	25
2.4 Summary	29
References.	29
3 A Big Data Primer	33
Judith J. Warren	
3.1 What Is Big Data?	33
3.1.1 Datafication and Digitization	36
3.1.2 Resources for Evaluating Big Data Technology	36
3.2 The V’s: Volume, Variety, Velocity	37
3.2.1 Volume	37
3.2.2 Variety	39
3.2.3 Velocity	39

- 3.3 Data Science. 40
 - 3.3.1 What Is Data Science? 40
 - 3.3.2 The Data Science Process 40
- 3.4 Visualizing the Data. 42
- 3.5 Big Data Is a Team Sport. 43
- 3.6 Conclusion. 45
- Case Study 3.1: Big Data Resources—A Learning Module 46
- Judith J. Warren and E. LaVerne Manos
 - 3.1.1 Introduction 46
 - 3.1.2 Resources for Big Data 47
 - 3.1.3 Resources for Data Science 50
 - 3.1.4 Resources for Data Visualization. 52
 - 3.1.5 Organizations of Interest 53
 - 3.1.6 Assessment of Competencies. 55
 - 3.1.7 Learning Activities. 56
 - 3.1.8 Guidance for Learners and Faculty Using the Module 57
 - References 57

Part II Technologies and Science of Big Data

- 4 A Closer Look at Enabling Technologies and Knowledge Value 63**
- Thomas R. Clancy
 - 4.1 Introduction 64
 - 4.2 Emerging Roles and the Technology Enabling Them 65
 - 4.3 A Closer Look at Technology 68
 - 4.3.1 Handheld Ultrasound. 70
 - 4.3.2 Point of Care Lab Testing 70
 - 4.3.3 The Quantified Self Movement 71
 - 4.3.4 Sleep Monitors. 72
 - 4.3.5 Activity Monitors. 72
 - 4.3.6 Data Mash-Ups 73
 - 4.3.7 Symptom Checkers 73
 - 4.3.8 Augmented Cognition 74
 - 4.4 Big Data Science and the Evolving Role of Nurses. 74
 - 4.5 Conclusion 76
 - References. 77
- 5 Big Data in Healthcare: New Methods of Analysis 79**
- Sarah N. Musy and Michael Simon
 - 5.1 Introduction 80
 - 5.2 Sources of Big Data. 81
 - 5.3 Big Data Analytics. 83
 - 5.3.1 Data Mining. 83
 - 5.3.2 Text Mining 84

5.3.3	Predictive Modelling	85
5.3.4	Machine Learning	85
5.4	Big Data Applications in Nursing	86
5.5	Challenges of Big Data	90
5.6	Conclusions	91
	References.	91
	Case Study 5.1: Value-Based Nursing Care Model Development	95
	John M. Welton and Ellen Harper	
5.1.1	Value-Based Nursing Care and Big Data.	96
5.1.2	The Cost of Nursing Care	98
5.1.3	Summary	100
	References	100
6	Generating the Data for Analyzing the Effects of Interprofessional Teams for Improving Triple Aim Outcomes.	103
	May Nawal Lutfiyya, Teresa Schicker, Amy Jarabek, Judith Pechacek, Barbara Brandt, and Frank Cerra	
6.1	Introduction	104
6.2	Raison D’être for the NCDR	105
6.2.1	Characteristics of the NCDR	106
6.2.2	Data Volume.	107
6.2.3	Data Velocity	108
6.2.4	Data Value	108
6.2.5	Ecosystem of the NCDR	109
6.2.6	Infrastructure	110
6.3	Conclusions	113
	References.	113
7	Wrestling with Big Data: How Nurse Leaders Can Engage	115
	Jane Englebright and Edmund Jackson	
7.1	Introduction	115
7.2	Defining Big Data and Data Science	116
7.3	Nursing Leader Accountabilities and Challenges	116
7.4	Systems Interoperability	117
7.5	Non-Standardization	118
7.6	The Invisibility of Nursing.	118
7.7	A Common Data Repository Across the System.	119
7.8	The Value of Big Data for Nurse Leaders	119
7.9	The Journey to Sharable and Comparable Data in Nursing.	120
7.10	Gaining Insight from Data in Real Time	123
7.11	Strategies for Moving Forward	123
7.12	Instilling a Data-Driven Culture Through Team Science.	124
7.13	Putting It All Together: An Example	125
7.13.1	Step 1: Diagnostic Analytics	125
7.13.2	Step 2: Diagnostic Analytics	126

- 7.13.3 Step 3: Predictive Analytics 126
- 7.13.4 Step 4: Prescriptive Analytics 126
- 7.14 Conclusions 127
- References. 127
- Case Study 7.1: Improving Nursing Care Through the
Trinity Health System Data Warehouse 129
- Nora Triola, Miriam Halimi, and Melanie Dreher
 - 7.1.1 Introduction 129
 - 7.1.2 Trinity Health. 130
 - 7.1.3 Case Studies. 132
 - 7.1.4 Conclusion 136
 - Acknowledgements 136
 - References 137

8 Inclusion of Flowsheets from Electronic Health Records to Extend Data for Clinical and Translational Science Awards (CTSA) Research. 139

Bonnie L. Westra, Beverly Christie, Grace Gao, Steven G. Johnson, Lisiane Pruinelli, Anne LaFlamme, Jung In Park, Suzan G. Sherman, Piper A. Ranallo, Stuart Speedie, and Connie W. Delaney

- 8.1 Introduction 140
- 8.2 CTSA's to Support Big Data Science. 140
- 8.3 Clinical Data Repositories (CDRs) 142
 - 8.3.1 CDR Structure and Querying Data 143
 - 8.3.2 Standardizing Patient Data. 144
- 8.4 What Are Flowsheets? 145
 - 8.4.1 How Do Organizations Decide What to Record on Flowsheets? 146
 - 8.4.2 Strengths and Challenges of Flowsheet Data. 147
 - 8.4.3 Example of Pressure Ulcer. 148
- 8.5 Standardization Essential for Big Data Science. 150
 - 8.5.1 Nursing Information Models 151
 - 8.5.2 Example Nursing Information Models and Processes. 151
 - 8.5.3 National Collaborative to Standardize Nursing Data. 152
- 8.6 Conclusion 154
- References. 155

9 Working in the New Big Data World: Academic/Corporate Partnership Model 157

William Crown and Thomas R. Clancy

- 9.1 The Evolving Healthcare Data Landscape. 158
- 9.2 The Promise and Complexity of Working with Multiple Sources of Data 159
- 9.3 Implications of Linked Claims and EHR Data for Nursing Studies 160
- 9.4 Big Data Methods 162

- 9.5 Beyond Research—Accelerating Clinical/Policy Translation and Innovation 164
- 9.6 Innovation and Management of Intellectual Property in Academic/Corporate Partnerships 165
- 9.7 The Ongoing Debate About the Merits of RCTs Versus Observational Studies 168
- 9.8 Conclusions 169
- References. 170
- Case Study 9.1: Academic/Corporate Partnerships: Development of a Model to Predict Adverse Events in Patients Prescribed Statins Using the OptumLabs Data Warehouse 172
- Chih-Lin Chi and Jin Wang
 - 9.1.1 Introduction: Research Objective. 172
 - 9.1.2 Resources Needed for Big-Data Analysis in the OptumLabs Project 174
 - 9.1.3 Research Process 177
 - 9.1.4 Conclusion 179
 - References. 179

Part III Revolution of Knowledge Discovery, Dissemination, Translation Through Data Science

- 10 Data Science: Transformation of Research and Scholarship 183**
- Lynda R. Hardy and Philip E. Bourne
 - 10.1 Introduction to Nursing Research 184
 - 10.1.1 Big Data and Nursing 185
 - 10.1.2 Nursing and Data 187
 - 10.2 The New World of Data Science 188
 - 10.3 The Impact of Data Proliferation on Scholarship 189
 - 10.4 Initiatives Supporting Data Science and Research 191
 - 10.4.1 National Institutes of Health 192
 - 10.4.2 National Science Foundation 193
 - 10.4.3 U.S. Department of Energy 194
 - 10.4.4 U.S. Department of Defense 194
 - 10.5 Summary 195
 - References. 195
 - Case Study 10.1: Complexity of Common Disease and Big Data 197
 - Sandra Daack-Hirsch and Lisa Shah
 - 10.1.1 Type 2 Diabetes (T2D) as a Significant Health Problem. 197
 - 10.1.2 Factors Contributing to T2D 198
 - 10.1.3 Epigenetics. 200
 - 10.1.4 Current Initiatives to Leverage the Power of Big Data for Common Disease 203
 - 10.1.5 Scope and Practice of Genetics/Genomics Nursing. 205
 - 10.1.6 Conclusion 206
 - References. 206

11	Answering Research Questions with National Clinical Research Networks	211
	Katherine K. Kim, Satish M. Mahajan, Julie A. Miller, and Joe V. Selby	
11.1	The Vision	212
11.2	Electronic Data	212
11.3	Distributed Data Networks	213
11.3.1	The Mini-Sentinel Distributed Database	214
11.4	PCORnet, the National Patient-Centered Clinical Research Network	214
11.4.1	The Partner Networks	215
11.4.2	Governance	216
11.4.3	Data Handling	216
11.5	Current State	217
11.6	Future Plans	218
11.7	PCORnet in Practice: pSCANNER	218
11.7.1	Stakeholder Engagement	219
11.7.2	Research in pSCANNER	221
11.7.3	UC Davis Betty Irene Moore School of Nursing's Role in pSCANNER	223
11.8	Role of Nursing Science in and with PCORnet	223
11.8.1	Nursing Data	223
	References	225
12	Enhancing Data Access and Utilization: Federal Big Data Initiative and Relevance to Health Disparities Research	227
	Rosalyn Correa-de-Araujo	
12.1	The U.S. Department of Health and Human Services and the Health Data Initiative	229
12.1.1	Integrating Nursing Data into Big Data	235
12.2	Eliminating Health Disparities and Building Health Equity with Big Data	236
12.2.1	The Social Determinants of Health	236
12.2.2	Health Disparities and Health Equity	238
12.2.3	Using Big Data to Eliminate Disparities and Build Equity in Symptoms Management	240
	References	242
	Case Study 12.1: Clinical Practice Model (CPM) Framework Approach to Achieve Clinical Practice Interoperability and Big Data Comparative Analysis	244
	Michelle Troseth, Donna Mayo, Robert Nieves, and Stephanie Lambrecht	
12.1.1	Introduction	244
12.1.2	A Framework Approach	245
12.1.3	CPG Pressure Ulcer-Risk For- Example	249
12.1.4	The Challenges of Utilizing and Sharing Big Data	249
12.1.5	Conclusion	250
	References	251

13 Big Data Impact on Transformation of Healthcare Systems 253
 Gay L. Landstrom

- 13.1 Introduction 253
- 13.2 Limitations of the Past 254
- 13.3 How Healthcare Systems Come Together Electronically 255
- 13.4 Big Data Emerging from Healthcare Systems 256
- 13.5 The Hope of Improving Health and Care Within Healthcare Systems Using Data 257
 - 13.5.1 Rapid Dissemination of Evidence-Based Care 257
 - 13.5.2 Integrating Individual Patient Care Data Across the Continuum 259
 - 13.5.3 Integration to Manage Patient Populations 260
- 13.6 Challenges of Gleaning Information and Knowledge from the Data and Recommendations for Optimizing Data Within HCS . . . 261
- 13.7 Conclusion 262
- References 262

14 State of the Science in Big Data Analytics 265
 C.F. Aliferis

- 14.1 Advances in Predictive Modeling and Feature Selection for Big Data 265
 - 14.1.1 Kernel-Based Transformation of the Data 269
 - 14.1.2 Advances in Feature Selection 270
- 14.2 Advances in Causal Discovery with Big Data, Causal Feature Selection and Unified Predictive and Causal Analysis 272
- 14.3 Unified Predictive-Causal Modeling and Causal Feature Selection 273
 - 14.3.1 Synopsis of Other Important Big Data Mining Advances 275
- 14.4 Conclusions 281
 - 14.4.1 Achievements, Open Problems, Challenges in Big Data Mining Methods 281
- References 281

Part IV Looking at Today and the Near Future

15 Big Data Analytics Using the VA’s ‘VINCI’ Database to Look at Delirium 287
 Charlene Weir, Joanne LaFluer, Bryan Gibson, and Qing Zeng

- 15.1 Introduction 288
 - 15.1.1 The Problem with Delirium 288
 - 15.1.2 Big Data Can Help 289
 - 15.1.3 VHA Data Resources 290
 - 15.1.4 Case Study 1: Identifying Patients at Risk for Delirium . . 291
 - 15.1.5 Case Study 2: Improving Classification Using Natural Language Processing 292
 - 15.1.6 Case Study 3: Building a Stewardship Program 295

- 15.2 Overall Discussion 296
 - 15.2.1 Quality of Data 296
 - 15.2.2 Matching Data Analytics to the Question and Producing Actionable Information 297
 - 15.2.3 Integrating the Patient’s Story 297
 - 15.2.4 Overall Conclusion 298
- References 298
- 16 Leveraging the Power of Interprofessional EHR Data to Prevent Delirium: The Kaiser Permanente Story 301**
 - Rayne Soriano, Marilyn Chow, and Ann O’Brien
 - 16.1 Introducing the Delirium Picture 301
 - 16.2 Introduction 302
 - 16.3 The Impact of Delirium 303
 - 16.4 Discovering the Delirium Story Through Multiple Sources of Information 304
 - 16.5 Accessing Data in the EHR 305
 - 16.6 The KP Discovery Journey 306
 - 16.7 Transforming Care with Actionable Information 307
 - 16.8 An Interdisciplinary Approach to Delirium Prevention 307
 - 16.9 Measuring Success of the Interdisciplinary Delirium Risk Score . . 309
 - 16.10 Summary 310
 - References 310
- 17 Mobilizing the Nursing Workforce with Data and Analytics at the Point of Care 313**
 - Judy Murphy and Amberly Barry
 - 17.1 Introduction 313
 - 17.2 Background 314
 - 17.3 Mobile Infrastructure 316
 - 17.3.1 Mobile Device and App History 316
 - 17.3.2 History of Mobile in Healthcare 316
 - 17.4 Mobile Impact on Nurses’ Roles and Processes 317
 - 17.5 Apps for Nurses: Education 318
 - 17.6 Apps for Nurses: Practice 319
 - 17.6.1 Primary Care 319
 - 17.6.2 Acute Care 321
 - 17.6.3 Home Care 322
 - 17.6.4 Care Coordination 323
 - 17.7 Apps for Patients 324
 - 17.7.1 Patient Portals 325
 - 17.8 The Value of Mobile with the Power of Analytics 326
 - 17.8.1 Extend Healthcare Services 326
 - 17.8.2 Patient Engagement 327
 - 17.8.3 Decision Support 327
 - 17.8.4 Insight through Analytics 327
 - 17.9 Summary 328
 - References 328

18 The Power of Disparate Data Sources for Answering Thorny Questions in Healthcare: Four Case Studies 331

Ellen M. Harper and Douglas McNair

18.1 Introduction 332

18.2 Nursing Informatics as a Valuable Resource and Analytics Team Member 334

18.3 The Knowledge Framework and NL 335

18.4 Conclusion 341

References 342

Case Study 18.1: Alarm Management: From Confusion to Information. 345

Kevin Smith and Vicki Snavelly

18.1.1 Introduction 345

18.1.2 Testing New Technology 345

18.1.3 Data-Driven Monitor Management 346

18.1.4 Results 348

18.1.5 Conclusion 351

References 351

Case Study 18.2: Nursing Time in the Electronic Health Record: Perceptions Versus Reality. 352

April Giard and Darinda Sutton

18.2.1 Introduction 352

18.2.2 Methods 353

18.2.3 Results 354

18.2.4 Conclusion 357

References 357

Case Study 18.3: Identifying Direct Nursing Cost Per Patient Episode in Acute Care—Merging Data from Multiple Sources 359

Peggy Jenkins

18.3.1 Introduction and Background 359

18.3.2 Definition of Direct Nursing Cost per Acute Care Episode 359

18.3.3 Data Sources and Data Management Plan. 360

18.3.4 Architecture for File Merger 360

18.3.5 Construction of Outcome Variable. 360

18.3.6 Data Analysis 362

18.3.7 Key Findings 362

18.3.8 Discussion 363

References 363

Case Study 18.4: Building a Learning Health System—Readmission Prevention. 364

Marlene A. Bober and Ellen M. Harper

18.4.1 Introduction 364

18.4.2 Methods 365

18.4.3 Results 366

18.4.4 Discussion 366
 18.4.5 Conclusion 368
 References 369

Part V A Call for Readiness

19 What Big Data and Data Science Mean for Schools of Nursing and Academia 373

Linda A. McCauley and Connie W. Delaney

19.1 Why is Big Data Important for Academic Nursing? 374
 19.2 Undergraduate Education 375
 19.3 Master’s Education 376
 19.4 Nursing Informatics Graduate Specialty 377
 19.5 Doctorate in Nursing Practice (DNP) 378
 19.6 PhD Education 378
 19.7 Challenges Ahead 379
 19.8 Curriculum Opportunities 381
 19.9 Conclusion 383
 References 383

Case Study 19.1: Informatics Certification and What’s New with Big Data 385

Cynthia Gadd and Connie White Delaney

19.1.1 Introduction 385
 19.1.2 AMIA’s Path Toward Establishing Advanced Health Informatics Certification 386
 19.1.3 Advanced Health Informatics Certification (AHIC) 388
 Acknowledgements 389
 References 390

Case Study 19.2: Accreditation of Graduate Health Informatics Programs 391

Judith J. Warren

19.2.1 Introduction 391
 19.2.2 Accreditation Standards 394
 19.2.3 Recommendations for Future Accreditation Requirements 396
 19.2.4 Conclusion 397
 References 397

20 Quality Outcomes and Credentialing: Implication for Informatics and Big Data Science 399

Bobbie Berkowitz

20.1 Introduction 399
 20.2 High-Quality Performance 400
 20.3 Credentialing and Patient Outcomes 402
 20.4 Conclusion 405
 References 405

21 Big Data Science and Doctoral Education in Nursing 407
 Patricia Eckardt and Susan J. Henly

21.1 Introduction 407

21.2 About Big Data and Nursing 408

21.2.1 Ubiquity of Big Data 408

21.2.2 Definitions 409

21.2.3 Nursing Interface with Big Data 409

21.3 Doctoral Education 410

21.3.1 Context 410

21.3.2 Framework 411

21.3.3 Big Data Knowledge, Skills, and Competencies 411

21.4 Summary 423

References 423

22 Global Society & Big Data: Here’s the Future We Can Get Ready For 427
 Walter Sermeus

22.1 Introduction: Are We Moving to a Global Society, Except for Healthcare?. 427

22.1.1 Phase 1: Thinking Local, Acting Local—Healthcare in the Past and Today 428

22.1.2 Phase 2: Thinking Local, Acting Global—Cross-Border Care and Medical Tourism. 430

22.1.3 Phase 3: Thinking Global, Acting Local—Global Healthcare Driven by Networks. 431

22.1.4 Phase 4: Thinking Global, Acting Global—Discovering the Long Tail in Healthcare 434

22.2 From Local to Global: What Would It Take?. 438

References 439

23 Big-Data Enabled Nursing: Future Possibilities 441
 Judith J. Warren, Thomas R. Clancy, Connie W. Delaney, and Charlotte A. Weaver

23.1 Introduction 442

23.2 The Future of Big Data in Education: Implications for Faculty and Students 442

23.2.1 Demand for Data Scientists 443

23.2.2 Precision Education for Students 444

23.2.3 Faculty Role Changes 446

23.3 Conclusion 447

23.4 The Future of Partnerships in Generating Big Data Initiatives, Products, and Services 447

23.5 Big Data Through the Research Lens 450

23.5.1 Forces Affecting Big Data and Related Discoveries in Nursing and Health Care 450

23.5.2 Anticipating the Future with Big Data. 453

- 23.5.3 Nursing’s Call to Action for Big Data and Data Science 454
- 23.6 Healthcare in 2020: Looking at Big Data Through the Clinical Executive’s Lens 454
 - 23.6.1 Healthcare’s Journey into Big Data 456
 - 23.6.2 Looking at Care Delivery in 2020 457
 - 23.6.3 Population Health Managed Care—An Example from Bon Secours Medical Group (BSMG). 458
 - 23.6.4 Looking at Near-Term Future Examples 458
 - 23.6.5 Looking Forward 459
 - 23.6.6 Personalization of Care 460
- 23.7 Final Thoughts About the Future with Big Data 461
- References 461

- Glossary 465**

- Index 473**

List of Contributors

C.F. Aliferis, MD, PhD, FACMI Institute for Health Informatics, University of Minnesota, Minneapolis, MN, USA

Amberly Barry, RN, PHN Analytics & Transformation, IBM Global Healthcare, Armonk, NY, USA

Murielle S. Beene, DNP, MBA, MPH, MS, RN-BC, PMP Department of Veterans Affairs, Veterans Health Administration, Washington, DC, USA

Bobbie Berkowitz, PhD, RN, NEA-BC, FAAN Columbia University School of Nursing and Columbia University Medical Center, New York, NY, USA

Marlene A. Bober, RN, MS Acute Enterprise Care Management, Advocate Health Care, Chicago, IL, USA

Philip E. Bourne, PhD Data Science Institute, University of Virginia, Charlottesville, VA, USA

Barbara Brandt, PhD National Center for Interprofessional Practice and Education, University of Minnesota, Minneapolis, MN, USA

Frank Cerra, MD National Center for Interprofessional Practice and Education, University of Minnesota, Minneapolis, MN, USA

Chih-Lin Chi, PhD, MBA OptumLabs™, Cambridge, MA, USA
School of Nursing, University of Minnesota, Minneapolis, MN, USA
Institute for Health Informatics, University of Minnesota, Minneapolis, MN, USA

Marilyn Chow, RN, PhD Kaiser Permanente, Oakland, CA, USA

Beverly Christie, DNP, RN Fairview Health Services, Minneapolis, MN, USA

Thomas R. Clancy, PhD, MBA, RN, FAAN School of Nursing, University of Minnesota, Minneapolis, MN, USA

Rosalyn Correa-de-Araujo, MD, MSc, PhD U.S. Department of Health and Human Services, Division of Geriatrics and Clinical Gerontology, National Institute on Aging, National Institutes of Health, Bethesda, MD, USA

William Crown, MD OptumLabs, Minneapolis, MN, USA

Sandra Daack-Hirsch, PhD, RN The University of Iowa, Iowa City, IA, USA

Connie W. Delaney, PhD, RN, FAAN, FACMI School of Nursing, University of Minnesota, Minneapolis, MN, USA

Melanie Dreher, PhD, RN, FAAN Trinity Health System, Livonia, MI, USA

Patricia Eckardt, PhD, RN Heilbrunn Family Center for Research Nursing, Rockefeller University, New York, NY, USA

Jane Englebright, PhD, RN, CENP, FAAN Hospital Corporation of America, Nashville, TN, USA

Cynthia Gadd, PhD, MBA, MS, FACMI Department of Biomedical Informatics, Vanderbilt University, Nashville, TN, USA

Grace Gao, DNP, RN-BC School of Nursing, University of Minnesota, Minneapolis, MN, USA

April Giard, MSN, NP-BC, NEA-BC Eastern Maine Health System, Brewer, ME, USA

Bryan Gibson, DPT, PhD Department of Biomedical Informatics, School of Medicine, University of Utah, Salt Lake City, UT, USA

Miriam Halimi Trinity Health System, Livonia, MI, USA

Lynda Hardy, PhD, RN, FAAN College of Nursing, The Ohio State University, Columbus, OH, USA

Ellen Harper, DNP, RN-BC, MBA, FAAN School of Nursing, University of Minnesota, Minneapolis, MN, USA

Susan Henly, PhD, RN, FAAN School of Nursing, University of Minnesota, Minneapolis, MN, USA

Edmund Jackson, PhD Hospital Corporation of America, Nashville, TN, USA

Amy Jarabek, MSA, MEd National Center for Interprofessional Practice and Education, University of Minnesota, Minneapolis, MN, USA

Peggy Jenkins, PhD, RN College of Nursing, University of Colorado, Denver, CO, USA

Steven G. Johnson, PhD-C, PhD Institute for Health Informatics, University of Minnesota, Minneapolis, MN, USA