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Population Health Management for Poly Chronic Conditions

Evidence-Based Research Approaches

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DEDICATION TO MY FAMILY
Sylvia J. C. Wan
George J. Wan
William K. Wan

Preface

The growth of an aging population, particularly those aged 80 and older, is pervasive across the globe, throughout advanced countries as well as less-developed countries. The extension of life expectancy is often associated with changes in people's lifestyles and health habits (P), health organization and medical care innovations (O), improved environmental conditions (E), and health technology applications (T). In their seminal work, *Vitality and Aging*, Fries and Crapo (1981) advocate that the phenomenon of compression of morbidity and mortality is occurring at the population level and the survival curve is approaching a rectangular shape.

The presence of chronic conditions often arrives with advanced age. Poly chronic conditions (PCC), also referred to as multimorbidities or multi-chronic conditions (MCC), occur when a person has more than one chronic disease (e.g., comorbid conditions such as hypertension, type 2 diabetes, and coronary heart disease). Population health management (PHM) is defined as a framework that guides treatment and management of patients through the identification of specific groups based on similar characteristics, such as disease, socioeconomic status, and region. Integration and coordination of care are important aspects that must be addressed in order to reach targeted populations, provide them with quality care, and reduce costs. Identifying the care and treatment patterns associated with higher risks and costs, and developing strategies and interventions to improve health outcomes for these patients, requires the involvement of patients, caregivers, providers, community entities, and other stakeholders. The adequacy of PHM is contingent on the integration of multiple tasks, such as wellness and lifestyle management, coordinated care or disease management, demand or utilization management, chronic care management, quality management, and health information and data management.

Little is known about how the patterns and trends of chronic conditions are influenced by contextual and personal factors that may directly and indirectly affect the trajectory changes of morbidity and mortality. Wan et al. (2016) conducted a large-scale, population-based study on contextual, organizational, and ecological determinants of health disparities and outcomes of chronic obstructive pulmonary disease (COPD) and asthma hospitalization. But, only a limited amount of the total variance in the risk-adjusted hospitalization rate is attributable to these three predictor variables (determinants). In a systematic review on the literature of diabetes care education and research, Wan et al. (2017) document several personal factors, such as lack of adherence to medical regimens, inadequate medical knowledge about diabetes control, and poor attitudes and motivations for preventive behavioral changes and preventive practices, which may have contributed to the variations in patient-care outcomes and hospitalization associated with type 2 diabetes. Furthermore, there is a knowledge gap in understanding the epidemiological triad of time, person, and place associated with the presence of poly chronic conditions (Wan et al. 2016a, 2016b).

Evidence-based care management and practice is needed in order to enhance the design, implementation, and evaluation of effective and efficient care-delivery systems from a global research perspective. Due to the complexity of their healthcare needs, patients with poly chronic conditions utilize more health services and are the costliest to treat. The Agency for Healthcare Research and Quality reported that in 2010, patients with poly chronic conditions accounted for 71%, or 71 cents of every dollar, of healthcare spending. Only 8.7% of individuals had five or more chronic conditions, yet accounted for more than one-third (35%) of healthcare spending (Gerteis et al. 2014). Medicare spending is largely consumed by patients with poly chronic conditions as well. Beneficiaries with two or more chronic conditions accounted for 93% of Medicare spending in 2010, with 14% of patients who had six or more chronic conditions accounting for 46% of total Medicare spending (Centers for Medicare and Medicaid Services 2012).

Patients with multiple chronic conditions accounted for more than 70% of all inpatient hospital stays in 2010, with more than half of these stays (38.5%) for patients with more than five chronic conditions (Gerteis et al. 2014). Using claims data provided by the 2012 Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project, State Inpatient Databases, analysis of patients with multiple chronic conditions hospitalized for potentially preventable acute and chronic conditions showed that more than 90% of patients hospitalized for ambulatory care sensitive chronic conditions had two or more chronic conditions and more than 20% had six or more chronic conditions. Approximately 80% of patients hospitalized for potentially preventable acute conditions had multiple chronic conditions, and more than 10% had six or more chronic conditions (Skinner et al. 2016).

The number of hospitalizations per year and the rates of hospital readmission have been shown to increase as the number of chronic conditions increases among Medicare beneficiaries. In 2010, 4, 13, and 30% of Medicare patients with zero or one chronic condition, two to three chronic conditions, and four to five chronic conditions, respectively, were hospitalized. Among patients with six or more chronic conditions, 63% were hospitalized, with 16% of these patients having more than three hospitalizations (Centers for Medicare and Medicaid Services 2012). In 2011, the rate of readmission within 30 days for Medicare patients with zero or one chronic condition was 8.9%. This number rose to 10.3% for patients with two to three chronic conditions, 13.5% for patients with four to five conditions, and 25% for patients with six or more chronic conditions (Lochner et al. 2013).

As a result of the enactment of the Patient Protection and Affordable Care Act (ACA) in the United States, many aspects of healthcare have improved regarding access, quality, and value. However, many barriers to treatment for poly chronic conditions remain, including a gap in coordinated care and service delivery. Our research suggests that population health management programs should be incorporated into most healthcare sites, due to their effectiveness in containing costs, delivering high-quality care, and improving health outcomes. Future work can focus on the methods of integrating the population health management framework into the care of patients with chronic conditions. Thus, the value-based transformation of the delivery system can be achieved.

The primary objective of this book is to identify the knowledge gap in the design, implementation, and evaluation of care-management research for targeted population groups afflicted by poly chronic conditions. The field of chronic disease epidemiology could benefit from applying innovative multi-tiered interventions to promote primary, secondary, and tertiary prevention of chronic diseases. Furthermore, it is believed that the inter-sectorial collaboration among population health professionals, behavioral and social scientists, management experts, clinicians, and policy decisionmakers can work together and integrate multiple scientific domains into transdisciplinary strategies to optimize population health. This book hopes to help enlighten scientists and practitioners to share a common vision in reducing health expenditures and healthcare disparities through evidence-based practices and research. Ultimately, we will share practical, efficient, and sustainable solutions to target the right (high-risk) population groups amenable to a better coordinated and managed chronic care system.

More specifically, through our research and educational exchanges among multisectorial investigators, it may enable us to achieve the following aims:

1. Identify relatively homogenous population groups that can benefit from multilevel preventive and therapeutic interventions for chronic care.
2. Learn and share strategies that can reduce the gap in chronic care.
3. Conduct collaborative and longitudinal studies on population health management.
4. Redesign and transform chronic care to improve the performance, such as effectiveness and efficiency, of the delivery system.
5. Disseminate evidence-based research results and promote the design, use, and evaluation of clinical and administrative decision support systems or related health information technologies.

This book with three parts contains 10 chapters. Part 1 illustrates how population health management has evolved from health demography to population health management and explains how varying strategies are employed to improve population health management. Part 2 identifies evidence showing how human factors may modify the risk for hospital readmissions. Part 3 presents the design, implementation, and evaluation research relevant to person-centric care strategies via the use of health information technology.

Part 1 has four chapters. The first chapter identifies the evolution of research foci in population health from health demography to care management of targeted population groups. The second chapter illustrates health trends in population health management, mechanisms for cost containment, and mechanisms for integrating multiple domains of the population health approach, as each relates to poly chronic conditions. There are several mechanisms for cost containment, though we focused on pay-for-performance (P4P), diagnosis-related group (DRG), hospital readmission penalty program (HRPP), and the value-based payments for quality and performance. The third chapter documents the patterns and trends of chronic disease epidemiology and highlights a series of gaps in delivering cost-effective patient care for poly chronic conditions. The fourth chapter furthers the understanding of patient-centric care management with poly chronic conditions effectively, utilizing and optimizing a population health management framework.

Part 2 includes three chapters. Chapter 5 discusses preventive aspects of chronic conditions. Chapter 6 offers a systematic review and meta-analysis on heart failure hospitalization and readmission. Chapter 7 presents an empirical study on the contextual, organizational, and ecological factors influencing the variations in heart failure hospitalization of rural Medicare beneficiaries in eight southeastern states of the United States, using a longitudinal study design.

Part 3 advocates the need for employing person-centric care-management strategies to optimize better outcomes and efficiency of chronic care coupled with health information technology. Chapter 8 synthesizes the literature in care-management innovation and adoption, particularly related to heart failure, type 2 diabetes, and renal failure. Chapter 9 features the design and process of an integrated healthcare system via a federated information network design for elders (FINDER) or health FINDER. Chapter 10 demonstrates the use of theoretically grounded predictive analytics, developed by a systematic review and meta-analytic approach to heart failure hospitalization as an example, in formulating a cloud-based decision support system for patients to avoid or minimize the risk of heart failure readmissions.

Finally, the book ends with concluding remarks for promoting population health management practice and research. The prospects for implementing and evaluating a global health oriented to population health management are presented.

Orlando, FL, USA Thomas T.H. Wan

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About the Author

Thomas T.H. Wan is a professor of public affairs, health management and informatics, and medical education at the University of Central Florida. He is an associate dean for research for the College of Health and Public Affairs. He has taught at the University of Maryland, Cornell University, and Virginia Commonwealth University. He received his MA in sociology/criminology and PhD in sociology/demography from the University of Georgia. He completed his postdoctoral fellowship and earned his MHS degree from the Johns Hopkins University School of Public Health. He is conducting a national study on rural health clinics in accountable care organizations (ACOs) funded by the NIH. This project enables him to investigate the effects of changing delivery systems or healthcare reforms on efficiency and effectiveness of patient-centric care in the United States. He is an editor of special issues of the *International Journal of Public Policy* and is an active board member of ten scientific journals. He has published more than 200 articles and book chapters and 13 books. He has served on a variety of NIH study sections for 20 years (Aging and Human Development, Nursing, and Health Services Organization and Delivery). In addition, he has served on the scientific review panel of the National Health Research Institutes in Taiwan for more than a decade. His engagement in health services management research and consultation has helped the development of formal MHA graduate programs in Kazakhstan, Czech Republic, and Taiwan.

Part I

Exploring Trends and Strategies in PHM

Chapter 1

Evolving Public Health from Population Health to Population Health Management

Abstract Population health management (PHM) focuses on individuals at risk for chronic conditions who also have the highest health-care costs. This chapter covers the (1) definitions of population health and population health management; (2) challenges in coordinated care; (3) strategic imperatives for development, implementation, and evaluation of PHM; (4) use of electronic health records and other data; and (5) prospects for PHM practice and research.

Keywords Coordinated care • Electronic health records • Evaluation • Implementation • Population health • Population health management

Public health efforts include curbing the detrimental impacts of infectious diseases and focusing on epidemiological findings to navigate their efforts. However, as chronic disease rates have steadily increased and become a health and financial burden to the United States, population-public health strategies need to evolve to address chronic conditions. Population health management (PHM) is that evolution, and it addresses the high costs of chronic conditions by focusing on value over volume and quality instead of episodes of care (AHP 2015). Whereas public health focuses on those at risk for contracting infectious disease, PHM focuses on individuals at risk for chronic conditions who also have the highest health-care costs (AHP 2015).

1.1 Defining Population Health

The current focus in health care is to address rising costs, inadequate health outcomes, and challenges in accessing services. This is represented by the Institute for Healthcare Improvement (IHI) Triple Aim initiative, which includes "improving the patient experience of care (including quality and satisfaction), improving the health of populations, and reducing the per capita cost of health care" (IHI 2017).

In addressing these challenges, various health-care stakeholders including providers, researchers, policymakers, and public health professionals have used the term population health (Stoto 2013). The term was utilized for the first time in the United States in a groundbreaking article written by Kindig and Stoddart (2003). Population health describes strategies that reward health outcomes over volume of

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services (Harris et al. 2016). Population health sets out to serve communities with tailored care that is evidence based and patient centric. Patient-centric care focuses on the unique needs and challenges of the individual patient instead of prescribing the same treatment options for everyone regardless of differing psychosocial factors that may impact effectiveness.

Population health identifies characteristics of defined populations to create specific plans for health management (McAlearney 2003). An example of population health would be targeting specific conditions that afflict a unique group of persons such as the higher prevalence of type 2 diabetes in a Native American community, since the rates are higher for that population than other demographic groups (McAlearney 2003). Population health looks at the social, environmental, and community factors that impact an individual's health and takes these into consideration when prescribing care (Harris et al. 2016). When characteristics of a target population are considered in tailoring health management, there is greater likelihood of success and improved health outcomes, and this is known as PHM (McAlearney 2003).

1.2 Defining Population Health Management

PHM covers many strategies with the intention of improving outcomes and reducing costs (McAlearney 2003). In the current climate, health-care providers face penalties if specific populations fail to meet outlined goals (e.g., heart failure patients and readmission rates). According to the World Health Organization (WHO), good health is not simply the absence of disease; it is well-being in multiple aspects including physical, mental, and social (WHO 1948). Building on the belief that all individuals have a right to health, the best way to provide that health has constantly been under scrutiny.

Recently, with the enactment of health reform, historical and monumental strides have been made in the delivery of health care. PHM is one model that is proving effective. Formerly known as disease management, PHM is a method of care delivery that looks at groups of patients with similar risks, identifies targeted treatment plans for the specific needs of the unique groups, and prescribes evidence-based care (Ernst and Young 2014). It is designed to keep groups of healthy individuals well and to manage care for groups of individuals with chronic conditions using targeted, effective, and evidence-based care to reduce costs and improve the efficacy of health care (Ernst and Young 2014). According to Ernst and Young (2014), PHM focuses on three areas: (1) targeting patients with chronic conditions, (2) reducing or preventing disease progression, and (3) creating a culture of wellness through health promotion. Darves (2015) identifies the following three items as the goals of PHM: (1) enhancing health through disease prevention and management, (2) improving care quality, and (3) reducing waste and variation to eliminate disparities from ethical and economic causes. PHM is a type of capitation that has included physician input into how to bundle services the most effectively for specific individuals, as opposed to being mandated by payers or other nondirect care providers, and replaces the ineffective fee-for-service design for treatment and capitation schemes of the 1990s (Darves 2015).

The Patient Protection and Affordable Care Act (PPACA) stipulates that nonprofit hospitals do community health needs assessments (CHNA), which could be an opportunity for organizations to identify the needs of population health (Pennel et al. 2016). However, results from this mixed-mode study that examined the effectiveness of this assessment showed they are not being utilized in an optimum way. The study examined the results of the 3-year assessment and was able to identify many recommendations for hospitals to be able to use this valuable information to provide tailored care to specific populations. Beyond the community assessment, health-care reform supports PHM in many ways. Access is one of the IHI Triple Aims, and the PPACA focuses on improving access to health care by expanding Medicaid coverage, creating state health insurance exchanges, supporting community health centers, and mandating that individuals secure health insurance (Stoto 2013). Quality is another IHI Triple Aim, and through mandates in the PPACA, quality has been addressed through the creation of the Patient-Centered Outcomes Research Institute, CMS Center for Medicare and Medicaid Innovation, and a National Strategy for Quality Improvement (Stoto 2013). Additionally, Affordable Care Organizations (ACOs) were promoted through health reform with the focus of incentivizing providers through improvement in population health outcomes (Stoto 2013).

PHM takes a long-term approach to care, replacing the current model of episodic and reactive practices based on acute-care episodes (Cunningham 2015). Treatment plans are well thought out and consider individualized needs to tailor care, utilizing a patient-centric model. PHM represents modalities for outlined treatment plans targeted for specific groups of patients based on similar characteristics including disease state, age, socioeconomic status, and region. The ultimate goal of PHM is to find effective and high-quality care while maintaining costs (McAlearney 2003). PHM strategies include many approaches such as demand management programs, disease management strategies, and disability management programs (McAlearney 2003), coupled with the patient engagement in wellness and preventive programs.

1.3 Mechanisms for Coordinated Care

The ability to maintain health is outside of the health-care setting and is within the confines of the individual’s life, based on birth circumstance and the environment in which they live their life. There is a lack of effective coordinated care among hospital, home, primary care, and other settings, which currently have long-standing silos of care delivery. The fragmented care delivery system is one main reason that there is a need for effective PHM strategies. PHM requires overhauling the care delivery system and restructuring with solid networking covering the full continuum of care, from acute to ambulatory to patient discharge to home health care. This shifts away from the silos of each health-care sector that previously focused solely on their own organization without consideration of how they fit into the overall puzzle (Darves 2015; McAlearney 2003; Sherry et al. 2016).

Having employee buy-in is the only way to ensure an effective transition to a new way of conducting business. However, PHM does not seem to have much difficulty being sold to practitioners. When the methodology is explained, most physicians agree that this is the way they had hoped to be practicing medicine from the beginning and is more true to what they believe to be effective for their patients. The approach needs to focus on improvement of clinical care with an advantage of having reduced costs, instead of approaching employees first with the cost savings, which turns away providers (Darves 2015).

PHM requires primary care offices, hospitals, and hospices to see beyond their own centric motivation and work together to ultimately improve the outcomes the organizations are after—improved health at lower costs with sustained results. This continuum can only be effectively navigated if all entities are able to share their data within accessible and accurate data warehouses that are currently siloed and disjointed. This leads us to the discussion of the role of electronic health records in executing PHM (Darves 2015), which will be further discussed in the next section.

1.4 The Current Health-Care Environment

PHM is needed now more than ever due to the current challenges facing the health-care system that was not present in previous decades. These unique challenges include a historically high Medicare enrollment due to the aging population, a Big Data and health-care IT revolution, epidemic proportions of preventable chronic disease (e.g., type 2 diabetes, obesity), regulatory changes from the Affordable Care Act (Block 2014), and impending health insurance and policy reforms.

1.5 Challenges in Implementation

There are always many challenges when shifting to a new model of business in health care or any industry. PHM is no exception. Changing the reimbursement and financial incentives for providers is a major challenge. Currently, the system rewards providers who are able to see more patients as opposed to rewarding providers who identify and treat high-risk and high-need individuals. When presenting the idea, it is important to emphasize that clinical care improvements, instead of cost savings, are the driving force for implementing the new models. This method has been shown to be more effective in ensuring provider buy-in. Additionally, employees must be engaged from the onset of implementation, not just at the end when the work starts taking effect. Active engagement from the beginning will ensure a smoother transition and the team approach that is required to successfully administer PHM. Including the whole staff from the beginning of the transition (even during early discussions before any changes take effect) will allow individuals to voice any concerns from the start and help shape the rollout instead of leaving them feeling disgruntled, leading to high rates of job turnover (Darves 2015).

Another challenge to PHM is that effecting positive change in a geographic population requires more than just medical care. Education, housing, and socioeconomic status have been proven to have a greater impact on a population's health than medical care; however, the medical community is restricted in their abilities to address these concerns. This is where public health efforts must be implemented to help individuals secure a greater understanding of how to take care of themselves (Casalino et al. 2015).

1.6 Strategic Imperatives for Development, Implementation, and Evaluation of Population Health Management Programs for Chronic Conditions

Strategic imperatives for the development, implementation, and evaluation of PHM programs for chronic conditions are aimed at keeping the afflicted individuals away from unnecessary hospitalizations by helping them stay as well as possible. This can be accomplished by focusing on the person, program, and place of treatment (Muenchberger and Kendall 2010). For the person, care must be patient centered to focus on symptom management and social supports. Programs must focus on empowering the patients to be knowledgeable and confident to manage their own care, including monitoring and managing symptoms by learning skills such as implementing action plans. Programs must be designed to coordinate care among all providers to facilitate effective communication and prevent contradictory advice and protocols (Muenchberger and Kendall 2010).

The place where a person resides impacts their well-being, including the effects of their environment (e.g., air quality and sun exposure), geographic access to health-care services (e.g., remoteness or difficult terrain in rural areas), and regional disadvantages due to socioeconomic constraints in providing adequate services or health insurance to community members (Muenchberger and Kendall 2010).

The development of population health programs includes identifying and monitoring populations, assessing the population's health, and stratifying the risks impacting that population (CCA 2012). The implementation of these programs will be based on health promotion and wellness efforts, health risk management techniques, care coordination and advocacy practices, and chronic condition case management (CCA 2012). Tailored and patient-centered interventions must address the specific needs of chronic conditions utilizing best and evidence-based practices to optimize treatment outcomes. Patient engagement will be a key indicator for success, and these efforts must be developed to ensure active participation in programs. Engagement strategies include utilizing predictive modeling for receptivity and willingness, online portals and virtual tools, social networks, employer-based on-site programs, health-risk assessments, incentive programs, gaming motivation, monitoring devices, and provider-based programs (CCA 2012).

To evaluate the effectiveness of population health efforts, health-care organizations must track and analyze the population by first identifying a time frame and then looking at many facets including psychosocial outcomes, behavior change, clinical and health status, patient and provider satisfaction, and financial outcomes (CCA 2012). The evaluations must assess a patient's ability to self-manage as well as identify if the programs are effective at screening populations for chronic conditions. Additionally, looking at quality of life (QOL) measures as well as the productivity of an individual will also serve as an indicator of whether the program is working as designed. Data sources for evaluation include patient-reported data, claims data (payers), clinical data (EHRs, lab results), billing systems data, and health management programs data (CCA 2012).

1.7 Electronic Health Records

The use and potential functionality of electronic health records (EHR) has increased in recent years with the ability to conduct epidemiological studies, including cross-sectional and longitudinal, beyond the clinical recordkeeping capabilities (Casey et al. 2016). This potential is valuable to clinical staff and researchers in identifying specific problems that plague a geographic region, a specific hospital, or a population. Medical experts have noted that every patient has a history that provides vital information on the current episode as well as future treatment options. If a medication that is regularly prescribed for a condition has already proved ineffective or, worse, caused an adverse reaction in the patient, reading that history will save time and, potentially, lives. However, the current state of EHR does not generally permit this type of access and providers must rely on patient memory, which unfortunately may be inadequate at recalling all previous events. This leads to ineffective care and soaring wasteful medical expenses (Darves 2015). Additionally, by aggregating patient information and data mining, trends can be identified to inform medical decision-making and identify potential risks that would otherwise been missed.

1.7.1 HIT and Coordination

Health information technology (HIT) applications are a vital resource that may inform the development of interventions for different populations. Many questions arise including protecting patient privacy and identifying health disparities based on data collection and analysis (Wan 2014). The first step to maximizing HIT is interoperable EHR systems. Currently, EHR systems are not interoperable between different agencies, and in some instances, even within a single organization, there may be operational barriers leading to fragmentation (Greene et al. 2012). Therefore, improving coordination is essential. Coordination of EHR means that each system can communicate effectively with other systems, and there is a shared interoperability between different health-care entities (e.g., hospitals, doctors' offices, county health departments, home health agencies, and pharmacies). When coordination is optimized, this leads to meaningful use of the information collected.

1.7.2 Meaningful Use

Once coordination is achieved, the next step is to ensure that the health information gathered in EHRs achieves meaningful use. The definition of meaningful use of EHR is when records are used to go beyond simply assisting in providing care and instead improve the quality of care (Ryan et al. 2014). Meaningful use may be identified as data mining for specific problems or questions that researchers select. For example, there may be a treatment protocol that is consistently recommended to treat a condition. If the patient has regular office visits, this is an opportunity to track the effectiveness of the intervention (or the lack thereof). Furthermore, EHR-based studies tend to have a much lower cost and be less time consuming compared to other epidemiological studies (Casey et al. 2016).

1.7.3 Problems with HER

Currently, EHR systems are not required to be able to communicate with one another. This was not a requirement in health reform and needs to be corrected immediately. The usability of EHRs is diminished if patients are unable to easily access their health records when seeing different providers or are at different levels of care (i.e., outpatient vs inpatient settings).

This presents a challenge to implementing effective coordinated care. For instance, someone with a chronic condition may see multiple specialists for specific aspects of their disease management. If the providers are unable to access the records with ease, waste or errors may occur. Waste may include duplication of tests. An error might be prescribing a medication that causes an adverse reaction in a patient, which would be documented in their EHR. The patient might consent to trying a drug because they do not know all the names of the specific drug (e.g., generic vs name brand), not realizing that they are putting themselves in danger.

Another challenge is the cost of implementation of EHR. Specifically, for smaller health-care organizations, the cost to overhaul and maintain a sophisticated IT system may be burdensome or cost prohibitive (Ryan et al. 2014).

In a study conducted with 400 health-care organizations, participants reported the greatest challenges to meaningful use of EHRs were reviewing information sent from specialists, communicating referrals, meeting reporting requirements of their state and centers for Medicare and Medicaid services, and using the EHR portal to communicate with patients (e.g., reminders) (Ryan et al. 2014). The study reported that after 2 years of EHR use, providers reported an improvement in ease of use, indicating that practice and familiarity with the system are possible over time. Concerns after 2 years included not being able to rely on vendors for adequate technical support and the fear of technical glitches or unreliable information.

A recommendation for future EHR use is to ensure the collection of the patient's social and behavioral factors to increase the ability to conduct meaningful analysis on population health (Casey et al. 2016).

1.8 Data-Driven Orientation

1.8.1 Utilizing Big Data to Inform Population Health Management

There is currently a large gap in utilizing Big Data. There are many sources collecting clinical data, and data mining may be utilized to identify patterns that result from different courses of treatment and may be able to predict a patient's response to a regimen. With the use of EHR, health-care providers are collecting data measures with every contact they have with patients. In aggregating the data, one use would be able to identify risk factors for specific diseases, allowing for early intervention (Chawla and Davis 2013).

Many health-care IT companies are looking for strategic ways to build platforms that integrate the siloed databases and merge them into a central repository with the ability of mining for phenotypic, genomic, and imaging-focused data. This gives researchers the ability to query specific questions from a central metadata repository that pulls information from multiple platforms (Murphy et al. 2016).

1.8.2 County Health Records

One useful source for collecting aggregate health data is county health records. There are currently reporting requirements for many diseases that must be submitted to county public health offices. Since these data are already being collected, it would be advantageous to formulate a system where county health records can also be connected to EHR systems and analyzed together.

A collaborative project between the University of Wisconsin and the Robert Wood Johnson Foundation has gathered a variety of health data and generated county health rankings. A population health framework has also been established to identify important determinants of health (see Fig. 1.1). In order to improve population or county health, it is imperative to set priorities that can reshape health trajectories and maximize the efficiency of health-care investments.

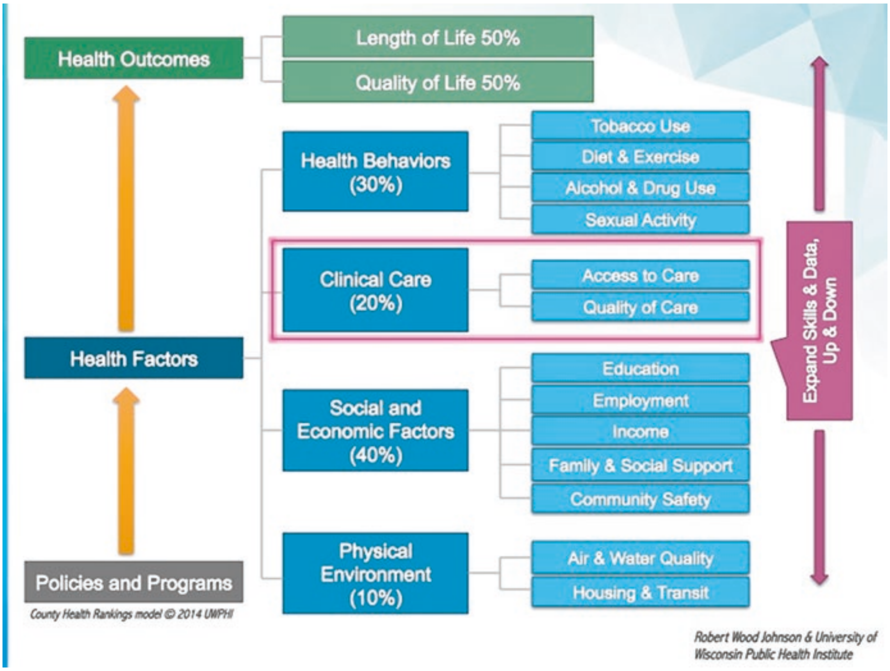

Fig. 1.1 The county health ranking model, as developed by the Robert Wood Johnson Foundation and University of Wisconsin

1.8.3 Data Sharing and Distribution

Health data is being collected every time an individual interacts with the health-care system. How does the data get distributed to researchers, policymakers, and other stakeholders to ensure there is a repository of well-kept and accurate data records?

1.8.4 Patient Privacy Concerns with Big Data

The priorities of Big Data and patient privacy often conflict. With sophisticated mechanisms, both priorities can simultaneously be implemented. One way to ensure patient privacy with Big Data is to house the sensitive personal information behind firewalls where software programs access and pull de-identified data to explore specific research questions. There is no actual central repository that holds full patient files; rather, there is a way for the software to communicate with the databases that store the protected patient information and pull out de-identified information. This model for managing Big Data for PHM is called a distributed data network and has already found success with the US Food and Drug Administration (FDA) Sentinel System, which tracks the safety and efficacy of FDA-regulated medical products (Popovic 2017).

1.8.5 Social Media and Digital Applications for Health Education and Promotion

With technological advances and smartphones becoming more widespread, it is easy to turn the smartphone or computer into a health device by utilizing applications and social media for health promotion and education efforts. Many unique platforms exist for social media, and there are already many successful applications available for free downloads (or at a charge for ad-free experiences). Published literature states that more individuals continuously seek health information over the Internet to guide their health-care decisions and lifestyle choices (e.g., dietary, sleep habits) (Jha et al. 2016).

1.8.6 Social Media

Social media has expanded to provide many platforms for patient engagement which can, in turn, be used as tools in PHM. The most popular platforms range from images only (Instagram and Pinterest) to limited word count posts (Twitter) to extensive posting (Facebook). Patients can be encouraged in different ways, from having them join virtual groups to following healthy lifestyle blogs.

One study analyzed State Health Department (SHD) Facebook pages with the Centers for Disease Control and Prevention (CDC) and Behavioral Risk Factor Surveillance System (BRFSS) data and found a disconnect between the content posted by SHDs and the health-care problems that plague their populations. SHDs and other health-care organizations need to invest more time and money in posting health promotion information that relates to the geographic populations they serve because it has been proven that people who seek out and access educational materials improve their health outcomes (Jha et al. 2016).

1.8.7 Mobile Applications

Many individuals utilize health apps including fitness trackers, calorie/nutrition trackers, exercise videos, and inspirational/spiritual connection. Currently, there are missing ethical guidelines to ensure health apps follow a specific protocol that protects patients and provides them with accurate information. In regard to privacy, app notifications and widgets put a patient at risk if they are not monitored effectively. There are many positive aspects to mobile applications including increased access to information, ease of tracking an individual's progress and health goals, improved communication between patients and providers, and connecting individuals to others in a similar situation (Jones and Moffitt 2016).

1.9 Current Policies in Place for Population Health Management

The Affordable Care Act outlined many policies that help bolster PHM. These policies are intended to improve patient outcomes by reducing costs. The most notable policy relates to the CMS hospital readmission penalty program. Acute-care hospitals have started monitoring their readmission rates regularly, since hospitals are penalized if their rates exceed the national average rates for specific chronic conditions such as heart failure, coronary heart disease, COPD and asthma, hypertension, diabetes, etc. In order to manage the target patient population effectively, many management strategies, including wellness or lifestyle management, disease management, demand management, catastrophic care management, and disability management, are emerging as part of the enterprise in PHM.

The American Health Care Act (AHCA) under President Trump's care management approach could lead to substantive changes in the coverage and delivery of health care in the United States. The Commonwealth Fund reports that under the AHCA the medically indigent will lose their coverage or protection of health insurance by dramatically reducing the Medicaid program, removing protections for individuals with preexisting conditions, and allowing insurance companies to charge the elderly up to five times as much as younger consumers for coverage (Blumenthal and Collins 2017). Other changes include providing waivers to states to forego covering the ACA's ten essential health benefits including prenatal and mental health care (Caffrey 2017). Furthermore, personal health expenditures will increase if the market force is not working in console with the demand for chronic care.

1.10 Concluding Remarks

1.10.1 Prospects for Population Health Management Research

In an effort to reach the stipulations of the Affordable Care Act, many improvements to the Institute for Healthcare Improvement's Triple Aim in health care have been identified; however, gaps in effective care for individuals with multiple chronic conditions remain (Clarke Bourn et al. 2017). Many aspects of American life are tailored to our specific needs, more so today than any time in history. With the advancement of technology, information and media are readily available. Unfortunately, when it comes to health care, the country has yet to figure out how to utilize the technological advances in a coordinated way, particularly in the development and validation of predictive analytics to guide health-care management and clinical practice.

1.10.2 Global Application

Conceptually, we need to have an integrated approach guided by a transdisciplinary orientation that will incorporate both a macro- and a micro-theoretical framework (a combination of contextual, ecological, organizational, and personal determinants of health) for promoting PHM (Wan 2014, 2017). Thus, policy decision-makers can prioritize how limited resources can be used to optimize health service needs of the chronically ill and disabled in the nation as well as around the globe.

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Chapter 2
Cost-Containment Strategies for Population Health Management and How They Relate to Poly Chronic Conditions

Abstract The effectiveness in population health management relies on employing multiple strategies in the improvement of the delivery system, particularly in the implementation of integrated care and continuity of care to avoid any drawbacks or ill side effects. Every nation has to refine outcome-based measurements and payment schemes to develop innovative and equitable rewards for key players or stakeholders in the health-care delivery system, to incentivize patients who are in tune to lifestyle changes (e.g., cessation of smoking, prevention and treatment of substance abuses, encouragement of patient participation in nutritional and dietary changes), and to facilitate patient engagement in the self-care practice of chronic disease management and prevention. This chapter offers an international perspective to examination of the prospective payment system, pay-for-performance evaluation, and value-based payment system.

Keywords Poly Chronic Conditions • Cost • Lifestyle • Management • Prospective payment system • Value-based payment

Health-care spending in the United States far exceeds expenditures in other developed nations, yet health outcomes in the United States are deemed worse than many other high-income nations (Squires and Anderson 2015). The prevalence of chronic conditions is rapidly increasing in the United States due to many factors, including an aging population and an increase in disease-specific risk factors such as obesity (Bodenheimer et al. 2009). The burden of chronic illness is not exclusively an American problem; many developed and underdeveloped nations alike are facing the same burden (World Health Organization 2005). Thus, there is a global need for effective strategies to contain health-care costs.

According to a recent panel survey of medical expenditures conducted by the Agency for Healthcare Research and Policy, Cohen and Meyers (2012) reported that the 1% of patients with chronic conditions accounted for 22% of the annual medical expenditures. The trends for medical expenditures are also shown in Figs. 2.1, 2.2.

In order to design and develop a comprehensive population health management (PHM) program, cost containment needs to take into account factors influencing

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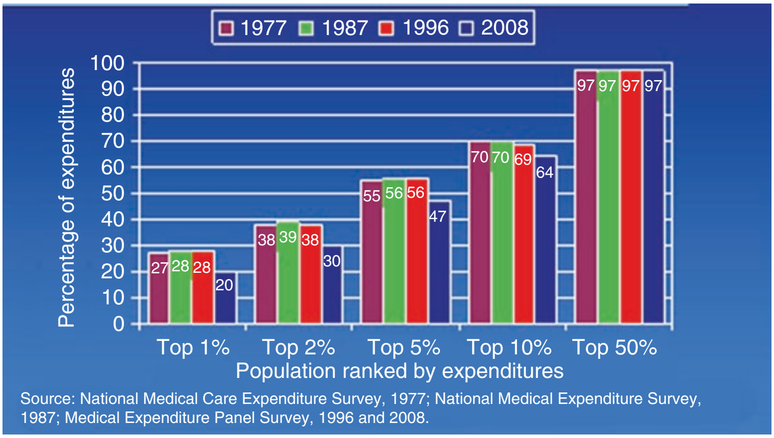
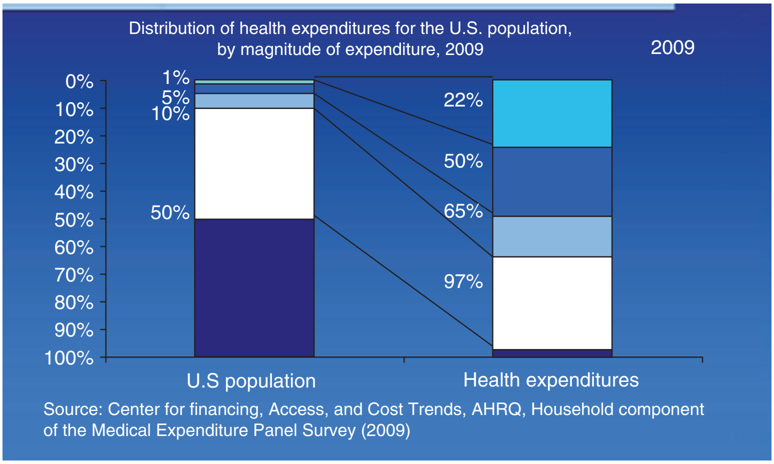


Source: National Medical Care Expenditure Survey, 1977; National Medical Expenditure Survey, 1987; Medical Expenditure Panel Survey, 1996 and 2008.

Fig. 2.1 Trends in concentration of health-care expenditures and distributions



Distribution of health expenditures for the U.S. population, by magnitude of expenditure, 2009

Source: Center for financing, Access, and Cost Trends, AHRQ, Household component of the Medical Expenditure Panel Survey (2009)

Fig. 2.2 Health-care costs concentrated in sick few—sickest 10% account for 65% of expenses

health expenditures such as chronic conditions (particularly cancer, heart disease, diabetes, obesity, COPD, and mental disorder), inpatient care and unnecessary readmissions, medical errors, and overutilization of health services. This chapter will analyze three cost-containment strategies, the prospective payment system (diagnostic-related groups), pay-for-performance system, and value-based payment system, and will explain how they were implemented in different nations, as well as how they relate to poly chronic conditions.

2.1 Prospective Payment (Diagnosis-Related Group) System

Diagnosis-related group (DRG), a prospective payment system implemented in the United States in 1984, is a way to categorize hospitalization costs and determine how much to pay for a hospital stay. Because of this, DRG is a cost-containment strategy based on a fee-for-service system. Cost-containment strategies based on fee-for-service systems fall into three categories: price controls, volume controls, and expenditure controls (Rice 1996). The DRG system is a price-control strategy (McAlearney 2003). DRG-based payments theoretically deliver incentives to increase the number of complex cases treated and reduce the number of services per case (Busse et al. 2011).

2.1.1 DRGs in the United States

The DRG system was adopted first in the private insurance system in the United States (Cacace and Schmid 2009). In 1983, it was implemented by the US government within the Medicare program (Busse et al. 2011) to establish relationships between the diagnosis of a condition and the adequate funding necessary to treat that condition (Altman 2012; Wan 1995). DRG categories are structured in such a way that a numerical weight corresponds to the cost of the services provided to similar patients across the country. Thus, illnesses that require higher resources have higher DRG weights. Though the weight stays constant for all hospitals, the dollar amount can vary from facility to facility, based on numerous factors including being in a rural area or an area with high input prices, treating a disproportionate number of low-income patients, or operating a teaching program (Altman 2012).

The system was made to stop hospitals from unnecessarily hospitalizing patients or prolonging their stay without a reason. Thus, DRGs incentivized hospitals to provide care in a timely manner and ready the patient for discharge in the shortest amount of time possible, to avoid unnecessary utilization of services, and to serve more patients (Sturgeon 2009).

DRG categories have undergone modifications over the years, but the system remains a challenge in hospitals, since it requires trained professionals to deal with its complex coding and billing system (Sturgeon 2009).

DRGs take into account poly chronic conditions. For instance, there are different codes for complex pneumonia without any comorbidity, complex pneumonia with another chronic condition, and complex pneumonia with more than one other chronic condition, and each of these has a different reimbursement amount attached to it.

2.1.2 Impact of DRGs in the United States

The DRG system is said to have been successful in the United States in slowing down cost escalation of inpatient care, while maintaining quality and access (Ellis 2001). A 1988 analysis of the first 3 years of DRG implementation found that the system reduced inflation in aggregate costs (Guterman et al. 1988).

However, empirical evidence tells us that there was no increased efficiency in the United States. A 1988 study in New Jersey found no positive impact on hospital efficiency (Borden 1988). Another study that compared efficiency scores from 1984 to 1993 in 80 hospitals in Virginia also found no significant difference in technical efficiency due to the introduction of DRGs (Chern and Wan 2000).

2.1.3 Adoption of DRGs Internationally

The adoption of DRGs in the United States had rippling effects in Europe and Australia. After Medicare adopted DRGs as a basis for paying hospitals in the United States, DRG systems became the basis for hospital payment in most European countries and in many other countries around the world (Busse et al. 2011), though their objectives and consequences can be very different (Cacace and Schmid 2009). While the United States used DRGs to change the cost-based reimbursement from retrospective to prospective, most European countries linked payment to activity in systems with global budgets (Busse et al. 2011).

In Europe, the EuroDRG project was formed, which presently includes 12 countries: Austria, England, Estonia, Finland, France, Germany, Ireland, the Netherlands, Poland, Portugal, Spain, and Sweden (EuroDRG 2013). Portugal was the first country to begin running a DRG-based hospital payment system in 1988, for payments from occupational health insurance schemes in the late 1980s. Australia was the first to use DRGs to set budgets for its public hospitals in 1993 (Busse et al. 2011).

Many of these countries used DRGs initially for patient classification, though later also as a payment system, in conjunction with other payment components. England, for instance, had a 10-year adaptation period; DRGs were used for patient classification and increased transparency purposes and only after for payment purposes. Ireland, on the other hand, only had a 1-year adaptation period until DRGs started being used for budgetary allocation in 1993 (Busse et al. 2011). However, different systems varied in DRG weights and the monetary value associated with each weigh.

2.1.4 Impact of DRGs Internationally

In some nations, hospital efficiency has improved after the introduction of DRGs. However, as Busse et al. (2011) puts it, determining the cause is challenging due to confounding factors. In terms of costs, DRG-based payments were associated with higher total costs in most cases (Forgione and D'Annunzio 1999; Anell 2005; Kastberg and Siverbo 2007; Moreno-Serra and Wagstaff 2010).

It is unclear how DRG systems affected patients with poly chronic conditions. The issue was raised in Australia, where their DRG system's performance toward patients with chronic conditions has been put into question (Griffiths and Hindle 1999).

2.2 Pay-for-Performance System

In the United States, health-care providers are typically paid for services through insurance payments or through payments made directly by patients. This fee-for-service system leads providers to focus on services that lead to high revenues, since it rewards the volume of services instead of the value or outcomes. However, creating another payment system that rewards quality without hurting providers, payers, or patients is challenging (Knickman and Kovner 2015).

A pay-for-performance (P4P) system, also called value-based payment or value-based purchasing, has become an umbrella term for an array of strategies that aim to improve the quality, efficiency, and overall value of health care. In this system, health-care providers are compensated for meeting specific performance measures and can be penalized for patients' poor outcomes or for being responsible for medical errors. Legislators and providers alike are turning to this model to control health costs and to increase the quality of care.

The move toward value-based payment is also driving the need for increased capabilities in PHM. According to the Health Intelligence Network (Healthcare Intelligence Network 2016), since providers who adopt P4P models have an economic interest in all aspects that impact their patients' health, they must develop new abilities and data-gathering skills and create community partnerships in order to understand and influence these factors.

P4P can be considered cost-effective if quality of care is improved at identical or lower costs. A study that evaluated the impact of different payment schemes (pay-for-coordination, pay-for-performance, and bundled payment) for integrated chronic care in different European countries found that P4P was the best at reducing health-care expenditure (Tsiachristas et al. 2012). However, a recent systematic review that evaluated 69 studies (58 of which were in outpatient settings) found that P4P programs are not consistently effective in improving health outcomes (Mendelson et al. 2017).

This section will examine pay-for-performance schemes in the United States and in other countries. Though some are similar, different countries' P4P programs differ. All the programs that were found incentivize clinical quality, though they vary in the scope of measure sets, payment size, and amount and aims.

2.2.1 P4P In the United States

In the United States, public and private payers alike have been creating incentives to reward providers for quality care, usually in addition to fee-for-service or other payment methods (Knickman and Kovner 2015). In 2007, there were an estimated 256 different P4P programs in the United States (Eijkenaar 2012).

In 2010, with the Patient Protection and Affordable Care Act, Congress legislated several Medicare programs meant to move in the value-based payment direction. Two different programs aimed at acute-care hospitals under the inpatient prospective payment system (IPPS) were implemented in October 2012. The Hospital Value-Based Purchasing Program rewards acute-care hospitals for quality of care that they provide to Medicare beneficiaries (US Department of Health and Human Services 2015). The Hospital Readmission Reduction Program consists of Medicare withholding payment from hospitals with high readmission rates (Centers for Medicare & Medicaid Services 2016b). These financial penalties are used to fund the Value-Based Purchasing Program (Centers for Medicare & Medicaid Services n.d.). This penalization program is why many IPPS hospitals have been steadily implementing techniques to reduce their unnecessary readmissions for individuals with chronic conditions and why cost-containment strategies aimed at chronic illnesses have been a highly discussed topic since the ACA.

Subsequently, two other programs aimed at physicians were implemented. The Physician Value Modifier Program rewards physicians with bonus payments when their performance attains specified measures of quality and cost. The adjustments are made on a per claim basis for items and services under the Medicare physician fee schedule (Centers for Medicare & Medicaid Services 2015). The Physician Quality Reporting System incentivizes physicians and group practices to report information to Medicare about the quality of their services (Centers for Medicare & Medicaid Services 2016a). In 2015, the program began applying a negative payment adjustment to physicians and practice groups who did not report data on the quality measures specified in the program (Centers for Medicare & Medicaid Services n.d.).

CMS is currently reviewing applications for programs that test whether access to services addressing health-related social needs has an impact on health costs, health outcomes, and quality of care for Medicare and Medicaid beneficiaries. This is due to a growing need for increased capabilities in PHM, which includes focusing on all areas that affect health (Healthcare Intelligence Network 2016).

Insurance companies have also implemented some other alternative payment systems, namely, bundled payments, reference pricing, and some forms of capitation (Knickman and Kovner 2015).

2.2.2 P4P and Chronic Conditions in the United States

In a systematic review of eight P4P schemes of PHM intended to improve delivery of chronic care (de Bruin et al. 2011), only two of the six in the United States had shown reports on quality, the Western New York Physician Incentive Project and the

Integrated Healthcare Association pay-for-performance program. None showed reports on costs. The Western New York Physician Incentive Project, which was implemented in 2001 in upstate New York, was designed to financially reward doctors for the quality of care delivered to patients with diabetes. Most participating physicians improved their average scores on most process and outcome indicators, including HbA1c control and LDL control (Beaulieu and Horrigan 2005). The other program, called Integrated Healthcare Association pay-for-performance, targeted 225 California managed care medical groups and independent practice associations. One study found that greater use of chronic care management processes (CMPs) was significantly associated with better clinical performance, namely, diabetes management and intermediate outcomes (Damberg et al. 2010).

A more recent systematic review attempted to examine the effects of different P4P programs in process of care and patient outcomes in outpatient and inpatient settings (Mendelson et al. 2017). They found that P4P may be associated with improved process-of-care outcomes in ambulatory settings but that there are no consistently positive associations between P4P and improved health outcomes in either setting. However, the review found that many of the studies that had found a positive effect on process-of-care outcomes had been conducted in the United Kingdom, where incentives are considerably larger than in the United States.

2.3 P4P in Countries Under the Beveridge Model

Many countries have a single-payer health system financed by the government through tax payments. These countries follow the Beveridge model. These include the United Kingdom, Spain, Portugal, most of Scandinavia, Hong Kong, New Zealand, and Cuba. Even though these systems tend to have low costs per capital, most of these countries have pay-for-performance strategies to control costs. This section will review P4P strategies in the UK and Portugal and how they relate to chronic conditions.

2.3.1 The United Kingdom

The United Kingdom has one of the largest pay-for-performance programs in the world, quality and outcomes framework (QOF). QOF was introduced in 2004, and it is focused on general practitioners. Even though it is a voluntary program, nearly all GP practices participate (Cashin 2011). Incentives are delivered on an annual basis in a point-based system. Practices can accumulate points based on their performance, up to a maximum of 1,000 points. QOF indicators and targets are updated every year, since the contract is renegotiated annually between the different parties (Cashin et al. 2012). As of 2015/2016, the flat rate per point was £160.15 (NHS Employers 2016b), which increased to £165.18 in 2016/2017 (NHS Employers 2016a). Payments are adjusted based on the size of the practice and the prevalence of disease relative to national average values (Cashin et al. 2012). The points are divided among different domains (Cashin et al. 2012).

P4P and Chronic Conditions in the United Kingdom In 2016/2017, the QOF clinical domain is worth up to a maximum of 435 points, divided among 69 indicators across 20 chronic clinical areas. These include atrial fibrillation, secondary prevention of coronary heart disease, heart failure, hypertension, peripheral arterial disease, stroke and transient ischemic attack, diabetes mellitus, asthma, chronic obstructive pulmonary disease, dementia, depression, mental health (schizophrenia, bipolar affective disorder, and other psychoses), cancer, chronic kidney disease, epilepsy, learning disability, osteoporosis, rheumatoid arthritis, and palliative care (NHS Employers 2016a).

In 2012, a systematic review of 94 studies analyzed the impact of this P4P framework in different areas, including effectiveness, efficiency, equity, and patient experience (Gillam et al. 2012). There were modest improvements in the quality of care for the chronic conditions included in the framework, including mortality reductions. There were noted improvements in better recorded care, improved processes, and better intermediate outcomes for most disorders, notably diabetes.

As previously mentioned, a recent systematic review found low-strength evidence that P4P programs in outpatient settings may improve process-of-care outcomes. Positive results were documented in the United Kingdom under the QOF where incentives are much larger than any P4P programs in the United States (Mendelson et al. 2017).

However, one study found that a small number of practices reached high achievement levels by excluding large numbers of patients, though further research is needed to determine if they were excluded for valid clinical reasons or if only for compensation (Doran 2006).

Though in some indicators QOF seems to be cost-effective (Walker et al. 2010), the true impact on costs remains uncertain (Gillam et al. 2012).

2.3.2 Portugal

Portugal has had a pay-for-performance scheme since 1998/1999 for GPs, though the design was restructured in 2006 (Johnson and Stoskopf 2010) to include family health units (USFs). USFs are multidisciplinary teams formed voluntarily that are now paid partially through incentive mechanisms such as performance compensations and capitations with the goal of bringing GPs closer to patients (Barros et al. 2011). The incentives are based on the performance of teams and physicians alike (Johnson and Stoskopf 2010) and on the case mix of their patients (Barros et al. 2011). 2006 was also the first year that Portugal met its budget for health care (Johnson and Stoskopf 2010). From 2006 to 2013, there was a modest decrease in public health-care expenditures as a total value (Pordata 2016a), on a per capita basis (Pordata 2016c), and as a percentage of the GDP (Pordata 2016b).

P4P and Chronic Conditions in Portugal The Regional Health Administration budget for primary care has seen a relative increase in the capitation component. The capitation component is adjusted by demography and by disease burden index by regional prevalence of certain conditions, namely, hypertension, diabetes, stress, and arthritis. Poly chronic conditions are found to be a very common occurrence in Portuguese primary care users (Prazeres and Santiago 2015), and a study in Portugal found that increased poly chronic conditions are linked to worse health-related quality of life (Prazeres and Santiago 2016).

One study analyzed the performance of USFs and primary care centers (Fialho et al. 2011). The number of days that a patient had to wait for an appointment with a GP was 54% lower in USFs, waiting times for emergency/acute consultations were shorter on average, and the average time spent in the waiting room for a nursing appointment was considerably lower. Also, there was a 45% reduction in the average number of days required to wait for a GP appointment and a 36% reduction in the average time spent in the waiting room for medical consultations. In terms of expenses, there was a 5% average reduction of total costs.

2.4 P4P in Countries Under the Bismarck Model

Countries that have a multi-payer insurance model follow the Bismarck model, and these include France, Germany, the Netherlands, France, Belgium, Switzerland, Japan, and some of Latin America. This section will cover the Netherlands' and France's P4P programs.

2.4.1 The Netherlands

The Netherlands has mandatory health insurance. However, much like the United States, the Netherlands' health-care funding is fragmentary, which kept long-term, pay-for-performance programs from being established. However, in 2007 a bundled payment program was approved to increase the quality of care for chronic conditions. Initially an experimental program with a focus on type 2 diabetes, the program was approved for nationwide implementation in 2010 and was extended to chronic obstructive pulmonary disease and vascular risk management (Struijs and Baan 2011). Insurers pay a bundled payment to a "care group," a principal contracting entity, to cover diabetes care services. The care group comprises multiple providers, often exclusively GPs. The care group assumes both clinical and financial accountability for all patients assigned to its program. By 2010, there were about 100 care groups operating diabetes management programs.

P4P and Chronic Conditions in the Netherlands In the years since P4P was implemented, patient mortality rates and costs have reportedly dropped significantly, though the specific numbers are yet to be published (Struijs 2015). Between 2007 and 2010, during the preliminary phase of the program, there were mild to moderate improvements in health-care delivery and several outcome indicators. Poly chronic conditions were reportedly not high on care groups' agendas during this experimental phase (Struijs et al. 2012), and it is unclear if that has changed.

2.4.2 France

In France in 2009, a P4P pilot program for primary care physicians was introduced named Contract for Improving Individual Practice (CAPI), which was implemented by the French national health insurance. In 2012, the program was extended to all GPs and to some specialists for a set of specific indicators and was renamed *Rémunération sur Objectifs de Santé Publique* (ROSP) (Cashin et al. 2014). Private physicians are enrolled automatically in the program, though they are free to opt out (L'Assurance Maladie 2016). However, even though the contract can be interrupted without any penalty, two thirds of French GPs choose not to participate. According to a cross-sectional survey with 1,016 respondents, the perception of ethical risks associated with the program seemed to have been the reason why most physicians did not sign the contract. These included "discomfort that patients were not informed of the signing of a P4P contract by their doctors" (OR = 8.24, 95% CI = 4.61–14.71), "the risk of conflicts of interest" (OR = 4.50, 95% CI = 2.42–8.35), "perceptions by patients that doctors may risk breaching professional ethics" (OR = 4. 35, 95% CI = 2.43–7.80), and "the risk of excluding the poorest patients" (OR = 2.66, 95% CI = 1.53–4.63) (Saint-Lary et al. 2013).

P4P and Chronic Conditions in France ROSP is meant to encourage physicians to better care for chronically ill patients. For diabetes patients, there have been improvements from late 2011 to late 2015 in HbA1c results and other diabetes indicators. These are indispensable to avoid further diabetes-related complications and comorbidities. HbA1c levels improved positively by 8.7% after 2011. Similarly, diabetic patients with high risk of cardiovascular disease improved by 7.2% (L'Assurance Maladie 2016). No information about the impact of the program on costs was found.

2.5 P4P in Countries Under a National Health Insurance Model

Countries that have adopted the NHI model include Australia, Canada, Taiwan, and South Korea. This section will focus solely on Taiwan's P4P program.

2.5.1 Taiwan

In 1995, Taiwan implemented a national health insurance program (Cheng et al. 2012). Health-care utilization in Taiwan is very high, with patients averaging 13.5 visits per year in 2004, compared to an average of 6.7 in other developed countries (Chang et al. 2012). In 2001, a pay-for-performance program for diabetes was implemented to create incentives for providers to deliver quality care, particularly regular checkups. The program was not mandatory and, after 5 years, fewer than 30% of diabetes patients were enrolled (Chang et al. 2012).

P4P and Chronic Conditions in Taiwan Various studies conducted in Taiwan saw improvements in quality of care and somewhat lower costs for diabetic patients enrolled in the program (Chiu et al. 2017). A population-based natural experiment used data from 2005 to 2006 and found that patients in the P4P program received significantly more diabetes-specific exams than patients who were not enrolled and had an average of two more physician visits (Lee et al. 2010). Also, patients in the program had fewer diabetes-related hospitalizations. The program was associated with lower hospitalization costs, though the overall cost of care for patients in the program was significantly higher; however, the total incremental expense was small. A large survey conducted in 2013 of 1458 diabetic patients found that P4P enrollees likely received better patient-centered care and that better perceptions of care also had better clinical outcomes (Chiu et al. 2016).

However, studies in Taiwan found that patients with greater disease severity (Chen and Chung 2010; Hsieh et al. 2015a, b) as well as patients with poly chronic conditions (Chen and Chung 2010; Hsieh et al. 2015a, b) were disproportionately excluded from the P4P diabetes program. This is likely due to the design of the program, which encourages physicians not to enroll their most complicated patients. In late 2006, the program was reformed to include achievement of intermediate health outcomes, but a study found that, even after the reform, sicker patients and patients with comorbidities were more likely to be excluded from the program, and the additional incentive for patients' intermediate outcomes moderately aggravated patient risk selection (Hsieh et al. 2015a, b). There are various suggestions to combat this, including reexamining the program's design (Lee et al. 2010; Hsieh et al. 2017) and making participation mandatory (Chen and Chung 2010).

A recent study analyzed the cost-effectiveness of a pay-for-performance program for diabetes patients with poly chronic conditions. Hsieh et al. (2015a, b) investigated cost-effectiveness of the P4P program for patients with diabetes alone and for patients with diabetes and comorbid hypertension and hyperlipidemia. Data from population-based longitudinal databases was used, and cost-effectiveness was compared between P4P and non-P4P diabetes patients. The study found that the program was cost-effective for both cohorts, and the return on investment was 2.60:1 in the diabetes alone cohort and 3.48:1 in the poly chronic cohort. Thus, the P4P diabetes program in Taiwan enables long-term cost-effectiveness and cost savings, especially for patients with poly chronic conditions. Similar results were also documented by Huang et al. (2016) in a cohort study of diabetes.

2.6 Value-Based Payment System as an Alternative Strategy

Value-based payment and diagnosis-related groups are vastly different cost-containment strategies, and they can even be implemented together. The evidence for both is mixed, and it is clear that neither strategy is consistently associated with cost-effectiveness or better outcomes for chronic conditions. Diagnosis-related groups have largely been linked to higher total costs, but in some countries, they are also correlated with higher efficiency. In the United States, the DRG system has mostly been effective in reducing inflation in total costs. There is also little evidence of its impact on caring for poly chronic conditions.

Evidence of pay-for-performance programs' effect on costs is scarce. P4P has been reportedly found to be cost-effective in Taiwan (Chiu et al. 2016), in the Netherlands (Pomp 2010), Portugal (Chipman 2015), and in some of the UK's indicators within the quality and outcomes framework. In terms of health outcomes, the evidence is mixed, though most cases reviewed seem to have moderately positive results. Some of the pay-for-performance programs involve patient-centric care and disease management, as is the case in the United Kingdom and Portugal, where multidisciplinary teams have been employed. The lack of fully integrated care in many health-care systems for chronic disease care or management is the fundamental concern in both high-income and low-income countries.

2.7 Concluding Remarks

The key lesson learned from this chapter is that successful health system and policy reforms need to execute concomitantly in the development of PHM, irrespective of the income status of a nation. Although both reform strategies might be suitable to alleviate the burden of chronic diseases within a PHM framework, it seems difficult to ensure the success of the strategies prior to implementation. Different nations have had different success rates with both strategies, though it remains hard to assess the causes due to many confounding factors such as the variation in health insurance coverage, the ability to integrate the medical care system with the social service system, and the meaningful use of health information technology and implementation. The effectiveness of the P4P movement is a lever of cost containment. However, the program's success must be maximized by employing multiple strategies in the improvement of the delivery system, particularly in the implementation of integrated care and continuity of care to avoid any drawbacks or ill side effects. Furthermore, every nation has to refine outcome-based measurements and payment schemes to develop innovative and equitable rewards for key players or stakeholders in the health-care delivery system, to incentivize patients who are in tune to lifestyle changes (e.g., cessation of smoking, prevention and treatment of substance abuses, encouragement of patient participation in nutritional and dietary changes), and to facilitate patient engagement in self-care practice of chronic disease management and prevention.

The availability of administrative and patient-care data generated from electronic medical records and personal health records has potential for clinicians, health services researchers, and data scientists to collaborate in the construction of valid, reliable, and practical predictive analytics to guide the promotion of PHM and research.

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Chapter 3
Integration of Principles in Population Health Management

Abstract The health-care and patient care outcomes for poly chronic conditions can be improved through the integration of multiple domains of the population health management approach and comprehensive coordination across multiple levels utilizing interdisciplinary care teams and appropriate applications of health information technology. Patient identification and risk stratification enable health-care providers to focus the appropriate resources on the patients with the greatest needs. By preventing acute events and worsening health status in higher-risk patients and providing preventative and wellness services for lower-risk patients, care management efforts can achieve optimal impact on health outcomes and cost-effectiveness. This chapter highlights the need for integrating contextual (macrolevel) and individual personalized care (microlevel) approaches to population health in solving multimorbidities.

Keywords Multimorbidities • Personalized care • Identification • Risk • Integration • Interdisciplinary approach

The challenges and inefficiencies stemming from the fragmentation and lack of coordination in the complex US health-care system are well documented. For patients with poly chronic conditions, the inadequacies of the health-care system are particularly problematic given the distinct needs and characteristics of these patients, as well the high service utilization patterns and costs associated with their care. Integration and coordination of care are fundamental in an improved health-care delivery system that functions to reach targeted populations, provide them with quality care, and reduce costs. Identifying the care and treatment patterns associated with higher risks and costs, and developing strategies and interventions to improve the health outcomes for these patients, requires the involvement of patients, caregivers, providers, community entities, and other stakeholders.

The term “care coordination” has been defined numerous ways. The Agency for Health Research and Quality (AHRQ) notes that it is important to consider care coordination from the perspective of the patient/family, health-care professionals, and system representatives, as these groups may have differing views. Defined broadly, care coordination is “the deliberate organization of patient care activities between two or more participants (including the patient) involved in a patient’s care

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to facilitate the appropriate delivery of health care services. Organizing care involves the marshaling of personnel and other resources needed to carry out all required patient care activities, and is often managed by the exchange of information among participants responsible for different aspects of care" (McDonald et al. 2014, p. 6). Lack of integration can result in patients with poly chronic conditions having unmet health-care needs, not receiving appropriate and/or high-quality care, and utilizing health services that could have been avoided, such as emergency room visits and hospital readmissions. Each year, Medicare beneficiaries see an average of two primary care practitioners and five specialists, and primary care practices consisting of 30% of Medicare patients with multiple chronic conditions (four or more) need to coordinate with 86 other providers in 36 practices (Tinetti et al. 2016). As the population health management (PHM) approach provides the opportunity to improve accessibility, quality, outcomes, and spending through the identification of groups of patients based on similar characteristics, it is important to understand the various elements involved with its implementation.

Recognizing the multiple domains or principles of the PHM approach and the ways in which components integrate is particularly important for the care of patients with poly chronic conditions, given the complexities of this population. In order to reach and care for patients with poly chronic conditions who would benefit from better coordinated care involving health services and social services, it is necessary to consider contextual aspects for identification and assessment of patient populations and the resources needed to care for them, as well as individual aspects for patient-centered care. Contextual elements pertain to population attributes, organizational structures of communities and health-care systems, and the geographic area. Individual personalized care elements include patient-centered needs across the health continuum and targeted interventions to effectively and efficiently address such needs. Technology is a critical component across all elements of the PHM approach. Meaningful and appropriate use of health information and enhanced communication with patients, providers, and other stakeholders help to facilitate actions and activities in the contextual and patient-centered domains, as well as impact evaluation and improvement components of the process.

Understanding how certain chronic conditions cluster based on clinical, financial, or social attributes and identifying homogeneous subgroups in the complex population of patients with multiple chronic conditions are important to integrating care effectively and efficiently. Patients, caregivers, providers, health plans, and other stakeholders can better transition from the traditional condition-based approach to a patient-centered approach by using information regarding these clusters and the ways in which chronic conditions group into common pairs or sets. Furthermore, identifying patterns in high-risk, high-cost patients with multiple chronic illnesses enhances the ability to predict vital patient characteristics, such as patients who are most likely to show significantly improved outcomes, have high future costs, and respond best to care management interventions (Kronick et al. 2007, pp. 35–37). A more precise depiction of the characteristics, variabilities, and potential challenges surrounding patients with multiple chronic conditions then makes it possible to develop and implement targeted interventions at multiple levels for these patients.

3.1 Contextual Domains or Ecological Parameters: Macrolevel Factors Influencing Population Health

The process of employing PHM strategies requires efforts to address contextual and ecological components to ensure an adequate understanding of the population attributes and accessibility of resources. The ecological parameters, which Otis Duncan called an ecological complex, include population (P), organization (O), environment (E), and technology (T). Population health is influenced by the dynamic interplay of POET components. The POET model is shown in Fig. 3.1 (Wan 2014).

3.1.1 Population Identification, Risk Assessment, and Segmentation: The First Parameter

The first parameter (P) involves identification, assessment, and segmentation of the patient population health status and risk stratification to determine the specific population needs and the availability of resources required to provide care. Steps taken to identify meaningful population subgroups, classified by demographic, social, and economic characteristics of the population, and ascertain the level of care needed for patients enable health-care providers to recognize gaps in the delivery system and develop appropriate, patient-centered interventions that are tailored to individual needs and communities.

The prevalence of poly chronic conditions and utilization of health services by patients who have them may vary due to social, demographic, or geographic factors. Variations in the prevalence of multiple chronic conditions among Medicare beneficiaries have been shown to be associated with certain demographic factors, including age, gender, and race/ethnicity. Based on an analysis of administrative claims data for 2010, multiple chronic conditions were more prevalent as age increased and in the population of beneficiaries dually eligible for Medicaid and Medicare. Across all age groups, the prevalence of two or more and four or more chronic conditions was higher in women, particularly non-Hispanic black and Hispanic women. Analysis of men age 65 or older showed greater prevalence of multiple chronic conditions in non-Hispanic whites; however, the rate of four or more chronic conditions was higher in non-Hispanic black men (Lochner and Cox 2013).

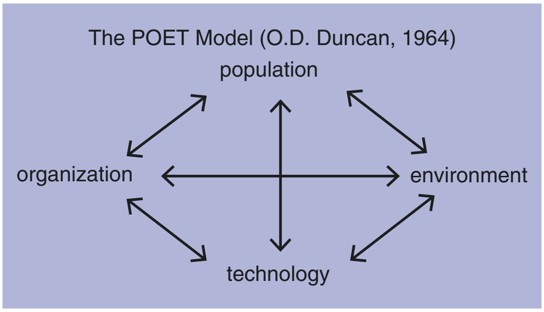

Fig. 3.1 POET model in ecological research

Patterns have been identified in the ways in which conditions group into pairs (dyads) or sets (triads) of diagnoses in populations of patients with multiple chronic conditions. Analyses of disabled Medicaid patients identified several specific conditions prevalent in dyads or triads among the 5% of highest-cost beneficiaries, including cardiovascular disease, central nervous system disorders, psychiatric illness, and pulmonary disease (Kronick et al. 2009, p. 12). Additionally, correlations between certain conditions have been identified, with the highest correlation being between diabetes and cardiovascular disease, followed by cardiovascular disease with pulmonary disease, skeletal and connective disease, and gastrointestinal disease (Kronick et al. 2007, p. 27).

While information concerning the grouping of diseases in population subsets is useful for identifying those considered to be high risk and determining the level of care needed, factors that are not disease specific must also be considered. The accessibility and coordination of health care for patients with multiple chronic conditions becomes even more challenging when there are social barriers (Miller et al. 2013, p. S17). Thus, a comprehensive assessment of the population health and risk stratification (segmentation) to group patients according to the type of care required entail incorporating information pertaining to the setting and societal characteristics. An analytical technique, such as predictor tree analysis or automatic interaction detector analysis (Wan 2002), could be used to identify relatively homogeneous subgroups of the population at risk so that subgroup-specific interventions could be implemented and evaluated.

3.1.2 Organizational Resource Identification and Allocation: The Second Parameter

The second parameter refers to organizational capacity and resource availability for achieving optimal health. PHM efforts are influenced by factors such as the availability of resources, the presence of collaborations and partnerships, and other characteristics of the health-care delivery system. These area-level factors can have an impact on patients with poly chronic conditions. For example, patterns of state-level variations have been identified in prevalence, health services utilization, and spending among Medicare patients with six or more chronic conditions. In 2011, states in the Northeast and South regions of the United States had a higher prevalence of Medicare beneficiaries with six or more chronic conditions, with prevalence approximately 30% higher than the national average in Florida and New Jersey. In Washington, D.C., hospital readmissions, emergency room visits, and Medicare spending were found to be at least 15% higher than the national average. While additional research is needed to determine the specific factors influencing such patterns, the supply of health-care resources has been associated with observed regional variations in care given that the likelihood of conditions being identified can increase when the availability of health-care resources is greater. Therefore, state-level variability in the prevalence of poly chronic conditions among Medicare beneficiaries may be partially associated with the state health-care resources (Lochner et al. 2013, pp. E13–E15).

Community coalitions may form in response to challenges, opportunities, or threats identified by local stakeholders. The coordination of efforts by community partners has the potential to bring about meaningful changes; however, there is still the possibility for overlap of programs and services if there is no mechanism for individual coalitions formed around specific health issues to streamline efforts across multiple health issues and segments of the community (Janosky et al. 2013, p. 247). The availability and strength of these types of partnerships have the potential to greatly impact patients with poly chronic conditions by ensuring that the necessary health services and social services are accessible.

The risk stratification process assists health-care providers in focusing the appropriate resources on patient population groups with the greatest need (Care Continuum Alliance 2012, p. 10). Understanding the level of care that patients require and the types of providers that will be needed to serve these patients can help health service delivery and resource use be more targeted and efficient. Communication and a shared approach across community collaborators can facilitate greater consistency in comprehensively addressing health issues and, thus, improve impact and resource use (Janosky et al. 2013, p. 247). Actions and activities undertaken in the contextual domains of the PHM approach inform the development of the appropriate interventions to manage care in a coordinated, patient-centered fashion. The scarcity of resources may trigger the need to prioritize or segment resources to target the services for those who will most likely benefit from the program or intervention.

3.1.3 Environment or Geographical Milieu: The Third Parameter

The third parameter pertains to environmental or geographic factors that could potentially impact population health. Unique characteristics of the physical space can provide a better understanding of the distribution of health needs and possible threats to health and well-being. This is a highly important part of the PHM approach for patients with poly chronic conditions given the complex health and care needs of these individuals and the lack of research that has generated comprehensive knowledge concerning optimal treatments and practices. By assessing the geospatial clustering of health needs and factors that may hinder healthy environments, efforts can become more focused in the development of targeted interventions for individuals with poly chronic conditions.

According to Rocca et al. (2014), "the characterization of multimorbidity patterns in a geographically defined population allows comparisons with other localized populations in the United States or worldwide to investigate geographic similarities or differences. In addition, these findings can be used to guide decisions for clinical practice or public health in the local community" (p. 1337). Analysis of state-level variations across the United States using 2011 Medicare administrative data reported differences in the prevalence and utilization of health services in patients with multiple chronic conditions. Analysis also highlighted the need for future research in order to understand the specific factors associated with the patterns of state differences, such as variances in the distributions of underlying risk factors, combinations and types of conditions, and the quantity and delivery of available health-care resources (Lochner et al. 2013, pp. E14–E15).

Geospatial methodologies have been used to assess local-level distributions of multiple chronic conditions. A single-state analysis uncovered spatially distinct areas in which the prevalence of combinations of multiple chronic conditions was considered to be high in comparison to what would be expected given the frequencies of these conditions in the total state population. To better understand the factors contributing to the differential patterns of spatial association, it is suggested that future research explore the role of individual behaviors such as smoking, occupational exposures such as to particulates, and environmental conditions such as air quality and proximity to major highways (Cromley et al. 2016, pp. 18–21). Thus, examination of smaller area variations in the prevalence of specific multiple chronic conditions allows for incorporation of information concerning community resources, cultural differences, industrial impact, and other environmental characteristics that may influence health behaviors, status, or care delivery.

Environmental hazards such as pollution may play a role when considering health and health care for poly chronic conditions. A longitudinal analysis of the impact of air quality on health among patients with chronic conditions reported increased use of health services with higher levels of exposure to air pollution (To et al. 2015, p. 1). Although various environmental pollutants may contribute to chronic disease and adverse outcomes, the relationships between chemical exposures and health are diverse and complicated. In a review of environmental determinants of chronic disease and medical approaches, Sears and Genuis (2012) concluded that “addressing environmental health and contributors to chronic disease has broad implications for society, with large potential benefits from improved health and productivity,” with risk recognition, chemical assessment, exposure reduction, remediation, monitoring, and avoidance identified as possible public health initiatives (Sears and Genuis 2012, pp. 1–2).

While additional research is needed to elucidate many of the causal factors impacting the patterns and variabilities in environmental and geographic components of the PHM approach, the opportunity remains for health-care providers to consider existing empirical evidence and the available information from individual patients when developing patient-centered interventions for poly chronic conditions. An awareness of the distinct environmental and geographic characteristics of the physical space in which patients with poly chronic conditions live and/or receive care can be a vital step in ensuring that interventions entail the appropriate types of care, care providers, and other resources to account for health needs and possible threats to health and well-being.

3.1.4 Technological Innovation and Use: The Fourth Parameter

The contextual domains of the PHM approach are heavily impacted by technology. The availability of information and the ability for data from multiple sources to be combined and analyzed in a meaningful way are critical components for patient assessment (Care Continuum Alliance 2012, p. 10). Patient data can be used to assess health status, progress, service utilization, and delivery system gaps or deficiencies. Predictive analyses using current patient medical information provide an opportunity to improve the coordination of treatment, costs, and inefficiencies (Miller et al. 2013, p. S18). The use of predictive modeling enables health-care providers to identify patients who are likely to become high risk in the future and intervene in ways to prevent these individuals from having an acute event and to maintain their health (Healthcare Informatics 2016, p. 8). Thus, the availability of useful patient health information and innovative technological resources provide the opportunity for a better understanding of the population health status and those who have the greatest need for care.

Variations in the availability and sophistication of technology resources influence the ways in which PHM components are delivered. Rural areas, for example, may implement PHM differently due to limited technological capabilities (Care Continuum Alliance 2012, p. 13). Furthermore, without appropriate health information technology tools, health-care providers that do have the capacity to identify patients with the highest level of need or gaps in care still may be limited in their ability to serve these patients. To be more effective, information technology solutions need to facilitate adequate planning for the staff resources and scheduling opportunities available to care for patients (Healthcare Informatics 2016, p. 11). Distinct contextual characteristics and resources play an influential role when considering health information technology strategies to achieve patient care objectives.

The influence of factors associated with local setting when implementing health information technology programs is highlighted in the reported experiences of communities participating in the Beacon Community Cooperative Agreement Program. This program was created by the Office of the National Coordinator for Health Information Technology following the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2010 to help communities build and strengthen their health information technology infrastructure. Due to variations associated with factors pertaining to the local context across these communities, their strategies for utilizing health information technology to support care management programs differed. However, three specific steps were identified as fundamental components for the design of these programs: (1) community needs assessment, (2) engagement of local and regional partners, and (3) assessment of available resources and infrastructure (Allen et al. 2014, pp. 150–152).

3.2 Individual Personalized Care Domains: Microlevel Factors Influencing Population Health

Individual personalized care elements are key components in the process of PHM. The most appropriate and effective methods to engage and communicate with patients can vary based on personal preferences, capabilities, resource availability, and level of need. Variations in the level of need for patients with poly chronic conditions may be rather complicated given that multiple illnesses must be considered in complex disease management efforts as well as lower-risk efforts such as prevention and wellness. The development of patient-centered interventions entails selecting delivery methods and treatment programs that are tailored to individuals' needs across the health continuum. Ideally, information obtained by health-care providers' contextual domain activities will facilitate meaningful conversations with patients. By integrating these domains, clinicians can better understand patients' circumstances and preferences and develop care plans that will be more effective in attaining improved outcomes and costs.

3.2.1 Engagement and Communication

Patients must be involved and informed throughout the process of care delivery. Engagement has been described as "a psychological state which manifests in positive behavior change" and consists of "self-determined participation in intervention-directed activities in alignment with patient goals to which the patient is dedicated" (Care Continuum Alliance 2012, p. 21). Patient health is influenced by patients, their caregivers, and providers in the health system, with the patient being the most influential of these factors. Healthy behaviors and adherence to care plans, such as medication compliance among patients with poly chronic conditions, can be improved by effectively engaging patients. These improvements, in turn, lead to increased quality and reduced costs (Proctor et al. 2016, p. 13). Thus, patient engagement is a critical component of the PHM approach.

Increased communication with patients and the incorporation of their input into care plans can lead to increased treatment adherence, greater patient satisfaction, and improved outcomes. Seeking to develop patient priority-directed care, an advisory group composed of patients, caregivers, clinicians, health information technology experts, health system leaders, and other stakeholders elected to address three potentially modifiable factors contributing to fragmentation, burdensome care, and poor outcomes for older adults with multiple chronic conditions. These included (1) focus on diseases not patients for decision-making and care; (2) lack of clearly defined roles, responsibilities, and accountability among clinicians; and (3) insufficient attention to the health outcome goals and care preferences that matter most to patients and caregivers. A proposed strategy for addressing these factors was for the care of all clinicians to be aligned around the same outcome based on the individualized goals and preferences of patients (Tinetti et al. 2016, pp. 263–264).

Self-management support has been defined as “the systematic provision of education and supportive interventions by health care staff to increase patients’ skills and confidence in managing their health problems, including regular assessment of progress and problems, goal setting, and problem-solving support” (Suter et al. 2011, p. 88). Activities to support self-management goals in order to achieve coordinated care involve education and support for patients and their caregivers through information, training, or coaching that is tailored to patient preferences and capacity and facilitates patient capabilities for self-care to encourage improvements in behavior change, navigation of care transitions, and self-efficacy (AHRQ 2014, p. 24).

The role of families and other caregivers involved with the management of patients with poly chronic conditions must be carefully considered. The ability to perform self-care, which is critical for managing risk factors associated with declining health or the development of additional chronic conditions, may be limited among patients who are severely ill due to the existence of multiple chronic conditions (HHS 2010, p. 9). Patients living with chronic conditions must have confidence in their abilities to perform the tasks needed to live well. Self-efficacy is an important precondition for behavioral change, as individuals who believe in their ability to carry out tasks that will facilitate desired outcomes are driven to adopt the necessary behaviors. Thus, confidence in one’s ability to perform certain behaviors influences actual behaviors (Suter et al. 2011, pp. 88–89). While person-centered care that empowers patients in care management is an important element for successful care coordination (HHS 2010, p. 7), engaging patients’ family members and immediate caregivers in the process of designing and delivering care management plans may be a fundamental component of effective interventions for patients with poly chronic conditions.

3.2.2 Patient-Centered Interventions

For some patients with poly chronic conditions, the existing disease guidelines may not be applicable, as randomized clinical trials often exclude older adults with complex conditions. Given the lack of evidence, the benefits of the treatments these patients are receiving may be unclear (Tinetti et al. 2016, p. 262). The US Department of Health and Human Services has outlined several strategies to address the need for guidelines that account for multiple chronic conditions. These strategies include guideline developers adding information pertaining to common comorbidity clusters with a chronic condition, risk factor management to prevent additional conditions, and ensuring that chronic disease guideline repositories support the promotion of guidelines that include information on patients with multiple chronic conditions (HHS 2010, p. 13). The lack of guidelines based on empirical evidence makes it even more important for health-care providers to communicate with patients to comprehensively understand their treatment needs and preferences, as the information derived from such interactions can be critical for determining the most effective interventions.

It has been reported that only 10–12 percent of overall health is determined by health-care services and treatments, while behavioral and socioeconomic factors account for approximately 57% (Proctor et al. 2016, p. 5). To improve the health of patients with poly chronic conditions, there must be increased coordination of complex medical and longitudinal psychosocial care, with patients having access to community and other public health services, in addition to better coordination of medical care (HHS 2010, p. 6). Thus, it is crucial that care plans for patients with poly chronic conditions are developed with consideration for unique patient needs beyond medical care, as the multitude of various types of support services can have a profound impact on health status and outcomes.

Furthermore, there is an increased likelihood of reaching goals aimed at engaging patients and supporting self-management for improved health outcomes when intervention modalities are matched to patient preferences. In-person visits may be most appropriate for some patients, while others would prefer information and education delivered online or through the mail (Care Continuum Alliance 2012, pp. 10–11). Along with patient preference, risk level must also be considered, particularly among patients with poly chronic conditions, given the complexity of medical problems that are likely to exist. Identifying the health and needs of populations and utilizing resources to intervene appropriately can improve outcomes and costs. For example, hospital readmission rates among Medicare beneficiaries have been shown to increase in direct relation to the number of chronic conditions a patient has (Lochner et al. 2013, p. E8). Among patients with multiple chronic conditions, the inclusion of an in-person home visit by a nurse case manager to the transitional care management following hospital discharge has been shown to significantly reduce readmissions and lower the total costs of care (Jackson et al. 2016, p. 167).

A 2017 data brief published by the US Centers for Disease Control and Prevention National Center for Health Statistics reported that an increasing number of individuals with two or more chronic conditions had experienced barriers to health care. From 2012 to 2015, the percentage of patients aged 65 or older who delayed or did not obtain needed medical care for any reason in the past 12 months increased from 13.5% to 15%. Among patients aged 18–64, the percentage of those who delayed needed medical care due only to a non-cost reason increased from 12.4% in 2012 to 14.6% in 2015. Non-cost reasons include factors such as lack of transportation, inability to reach providers through the telephone or obtain an appointment soon enough, or health-care provider offices not being open during times that the patients were able to get there (Ward 2017, pp. 5–6). The implications of disparities in access to necessary medical care, social services, and other community resources can be even more severe for patients with poly chronic conditions given the complexity of their health status and needs and the importance of trying to maintain or reduce the risk level of these individuals by preventing new conditions from developing and mitigating the adverse effects of existing conditions.

Understanding the unique needs and circumstances of individuals is fundamental to ensuring that patient-centered interventions are tailored to address the types of care and appropriate service providers required. Through increased coordination and integration of medical and social services to provide patient-centered interventions for individuals with poly chronic conditions, the utilization of unnecessary or avoidable services can be reduced, and barriers to needed care can be alleviated. There are obvious challenges concerning communication and coordination across multiple medical care providers and others involved with the care for patients with poly chronic conditions. However, the PHM approach and adoption of innovative health information technology provide the opportunity to overcome such challenges and offer tangible improvements in the effectiveness and efficiency of health care and outcomes.

3.2.3 Technology Adoption and Use Behavior

Complex medical problems can be monitored and assessed through the use of technology for chronic disease management. Coordination of care can be improved through the integration of communication across institutions and organizations by utilizing health information technology. For patients with chronic conditions, problems occurring during care transitions, in long-term care management, and when acute intervention is needed for clinical episodes could be alleviated. Yet still, health-care access, outcomes, and value are compromised by the inefficiencies and wasted resources associated with the lack of widespread adoption and use of health information technology (Clarke et al. 2016, p. 24).

Clinicians, patients, families, and delivery systems all benefit from interoperable health information technology that improves the coordination of care and provision of uniform information to health-care providers involved with the care of individuals with poly chronic conditions. The implementation and effective use of health information technology to improve the care for patients with poly chronic conditions can be facilitated through strategies that support meaningful use of electronic and personal health records, patient portals, and registries, utilize secure information exchange platforms such as telemedicine and remote monitoring, and employ health information technology as a public health tool to monitor the health of the population and performance measures (HHS 2010, p. 8).

Telehealth technology provides the opportunity not only to identify disease exacerbation and provide timely interventions for chronically ill patients but also to improve patient self-efficacy for disease management through the inclusion of education and self-confidence building tools. However, issues such as those pertaining to reimbursement for remote patient-monitoring equipment and telemonitoring visits and the financial ability for some health-care providers to purchase monitoring units have created barriers in the widespread adoption of telehealth (Suter et al. 2011, pp. 91–92). Thus, while patient-centered approaches utilizing telehealth can help facilitate greater improvements in patient outcomes and costs, various obstacles may have to be overcome to increase the accessibility and utilization of such technology.

3.3 Outcome Evaluation and Improvement

The use and impact of interventions for patients with poly chronic conditions can be improved through monitoring and providing ongoing feedback (HHS 2010, p. 9). A process must be in place for evaluating the impact of interventions and applying evaluation information to make improvements as needed. Quality, cost-effectiveness, and significance are three broad areas that can be assessed to evaluate the overall impact of interventions in order for health-care providers to determine the value of their efforts and identify areas for improvement (Care Continuum Alliance 2012, p. 23). Outcome evaluation and improvement efforts should consider the multiple relevant levels involved given the importance of developing patient-centered interventions that incorporate medical and social services to comprehensively care for patients with poly chronic conditions.

Efforts to improve coordinated care for patients with poly chronic conditions are complemented by delivery system and provider payment changes accompanied by quality and performance metrics, as well as an increased degree of involvement of the public health system (HHS 2010, p. 7). Recognizing distinct community characteristics is essential when involving various types of care providers across multiple levels of the public health system in evaluation and improvement efforts. Health outcomes can be improved through increased communication and awareness across local stakeholders and the adoption of a context-specific approach to account for the distinct challenges and resources impacting health issues and mediating the effectiveness of health interventions in communities (Janosky et al. 2013, p. 248). When developing improvement plans and identifying the performance measures associated with such plans, various aspects of the community must be taken into consideration. Factors such as the population's health needs, the availability of resources, and the accountability that health-care providers, organizations, and other involved entities are willing to accept for specific actions or contributions should be identified to ensure that strategies appropriately fit the communities in which they will be implemented (Stoto 2013, p. 4).

The opportunity exists for more widespread implementation of the PHM approach as recent changes to the US Medicare system encourage greater quality. The Medicare Access and CHIP Reauthorization Act of 2015 (MACRA) ended the Medicare Part B Sustainable Growth Rate formula and replaced it with the Quality Payment Program, a value-based reimbursement system intended to improve Medicare through enhanced focus on quality care for patients. Through the Quality Payment Program, participating Medicare Part B providers can choose from two tracks: the Advanced Alternative Payment Models (APMs), which entails earning an incentive payment for participation in an innovative payment model, or the Merit-based Incentive Payment System (MIPS), which involves earning a performance-based payment adjustment. The first performance period is from January 1 to December 31 of 2017. During this performance period, providers must record quality data and note how technology was used to support their practice and then submit this data in 2018. Medicare will offer feedback to providers based on the data submitted, and for 2019 providers may potentially earn a positive payment adjustment under MIPS, or a 5% incentive payment for participation in an Advanced APM (Center for Medicare and Medicaid Services 2017).

The complex care needs of patients with poly chronic conditions often require various categories of providers and for providers to spend additional time with patients. Financial incentives can encourage care models to improve the health status and outcomes for patients with multiple chronic conditions (HHS 2010, p. 8). In a 2007 report developed to provide a greater understanding of the care needs of Medicaid beneficiaries who have multiple chronic conditions and are substantially driving costs, integration and coordination of care, performance measurement, financing, and evaluation were identified as key issues that must be addressed to improve the quality and cost of care for these patients (Kronick et al. 2007, p. 36). Reform efforts such as the Quality Performance Program hold the potential to comprehensively address these key issues by offering health-care providers tools and resources to a greater extent than in the past.

3.4 Integration and Coordination of Care

Patients with poly chronic conditions have complex, distinct needs for health and social services. Efforts to improve population health should include interventions that account for contextual and social factors, as well as individual factors. The balance of these types of interventions should be based on the distinct needs of patients and the communities in which they are being implemented in order to efficiently utilize resources and avoid gaps in the availability and accessibility of programs and services. Community coalitions of diverse members focused on a common goal provide the opportunity for complex health issues to be addressed at the local level by leveraging and increasing access to resources, coordinating services, reducing duplicative efforts, and garnering public support (Janosky et al. 2013, p. 246). Although measurement of the factors influencing population health outcomes may be arduous, a set of measures that operationally define population health dimensions is important for the various entities that must work cooperatively to improve the health of a population to monitor progress (Stoto 2013, p. 3).

The Health Impact Pyramid has been presented as a conceptual framework to depict the varying population impact levels of health interventions using a five-tier pyramid that incorporates both biomedical and social determinants of health. According to this framework, health interventions that accommodate socioeconomic factors and contextual/environmental factors require the least amount of individual-level behavior change and may have the greatest potential for impacting population health. Interventions involving the most individual effort and affecting the least change in population health are those focused on counseling, education, and clinical care. Protective interventions, including screenings and immunizations, which take place at a limited point in time and have the potential for long-term health impacts are depicted in middle-level of the pyramid. By coordinating interventions at each level of the pyramid, communities may achieve the maximum population health impact (Janosky et al. 2013, pp. 247–248).

In 2010, the US Department of Health and Human Services (HHS) developed a strategic framework intended to inspire a shift toward a multiple chronic conditions approach as opposed to the traditional approach of focusing on individual chronic illnesses. Four specific goals were outlined based on the HHS vision of "Optimum Health and Quality of Life for Individuals with Multiple Chronic Conditions." These goals are "(1) Foster health care and public health system changes to improve the health of individuals with multiple chronic conditions, (2) Maximize the use of proven self-care management and other services by individuals with multiple chronic conditions, (3) Provide better tools and information to health care, public health, and social services workers who deliver care to individuals with multiple chronic conditions, and (4) Facilitate research to fill knowledge gaps about, and interventions and systems to benefit, individuals with multiple chronic conditions" (HHS 2010, p.6). In this organizing structure developed by HHS, health care management, interventions, and research are needed to address multiple chronic conditions (Lochner and Cox 2013, p. 1). Given that numerous federal programs related to chronic disease prevention and management are administered by HHS, the adoption of this framework holds the potential for widespread progress toward improving the health care and outcomes for patients with poly chronic conditions.

PHM efforts require new appropriate care processes and support for care processes using care managers and health information technology solutions that complement electronic health record capabilities. Also required are the right people to serve patients, with team-based care accepted as being essential (Healthcare Informatics 2016, p. 19). An interdisciplinary team with specialization in managing care transitions, the ability to be accessed on demand, and consistent communication across all stakeholders have been identified as essential components of solutions to effectively improve transitions of care, provide long-term care management, and reduce unplanned episodes of care (Clarke et al. 2016, p. 26).

The central goal of care coordination is to meet the needs and preferences of patients in the delivery of high-quality, high-value care (McDonald et al. 2014, p. 16). To that end, innovative approaches to effectively deliver comprehensive and appropriate health care continue to be explored. For example, the mobile integrated health-care model, which leverages EMS systems, has been introduced as a community-based and technologically sophisticated approach to address the gaps in coordinated care and service delivery for patients with chronic conditions. These programs utilize physicians, nurses, pharmacists, social workers, community health workers, emergency medicine professionals, and other resources and personnel. Central elements of the mobile integrated health-care model include an interprofessional team that is available around the clock, an operational dispatch and communications center, a transitional care team, longitudinal high-risk care involving in-home/at-work visits, advanced illness management involving the patient's family and caregivers, and utilization of mobile clinicians and telemedicine to coordinate care for unplanned acute episodes (Clarke et al. 2016, pp. 27–28). This type of integration holds the potential to efficiently and effectively provide patient-centered care for individuals with poly chronic conditions, which in turn can result in improved health outcomes and reduced costs.

3.5 Conclusions and Implications

The health care and outcomes for patients with poly chronic conditions can be improved through the integration of multiple domains of the PHM approach and comprehensive coordination across multiple levels utilizing interdisciplinary care teams and appropriate applications of health information technology. Patient identification and risk stratification enable health-care providers to focus the appropriate resources on the patients with the greatest needs. By preventing acute events and worsening health status in higher-risk patients and providing preventative and wellness services for lower-risk patients, care management efforts can achieve optimal impact on health outcomes and cost-effectiveness. Consideration for environmental and geographic characteristics provides the opportunity to better understand patterns of need distribution and potential hazards to health and well-being. Purposeful engagement strategies and communication facilitate patient involvement in interventions tailored to their specific health-care needs and personal health goals. Innovative uses of technology and analytic tools are essential throughout this process.

The use of technology to address complex medical problems is an area that continues to expand and evolve. A research report developed by Healthcare Informatics states that "applications for registries, care gap identification, risk stratification, predictive modeling, utilization management, benchmarking, clinical dashboards, patient outreach, and automated work queues" are required for PHM (Healthcare Informatics 2016, p. 13). While the level of resources and capabilities varies across the organizations and communities providing health care, there must be continuous efforts toward adopting health information technology that facilitates interoperability, data sharing, and effective communication to ensure that applicable knowledge is derived from the information available.

Multiple implications of PHM for poly chronic conditions suggest that concerted efforts in promoting preventive strategies can yield numerous benefits. For example, these efforts will not only provide the opportunity to positively impact both patients and health-care providers but also offer alternatives to institutional care of the vulnerable population. Patients can experience improvements in health behaviors, self-efficacy, health status, quality of life, and health services utilization. Clinicians can experience improvements in resource efficiency, understanding patient health risks, quality care, and patient satisfaction and outcomes (Care Continuum Alliance 2012, p. 19). Sustainable improvements in the coordination of care require empowered patients who are able to self-advocate and utilize preventive care services and health-care providers who have new ways of viewing complex patients (Miller et al. 2013, p. S18). The process of integrating contextual and individual patient-centered domains of the PHM approach entails effort from clinicians, patients, caregivers, and other stakeholders. Continuous improvement efforts through impact evaluation and a commitment to the adoption of the health information technology resources needed are also critical aspects of this process. Patients with poly chronic conditions have complex needs and are often high utilizers of health services. Great potential exists to improve the health and health care of these individuals through improved coordination, integrating multiple domains of the PHM approach.

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Chapter 4
Strategies to Optimize Population Health Management: Implications for Elder Care with Poly Chronic Conditions

Abstract Population health management targets subpopulation groups that have varying health-care needs. This chapter sheds the light on how health-care informatics and management enable care providers and managers to improve patient-centered care for frail seniors and to use electronic health records (EHRs) effectively. Its strategic aims are to (1) develop a coordinated Health-Federated Information Network for Data Electronic Retrieval (Health-FINDER) system, (2) impart knowledge and skills for integrated care for high-risk elders, (3) provide IT integration service for primary care physicians and staff for evidence-based care management, (4) design and implement quality improvement initiatives via health information exchange (HIE) for poly chronic conditions, (5) prevent and divert inappropriate hospitalization or institutionalization, (6) assist providers with Health-FINDER to promote population health management, (7) engage in interdisciplinary informatics research by partnering with community stakeholders, and (8) leverage community, state, and federal resources to optimize success for elder care. A transdisciplinary perspective to PHM is suggested.

Keywords Elder care • Transdisciplinary perspective • Health-FINDER • Health information exchange • Subpopulation • IT integration • Integrated care • Patient engagement

Population health management (PHM) targets subpopulation groups that have varying health-care needs. Health care for three categories of elderly patients overburdens the financial and workforce capacities of most communities. One category includes elders with multiple chronic illnesses, living independently. A second category includes elders with functional limitations requiring long-term assistance. Collectively, they comprise 2–5% of any community. A third category includes elders making transitions across the care continuum, such as moving from a hospital to a rehabilitative facility after surgery. Each patient category presents a unique population group, including common but varying health-related problems associated with aging. Thus, their complex needs reflect the design and implementation imperatives for optimizing resources and information exchanges required for enhancing coordinated care.

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This chapter sheds light on how health-care informatics and management enable care providers and managers to improve patient-centered care for frail seniors and how to use electronic health records (EHRs) effectively. The strategic aims are to (1) develop a coordinated Health-Federated Information Network for Data Electronic Retrieval (Health-FINDER) system, (2) impart knowledge and skills for integrated care for high-risk elders, (3) provide IT integration service for primary care physicians and staff for evidence-based care management, (4) design and implement quality improvement initiatives via health information exchange (HIE) for poly chronic conditions, (5) prevent and divert inappropriate hospitalization or institutionalization, (6) assist providers with Health-FINDER to promote PHM, (7) engage in interdisciplinary informatics research by partnering with community stakeholders, and (8) leverage community, state, and federal resources to optimize success for elder care.

4.1 Transdisciplinary Framework

An integrated health and social service network under the theoretical guidance of a transdisciplinary framework could be used to generate marginal benefits from clinical practice and research. Ultimately, this strategy could help avoid costly institutional care and enhance seniors' health. This approach could be modulated and disseminated throughout the world to formulate clinical and executive decision support systems for promoting PHM.

The growth of the aging population and its demand for chronic care around the globe, coupled with a fragmented and poorly coordinated care system, have posed threats to the health security of the elderly. Opportunities for enhancing care management technologies through health information exchange (HIE) abound. The need for adopting a patient-centered care modality for seniors and using electronic health records (EHRs) effectively is paramount. Eight specific strategies are noted. This proposed approach will help channel coordinated care to high-risk seniors requiring acute, subacute, and community-based long-term care. Using a transdisciplinary approach and integrating contextual, ecological, and individual determinants into the investigation of variations in health and social service disparities, researchers and practitioners in health-care informatics and management may form partnerships to promote PHM. This theoretically based development would enable scientists to test what works and what does not work in clinical practice. Consequently, the Health-FINDER system could be modulated and applied in many countries. It is through the evidence-based practice and research that clinical and health executive decision support systems could be formulated and validated. This chapter outlines eight strategic aims under a transdisciplinary framework to integrate both macro- and microlevel predictors for explaining the variability in personal and population health.

4.2 Strategies for Optimizing Population Health Management

4.2.1 First Strategy: Develop a Coordinated Elder Care Health-FINDER System

The National Health Information Infrastructure Act stipulates that there is a critical need in the United States for investment in HIT, including electronic health record (EHR) systems. The Institute of Medicine's reports on *Crossing the Quality Chasm* and *Improving the Quality of Health Care for Mental and Substance-Use Conditions: Quality Chasm* have confirmed this stipulation. Innovative applications of HIT and HIE may fill the gaps of a fragmented health-care system. In addition, the Institute of Medicine's quality improvement initiatives advocate that barriers to HIT/HIE adoption should be identified and removed (Institute of Medicine 2001, 2006, 2009). The proposed strategy is a direct response to the need for enhancing the quality of health care and reducing the disparities in health and health care in the United States through the meaningful use of EHRs. Thus, relevant information sharing through EHRs may translate data into context-specific information that can empower providers with evidence-based knowledge for improving the practice. Yet, widespread implementation of HIT has been limited because of the lack of knowledge about what types and implementation methods of HIT will improve care management and contain costs for care.

Currently, EHRs have been implemented and used by some physicians who are based solely in hospitals. However, its use beyond the hospital-based physicians is not widespread. Massive amounts of patient care data have been gathered, but limited effort has been made to provide information on how to improve health-care processes and outcomes. Further, scant effort has been made to take such information to improve health care and overall patient and population health. Over the past 10 years, concerted efforts have been made to design and implement the concept of patient-centered care through the use of care management technologies (Breen et al. 2008; Marathe et al. 2007; Wan et al. 2002). In recent years, there has been an explosion of evidence-based medicine and practice. Massive amounts of clinical and administrative data have been gathered. Little has been done, however, to coordinate the relational databases that can generate information for improving health-care processes and outcomes. Such systematic information for formulating predictive analytics is needed to build a repository of knowledge for the use of policy decision-makers, providers, administrators, facility designers, researchers, and patients. Evidence-based knowledge gives users a competitive edge in making policy, clinical, administrative, and constructional decisions that improve personal and public health (Wan 2002; Wan and Connell 2003).

An article appearing in the *Journal of American Medical Association* states that practice-based research will generate new knowledge and bridge the chasm between recommended care and improved health (Westfall et al. 2007). This approach provides a framework for an innovative and meaningful use of resources for moving the United States to a leadership position in using information technology in education, innovative product development, and effective patient-centered care in the twenty-first century.

The proposed strategy will shape the analytic work on massive amounts of existing patient care data to design a patient-centered care management technology model that will be used to coordinate and enhance patient care. This model will rely on EHRs and will include an innovative HIE system integration called Health-FINDER. The integration technology will interoperate with existing data sources, rather than draw down resources to create a new EHR. Health-FINDER will be the hub of the HIE integration solution. It will leverage resources from multiple stakeholders to optimize the system's success. Strategically, it will strive to serve the public good and community welfare, provide positive economic and health impacts on the community, and establish a strong collaboration among all participants and stakeholders. The creation of the Health-FINDER system will achieve several objectives (Table 4.1). It will need to pull patient and administrative data into a repository, giving a single view to the multiple interdependent back-end data sources that already exist, such as the EHR, drug history, etc. An integrated software is used to design coordinated care modules, monitor and evaluate performance of the subsystems and components, and enhance interoperability to increase the meaningful use of EHRs.

4.2.2 Second Strategy: Impart Knowledge and Skills for Integrated Care for High-Risk Elders

An overarching goal of the health information system design is to improve the care of seniors with poly chronic illnesses by giving their care providers and managers better access to patient information through an innovative health information exchange system. Primary objectives for this system design are to (1) improve patient care outcomes and reduce costs for elders by improving the effectiveness and efficiency of their coordinated care through the use of a federated information network and data electronic retrieval (Health-FINDER) system that interoperates with existing data sources, to share and exchange patient information, (2) enhance best practices in clinical care for elders through simulated learning of clinical case reviews, and (3) promote PHM by using web-enhanced health education modules for chronic conditions (Fig. 4.1). Encouraging the use of innovative care management technologies imparts the knowledge and skills essential for integrated care for a high-risk group of elders with multiple chronic conditions. The high-risk patient population can be identified by employing predictor tree analysis or similar analytical methods. Hopefully, mutually exclusive subpopulations could be singled out as target groups for designing and implementing specific interventions. In other words, a one-size-fits-all intervention approach is undesirable since a diverse group of patient populations may reveal varying service needs and interventions required for achieving optimal health and management of chronic conditions.

Table 4.1 A summary of strategic aims, objectives, and metrics for evaluation

Strategic aims	Objectives	Metrics
Develop a Health-FINDER system for coordinated elder care	• Pull patient and administrative databases into a master person index (MPI) • Use integration modeling software to design coordinated care modules • Monitor and evaluate performance of subcomponents of the system • Build workflows to reach interoperability and meaningful use of EHRs	• Baseline and then increase completeness of information held in MPI • Level of integration of multiple data sources • Baseline and then increase the percentage of the use of the Health-FINDER system
Impart the knowledge and skills essential for integrated care for a high-risk group of elders with multiple chronic conditions	• Configure innovative case management technology • Incorporate patient-centered care technologies for primary care • Perform and deliver coordinated care via application system	• Baseline and then increase number of participants in database • Increase adoption rate • Hit nationwide meaningful use targets established for 2015 • Baseline and then increase user satisfaction with coordinated care • Increase number of services provided
Provide IT integration service through which primary care physicians and staff apply evidence-based care management technologies	• Incorporate patient-centered care technologies for primary care • Apply integrated health and social services to the frail elderly • Increase care coordination and referral networks	• Adequacy of patient-centered care management technology used • Formal evaluation results • Baseline and increase patient assessment and outcome measures
Design and implement quality improvement initiatives via HIE	• Monitor and assess the project outcomes • Determine the level of satisfaction with coordinated care by users and providers • Identify tractable outcomes relevant to the project • Formulate strategies and plans for continuous improvement	• Disease-specific outcomes • Adequacy of the quality improvement (QI) plan • Adequacy of the feedback from physician participants • Change in practice for better outcomes • Participation rate of QI activities • Reduce medical errors and treatment problems • Other patient safety measures (polypharmacy or drug interaction incidents)

(continued)

Table 4.1 (continued)

Strategic aims	Objectives	Metrics
Prevent and divert inappropriate institutional care for the eligible	• Channel coordinated care to high-risk patients who are likely to be institutionalized • Detect barriers to community-based care • Avoid premature institutionalization	• Decrease number of skilled nursing facility (SNF) days • Decrease number of repeated visits at clinics • Reduce readmissions
Promote population health in assisting health providers to use Health-FINDER system	• Use syndromic surveillance modeling to establish early warning systems for the outbreak of infectious diseases • Apply GIS techniques to identify service needs • Achieve an optimal return for patient education	• Reduce number of sentinel health events • Reduce the number of ambulatory care sensitive conditions reported
Engage interdisciplinary health informatics research by partnering with community stakeholders	• Design and execute scientific studies • Disseminate research and evaluation studies • Foster the partnership between the academic and community stakeholders • Train health informaticians/informaticists	• Number of published papers/book chapters/books generated from health-care informatics and management research • Number of professional presentations • Frequency of consultations to other organizations or communities
Leverage federal, state and local community resources and assets to optimize the success of the proposed project	• Serve the public good and community welfare • Enhance the visibility of the partnerships • Make economic and health impacts on the community we serve • Establish a strong collaboration with the community and other organizations	• Connectivity with other HIT systems • Shared use rate • Joint projects developed • Ability to coordinate with multiple entities that are interested in applying HIT/HIE innovations • Regional and national recognition

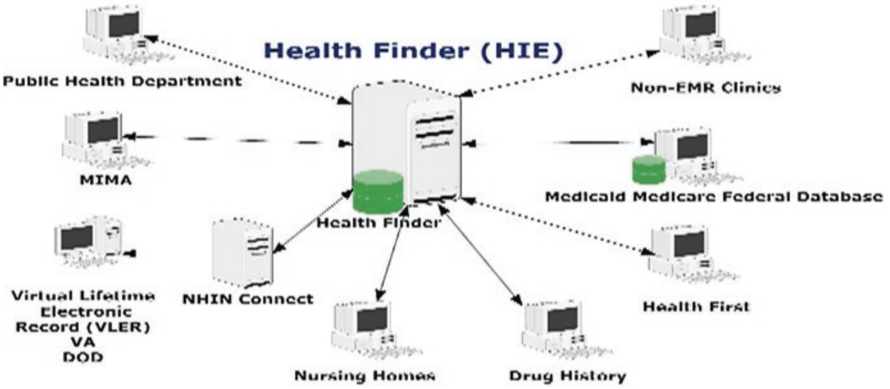

Fig. 4.1 The Health-FINDER system (Wan 2011)

4.2.3 Third Strategy: Provide Health Information Technology (HIT) Integration Service for Primary Care Physicians and Staff for Evidence-Based Care Management

By incorporating patient-centered care technologies for primary care, the performance and delivery of coordinated care solutions are enabled. IT integration service will help primary care physicians and staff apply evidence-based care management. This will require incorporation of patient-centered care technologies, enabling caregivers to apply integrated health and social services to the frail elderly. Further, it will enhance care coordination and referral network utilization (Wan 2006).

4.2.4 Fourth Strategy: Design and Implement Quality Improvement Initiatives via HIE for Elders

A small number of studies have been conducted to examine HIT effectiveness and impact and/or EHR outcomes (Wan 1989; Wan et al. 2004). Although the studies do not permit definitive assessments of either HIT or EHR outcomes, they do point to the potential for both as a quality-of-care strategy while acknowledging a developmental curve for the technologies, which have yet to achieve optimal use (Lee and Wan 2002, 2004). To that end, innovative applications of HIT and the meaningful use of EHRs, deployed within a rigorous evaluation framework, should advance our knowledge and move us toward greater optimization while closing critical gaps in context-specific information and practice. Häyrinen et al. (2008) reviewed the literature on the definition, structure, content, use, and impacts of EHRs and recommended that (1) the needs and requirements of different users should be taken into account in the future development of information systems, (2) different kinds of standardized instruments, electronic interviews, and nursing documentation systems should be included in EHR systems, (3) the completeness and accuracy of different data components should be checked and validated by health-care professionals, (4) EHRs should provide important information for health policy planning, and (5) the use of international terminologies is essential to achieve semantic interoperability. The challenge for implementing and diffusing HIT/HIE innovations is further complicated by personal and organizational barriers as noted in the development of EHRs.

Quality improvement initiatives via HIE enable system users to monitor and assess patient care outcomes, determine the level of satisfaction with coordinated care by users and providers, identify tractable outcomes relevant to the system, and formulate strategies and plans for continuous improvement. The FINDER-based HIE system serves several purposes. One purpose is to prevent and divert inappropriate institutional care for eligible patients. Using the HIE system developed for the elderly, we will channel coordinated care to high-risk patients who are likely to be institutionalized; we will also detect barriers to community-based care, advancing the goals of community care and delivering in the least restrictive environments. The HIE system will seek to avoid premature institutionalization, serving the goal of reducing institutional costs and burdens. The net effect will be to promote PHM. The system will support providers in achieving this goal by assisting them with training, technical assistance, and support in using the Health-FINDER system. To monitor and evaluate quality usage, we could use syndromic surveillance modeling to establish early warning systems for the outbreak of infectious diseases or newly emerging health problems and apply GIS techniques to identify service needs and achieve an optimal return on patient education.

4.2.5 Fifth Strategy: Prevent and Divert Inappropriate Hospitalization and Institutionalization

In 2015, the Centers for Medicare and Medicaid Services launched an important initiative called Hospital Penalty Policy for Readmissions (Wan et al. 2017a). This policy has a significant potential to reduce readmission rates for heart failure, diabetes, joint replacement, and other chronic conditions. However, thoroughly designed and executed systematic reviews and meta-analyses are needed to tease out the relevance of human factors that are likely affecting hospitalization or institutionalization for chronic conditions (Wan et al. 2017a, b).

4.2.6 Sixth Strategy: Assist Providers with Health-FINDER to Promote Population Health Management

It is imperative that patient-centered care management technology (PCCMT) manages chronic diseases and the associated financial and social impact on individuals, families, organizations, and society better than the current system, which is fraught with high costs and low effectiveness. The PCCMT model depicts a patient-centered care system acting as a well-versed family medical social navigator trained to guide patients through their health-care choices and coordinate provider care. In the manner of a decision support "navigator" tool that straddles family medical care and social services, the system can manage a multitude of patient care needs from appointments to proper health education and case management. This multidimensional, coordinated approach to care with a patient-centered focus is greatly needed to fill a significant and troublesome gap in the information systems architecture of today, which remains fragmented and relatively ineffective at the cost of the health-care system performance and, ultimately, PHM. Indeed, the National Academy of Engineering and Institute of Medicine states that *the health-care delivery system involves the coordination and management of numerous highly specialized, distributed personnel, multiple streams of information, and material and financial resources across multiple care settings. However, health care has yet to be made better use of the design, analysis, and control tools of systems engineering* (Reid et al. 2005). This view, deploring the underutilization of systems engineering, was reinforced by Lee and Mongan (2009), who then addressed the conditions for development of a better organized, high-performing health-care system. The performance-enhancing conditions posited by Lee and Mongan (2009) involved coordination and monitoring architecture of the type proposed here.

In 2003, the Institute of Medicine identified the deficiencies in health care and made continuity of care a primary goal of its comprehensive call for transforming the quality of care in the United States (Institute of Medicine 2003). In 2006, the American College of Physicians (ACP) established continuity of care as a central theme for restructuring or reengineering health care (Goroll et al. 2007). Recent research of life-limited patients receiving patient-centered care management showed a notable 38% reduction of hospital utilizations and a 26% reduction of overall costs with high patient satisfaction (Sweeney et al. 2007). Thus, it is imperative to establish scientific evidence in support of the need for expanding EHR/patient health records (PHR) as part of the patient-centered care management technology.

4.2.7 Seventh Strategy: Engage in Interdisciplinary Health-Care Informatics Research by Partnering with Universities and Community Stakeholders

Partnering with community stakeholders is needed when conducting interdisciplinary health-care informatics research (Wan 2006). Collectively, we will design and execute scientific studies, disseminate research and evaluation studies, and foster a partnership between the academic and community stakeholders. The academic institution affiliated with a medical center is in a unique position to provide both systems engineering knowledge and tools and extensive practical experience in the design, testing, validation, and maintenance of complex human-centered and community-centered IT health-care systems. Furthermore, it is imperative to employ a comprehensive framework, such as a transdisciplinary approach, to guide the selection of variables from the data files and to generate useful and meaningful knowledge for optimizing clinical practice and improvement.

The realization of an advanced patient-centered health IT infrastructure necessitates faithful adherence to systems engineering best practices for complex sociotechnical system design. These practices ensure that (1) the right system is designed, (2) the system performs over its entire design life as expected, and (3) the system is designed, developed, used, maintained, and replaced at minimum cost. Two approaches play a critical role in shaping program activities: simulation-based concept exploration and model-based systems architecture. Fundamental information technology problems have been observed at the personal, organizational, and community levels for which properly designed and coordinated EHRs can provide meaningful solutions, that is, solutions that are effective, robust, and sustainable. The meaningful use of EHRs is contingent upon multiple factors, including (1) the integrity and coverage of the information system, (2) the graphical-user interface design, (3) interoperability and standardization, (4) security and privacy concerns, and (5) cost. The ready availability of open-source software and integrators enables the development and implementation of a patient-centered care management technology modality that is needed to coordinate and enhance care for the elderly. It is imperative to reconfigure and integrate massive amounts of patient care data into an interoperable system in order to effectively and efficiently deliver integrated patient data.

4.2.8 Eighth Strategy: Leverage the Local Community, State, and Federal Resources of Partners to Optimize Success of a Community-Based Integrated Delivery System

The partners should be guided by strong scientific and community advisory boards that can facilitate both community engagement and scientific investigations of HIT/HIE demonstrations. Wan et al. (2016) reported on how a physician at Medical Specialists, Inc., in St. Augustine, FL, designed a patient-centered care model for rural clinical practices. A health navigator was included and supported by an EMR system to perform coordinated care services for the clinical population with diverse ethnic and racial backgrounds. The patient flow showed how clinical care was rendered, and outcomes were tracked in an integrated computing system. This demonstration project was partially supported by the Florida Blue Foundation to assess clinical outcomes for diabetes. In addition, Marathe and associates (2007) conducted a thorough evaluation of 400 community health centers' performance in terms of technical efficiency and financial success and failure. The analysis clearly indicates the need to develop an executive decision support system to enhance the performance of community health centers.

4.3 Evaluation of the Proposed Patient-Centered Care for Elders

A patient-centered care modality for delivering PHM should target elder care first and then expand to primary care for the general population in the community. The outcome variables are evidence-based, valid, and reliable (www.ncqa.org) indicators that serve as observable variables to measure safety, effectiveness, efficiency, equity, timeliness, and patient centeredness. In the primary care setting, for example, effectiveness can be measured by HEDIS scores (i.e., A1c, blood pressure, and cholesterol) and frequency of ER visits, hospitalizations, mortality, morbidity, quality of life (QOL), health status, safety by prescription errors, equity by patient satisfaction surveys, timeliness by waiting time for new/follow-up appointments, waiting time in provider's office, efficiency by cost of care, equity by patient survey, and patient centeredness by patient satisfaction surveys. Table 4.2 provides details regarding the outcome variables and their relationship to the three major constructs (e.g., access, quality, and cost) in the quality improvement arena.

Cost efficiency metrics should be gathered to demonstrate the reduction in the cost of care associated with the Health-FINDER system. These include (1) preventable emergency room visits and hospitalizations, including readmissions, and (2) reduced short-term skilled nursing home stays following a hospital stay. The integrated data system will merge a variety of data sources, such as hospital discharges, readmissions, nursing home use, ambulatory care visits, prescription drug purchase and use, and other durable equipment leased or paid. A list of inputs (resources/services used in terms of costs) and outputs (functional outcomes and health-related quality of life indicators) has been identified to perform efficiency analysis and identify the efficiency frontiers as a guide to optimize the performance of health services organization. Again, for illustrative purposes, the targeted disease, type 2 diabetes, is highly prevalent and could be effectively treated at noninstitutional settings such as primary care clinics. Patients afflicted by the disease are at a high risk for hospitalization and poly chronic conditions. A large amount of savings can be generated from the deployment of the proposed patient-centered care modality, as well as the health information technology and simulated learning software (e.g., a web-based decision support system design).

4.4 Concluding Remarks

The implementation of a functional and integrated health information system has to be guided by a theoretically informed framework. Thus, the appropriately collected data could produce useful information and evidence-based knowledge to promote health services outcome and quality improvement. Measurable patient care outcomes and their benchmarks should be used to evaluate the system's performance.

Table 4.2 National health goals and the associated observable variables

	Performance measurement	Patients	Providers	Community
ACCESS	*Timeliness* (reducing waits and sometimes harmful delays for both those who receive care and those who give care)	1. Patient satisfaction survey with >80% "satisfied" (Press-Ganey). 2. Time for new appointment. 3. Open versus closed access. 4. Waiting time in office for established patient. 5. Waiting time in office for walk-in patient. 6. Door-to-door time. 7. Time to complete referrals. 8. Sample chart audit	1. Provider satisfaction survey with >80% "satisfied." 2. Sample chart audit	1. Stakeholder satisfaction survey with >80% "satisfied" (Press-Ganey Survey 2017). 2. Sample chart audit
	Patient centeredness (providing care that is respectful and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all decisions)	1. Patient satisfaction survey with >80% "satisfied" (Press-Ganey). 2. Sample chart audit	1. Provider satisfaction survey with >80% "satisfied." 2. Sample chart audit	1. Stakeholder satisfaction survey with >80% "satisfied" (Press-Ganey). 2. Sample chart audit
QUALITY	*Effectiveness* (providing services based on scientific knowledge to all who could benefit and refraining from providing services to those unlikely to benefit—avoiding underuse and overuse, respectively)	1. HEDIS 2007 scores for physician practice (NCQA). 2. Health status (SF12). 3. Quality of life (Duke QOL). 4. Patient satisfaction survey with >80% "satisfied" (Press-Ganey). 5. Sample chart audit	1. Provider satisfaction survey with >80% "satisfied." 2. Sample chart audit	1. HEDIS 2007 scores for physician practice (NCQA). 2. Stakeholder satisfaction survey with >80% "satisfied" (Press-Ganey). 3. Sample chart audit
	Safety (avoiding injuries to patients from care that is intended to help them)	1. HEDIS 2007 scores for physician practice (NCQA). 2. National Patient Safety Foundation Survey. 3. Patient satisfaction survey with >80% "satisfied" (Press-Ganey). 4. Sample chart audit	1. Provider satisfaction survey with >80% "satisfied." 2. Sample chart audit	1. Stakeholder satisfaction survey with >80% "satisfied" (Press-Ganey). 2. Sample chart audit
	Equity (providing care that does not vary because of personal characteristics such as gender, ethnicity, geographic location, and socioeconomic status)	1. Patient satisfaction survey with >80% "satisfied" (Press-Ganey). 2. Sample chart audit	1. Provider satisfaction survey with >80% "satisfied." 2. Sample chart audit	1. Stakeholder satisfaction survey with >80% "satisfied" (Press-Ganey). 2. Sample chart audit

COST	*Efficiency* (avoiding waste, including waste of equipment, supplies, ideas, and energy)	1. Cost per outpatient encounter (FQHC data from BPHC division of CMS and MGMA data). 2. Number of encounters. 3. ER visits and hospitalizations	1. Cost per outpatient encounter (FQHC data from BPHC division of CMS and MGMA data). 2. Number of encounters	1. Stakeholder satisfaction survey with >80% “satisfied” (Press-Ganey). 2. Sample chart audit

The multisite evaluation of a patient-centered care model should be guided by the structure-process-outcome perspective developed by Donabedian (1980). We should use clinical and administrative data to prescribe the best performance practices based on research evidence. Analysis of clinical and administrative data should be planned to determine factors contributing to improved performance. Analysis can be performed in terms of improved patient outcomes, patient cost, quality of care, and patient safety based on measured performance comparing intervention to controls. The results could serve as a sound evidence-based prescription for performance monitoring and feedback. Knowledge management techniques ensure that the right people are receiving the right information at the right time via the right method to ensure the right care plan. The ultimate test of the system is to enhance the ability to use current data to make safe clinical decisions and then track both self-reported and objectively assessed outcomes of those decisions to continue to inform decision-making. The more innovative the technology applied, the more flexible and boundless the options to refine efficiency and effectiveness of patient-centered care.

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Part II

Identifying Evidence-Based Approaches to PHM

Chapter 5
Poly Chronic Disease Epidemiology: A Global View

Abstract The delivery and quality of health care for patients with poly chronic conditions can be improved through a comprehensive understanding of the patterns and trends of disease occurrence. Epidemiological studies examine the trilogy of agent, host, and environmental relationships to health or illness. Applying fundamental epidemiologic principles to the study of poly chronic diseases provides the opportunity to identify the influential individual and contextual factors that need to be addressed in order to improve the health care and outcomes for patients with multiple chronic conditions. One promising analytical strategy is to leverage the available massive data from varying sources, develop predictive analytical models, and formulate clinical and administrative decision support systems to improve patient-centered care and self-care management of chronic disease. Prevention of poly chronic conditions is a highly feasible option to realize optimal health of the population.

Keywords Epidemiological trilogy • Agent • Host • Environment • Predictive analytics • Data science • Prevention • Patient-centered care • Self-care management

5.1 Descriptive Chronic Disease Epidemiology

The delivery and quality of health care for patients with poly chronic conditions can be improved through a comprehensive understanding of the patterns of disease occurrence. The rates of comorbidity are higher for some chronic conditions and lower for others. Such variations in the coexistence of specific types of chronic conditions add to the complexity of providing these patients with effective and efficient treatment and coordinated care plans (CMS 2012). A systematic review of multimorbidity prevalence, determinants, and patterns in primary care showed that the most frequent disease patterns reported in observational studies were combinations including osteoarthritis and a cardio-metabolic cluster of conditions (e.g., high blood pressure, diabetes, obesity, and ischemic heart disease) (Violan et al. 2014).

Among Medicare beneficiaries with at least three chronic conditions, the five most common disease triads were identified as (1) high cholesterol, high blood pressure, and ischemic heart disease; (2) high cholesterol, high blood pressure, and diabetes; (3) high cholesterol, high blood pressure, and arthritis; (4) high cholesterol, diabetes, and ischemic heart disease; and (5) high cholesterol, ischemic heart disease, and arthritis.

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Table 5.1 List of mostly costly triads of disease with their associated prevalence and cost per capita (Cheng et al. 2015)

Five most prevalent triads	Prevalence (%)	Per capita ($)
High cholesterol, high blood pressure, and ischemic heart disease	33.7	$19,836
High cholesterol, high blood pressure, and diabetes	29.9	$17,451
High cholesterol, high blood pressure, and arthritis	25.7	$18,238
High cholesterol, diabetes, and ischemic heart disease	21.5	$25,014
High cholesterol, ischemic heart disease, and arthritis	19.3	$24,539
Five most costly triads		
Stroke, chronic kidney disease, and asthma	0.2	$69,980
Stroke, chronic kidney disease, and COPD	0.8	$68,956
Stroke, chronic kidney disease, and depression	0.8	$65,143
Stroke, chronic kidney disease, and heart failure	1.5	$63,242
Stroke, heart failure, and asthma	0.3	$62,819

The five most costly triads were identified as (1) stroke, chronic kidney disease, and asthma; (2) stroke, chronic kidney disease, and COPD; (3) stroke, chronic kidney disease, and depression; (4) stroke, chronic kidney disease, and heart failure; and (5) stroke, heart failure, and asthma. Table 5.1, adapted from the 2012 Chronic Conditions among Medicare Beneficiaries Chartbook developed by the US Centers for Medicare and Medicaid Services, shows the percentages of patients and per capita costs for each of the most prevalent and most costly triads.

Broadly, the objectives of descriptive epidemiology have been identified as (1) to permit evaluation of trends in disease and health; (2) to provide a basis for health service planning, provision, and evaluation; and (3) to identify problems and areas to be investigated by analytic methods. The field of descriptive epidemiology focuses on describing patterns of disease occurrence with respect to characteristics of time, person, and place (Friis and Sellers 2014). These measures of time, person, and place can be used in the study of health problems to identify at-risk populations, subgroups, and areas, prioritize issues, assess trends, and evaluate program and policy efficacy in achieving health-related goals (Oleske 2009). In descriptive chronic disease epidemiology, these fundamental elements of time, person, and place can be studied to better understand the determinants of chronic disease development in populations and inform efforts to devise preventive strategies that take into consideration individual-level and contextual factors.

5.1.1 Time

Time is a factor that influences disease frequency, which can be described as incidence (i.e., the number of new disease cases diagnosed during a period of time) or prevalence (i.e., the number of cases of disease diagnoses at a given moment) (Krickeberg et al. 2012). A better understanding of disease patterns, effects on quality of life, and health-care costs can be obtained by monitoring the prevalence of poly chronic conditions over time (Gerteis et al. 2014). Understanding temporal aspects of disease progression in individuals, which often occurs over years or even decades for some chronic conditions, and disease occurrence in populations can assist with identifying influential factors and opportunities for intervention. In a study of the epidemiology of multimorbidity, Barnett et al. (2012) found that there was a 10–15-year difference in the onset of multimorbidity between population groups, with an earlier occurrence in those in socioeconomically deprived areas compared to more affluent areas. Thus, time is a critical element of chronic disease epidemiology.

5.1.2 Person

Numerous personal or host characteristics may influence the epidemiology of chronic disease, including factors such as age, gender, race, ethnicity, and personal behaviors. Personal behaviors are particularly important given that altering certain behaviors and risk factor exposure, such as dietary practices, exercise, stress management, smoking, and alcohol consumption, can prevent the development or minimize the severity of some chronic diseases (Timmreck 1998). For example, when compared to pharmacotherapy, lifestyle interventions have been found to more effectively reduce the risk of prediabetes development in patients with manifestations of metabolic syndrome and the progression to type 2 diabetes in patients with prediabetes (Mayans 2015).

While personal behaviors can be altered by lifestyle modifications, that is not the case for most elements of the person. Factors such as race/ethnicity and age are important personal characteristics to consider in the study of chronic disease development. For example, when compared to Europeans, Asians have been shown to be at risk for type 2 diabetes at a much lower obesity level (Kaur 2014). Additionally, African Americans have been found to have higher rates of obesity, insulin resistance, and hypertension, which are risk factors associated with chronic conditions such as diabetes and cardiovascular disease (Ryan et al. 2010).

Advanced age is often associated with poly chronic conditions. Nearly one-third (31.5%) of the US population was reported to have more than one chronic condition in 2010. Among adults aged 65 and older, 80% had multiple chronic conditions (Gerteis et al. 2014). An examination of Medicare beneficiaries determined that in 2011, 67.3% of these patients had two or more chronic conditions, while 14% had six or more (Lochner et al. 2013). Thus, the increase of an aging population brings great urgency to the need for effective and efficient interventions for patients with poly chronic conditions.

5.1.3 Place

An understanding of the determinants of chronic diseases may be informed by the ways in which disease occurrence varies by location. Differences in disease frequency among neighborhoods, counties, states, countries, or other specified settings help facilitate further analyses of place-based characteristics that may be influencing chronic disease development. The traditional approach to health care in the United States has been to focus on individual diseases, thus requiring health-care providers who are disease specialists. Socially deprived population groups are likely to have less access to the specialist services needed. Given that these individuals are also more likely to have multiple morbidities, which would require more types of specialists, such populations may be more vulnerable to experiencing adverse effects and costly, uncoordinated care (Starfield 2011). A more patient-centered approach in caring for patients with poly chronic conditions provides the opportunity to address the multifaceted needs and challenges associated with place-related factors.

5.2 Epidemiological Triad or Etiology

The epidemiological triad includes the agent, host, and environment. It is a triangular model that allows for the conceptualization that the cause of health problems may be due to the interaction of factors rather than just a single factor, and health problems can be diminished or prevented by modifying or severing any side of the triangle (Oleske 2009). Thus, it is important for studies of chronic disease epidemiology not only to examine factors of each of the three individual model components but also to explore the interrelatedness or interactions of factors in order to facilitate a better understanding of the potential causes for poly chronic disease development and occurrence and the ways in which they can be prevented.

5.2.1 Agent

Agent is the term used to refer to a factor that must be present for disease to occur. For some conditions, the occurrence may be attributable to multiple causes, and thus there is more than one agent contributing to the given illness (Timmreck 1998). Certain diseases predispose other diseases or conditions, and individuals with chronic conditions are vulnerable to having a greater number of various illnesses (Starfield 2011). Therefore, the agent, or agents, to consider in patients with poly chronic conditions may be the presence of other illnesses or complications related to such illnesses.

5.2.2 Host

The human harboring the disease is referred to as the host. The effect that a disease has on an individual can be determined by numerous factors within the host, such as health status, the level of physical fitness, genetic makeup, the level of immunity, and levels of exposure (Timmreck 1998). As noted previously, the presence of one chronic condition may be predisposing to the occurrence of others. Individuals with multiple chronic conditions are likely to have an overall diminished level of health, in addition to various genetic or behavioral characteristics that may have contributed to the initial onset of disease. Analysis of national survey data collected in England showed an association between decreased health-related quality of life and the number of chronic conditions; in individuals with diabetes, the presence of multiple chronic conditions was associated with substantially worse health-related quality of life compared to other long-term conditions (Mujica-Mota et al. 2015).

5.2.3 *Environment*

Environment refers to the conditions or surroundings within the host or external to it in the community. Environmental aspects include biological, social, cultural, and other external physical factors (Timmreck 1998). Socioeconomic factors have been shown to impact the occurrence and severity of disease. The direction of this association among individuals with poly chronic conditions has been shown to vary in different population groups. In Scotland, individuals living in socioeconomically deprived areas were shown to experience higher rates of multimorbidity and be more likely to have both physical and mental health conditions (Barnett et al. 2012). A study of multimorbidity in China reported an association between higher household income and increased prevalence of self-reported multimorbidity. While additional research would be needed to clarify this, it is possible that this reflects patterns of some more affluent brackets making unhealthy lifestyle changes or that there are lower rates of diagnosed conditions among individuals with lower incomes due to health-care affordability and adequacy (Wang et al. 2014).

5.2.4 *Interactions of Agent, Host, and Environment*

A better understanding of factors contributing to poly chronic disease development and occurrence requires assessment and analysis of the interactions of (1) agent and host, (2) host and environment, (3) agent and environment, and (4) agent, host, and environment. Uncovering such interaction effects, however, can be quite complex given the multifaceted individual and contextual factors associated with poly chronic disease. Take, for example, cardiovascular diseases, which typically develop subsequently to conditions such as obesity, hypertension, and type 2 diabetes. Primary risk factors at the root of pathways for cardiovascular diseases include age, gender, ethnicity, smoking, dietary practices, physical inactivity, and psychosocial and socioeconomic factors (Krickeberg et al. 2012). The interaction effects of such risk factors, however, vary across individuals and populations, thus highlighting the need for evidence-based predictive tools in order to better determine the interrelatedness and synergistic impact of various factors on the presence of poly chronic conditions.

5.3 Epidemiology of Poly Chronic Conditions Associated with Metabolic Syndrome

Metabolic syndrome has been generally defined as “a cluster of conditions—increased blood pressure, high blood sugar, excess body fat around the waist, and abnormal cholesterol or triglyceride levels—that occur together,” which increase the risk of serious disease, including heart disease, stroke, and diabetes (Mayo Clinic 2017). There is an approximately fivefold increase in diabetes developing among individuals diagnosed with metabolic syndrome. The risk for developing cardiovascular disease increases twofold; however, the diagnosis of diabetes is already a risk factor for cardiovascular disease (Mayans 2015; Samson and Garber 2014). Factors pertaining to individuals’ genetic background, health and lifestyle behaviors, environment, and socioeconomic status can influence metabolic syndrome. The prevalence of metabolic syndrome has been found to vary depending on the definition used, as well as population characteristics such as age, sex, race, ethnicity, body weight, physical activity, smoking, education level, family history, and geographic region (Rao et al. 2014; Kaur 2014). The interactions among these factors, which can be categorized as components of the agent, host, or environment, provide the insight needed to better understand what triggers the manifestation of chronic diseases. Given what is currently known about the risks associated with metabolic syndrome, particularly its link to diabetes, there is an important need for additional research concerning the epidemiology of poly chronic conditions associated with metabolic syndrome to address the questions surrounding this issue.

Reducing the risk of type 2 diabetes is one of the primary goals of managing metabolic syndrome. Metabolic syndrome often coexists with prediabetes, with approximately half of those with prediabetes meeting the criteria for metabolic syndrome diagnosis. While the criteria used to diagnose each of the two conditions differ, they share many of the same comorbidities, and the coexistence of these two conditions increases the risk of cardiovascular disease above the risk associated with only prediabetes (Hood et al. 2017; Mayans 2015).

The Centers for Disease Control and Prevention (CDC) estimates that 29.1 million people in the United States are affected by diabetes. Of these individuals, 21 million have been diagnosed with diabetes, primarily type 2, while 8.1 million people meet clinical criteria, but remain undiagnosed (CDC 2014). The prevalence of type 2 diabetes varies by age, ethnicity, and geographic area. New cases of type 2 diabetes occur most commonly in adults between the ages of 45 and 64 and will have a significant impact on health as individuals age. Type 2 diabetes occurs more commonly in people of non-Hispanic black, Hispanic, Asian/Pacific Islander, and American Indian/Native Alaskan ethnic backgrounds. Nationally, the prevalence of diabetes is 9.0/100 people. Southern states have the highest prevalence rates of diagnosed diabetes. State-specific prevalence rates in this region are as follows (Table 5.2):

Prediabetes is a major risk factor for progression to type 2 diabetes. Approximately 70% of individuals with prediabetes will develop type 2 diabetes (Hood et al. 2017;

Table 5.2 The prevalence rate of diabetes by state

State	Diabetes prevalence/100
United States	9.0
Florida	9.4
Georgia	10.4
South Carolina	11.3
North Carolina	10.5
Tennessee	11.1
Arkansas	10.5
Kentucky	10.1
Louisiana	10.8
Mississippi	12.0
Alabama	12.7

Source: Centers for Disease Control National Diabetes Surveillance System (http://gis.cdc.gov/grasp/diabetes/DiabetesAtlas.html)

Nathan et al. 2007). It is estimated that 86 million Americans are affected by prediabetes. Obesity is one of the greatest risk factors for this condition. It is estimated that only 11% of the individuals who meet diagnostic criteria for diabetes are aware of this and thus able to act on lifestyle changes that may reduce diabetes risk. The Behavioral Risk Factor Surveillance System utilized self-report data to estimate the prevalence of prediabetes nationally and by state. As shown below, the majority of Southern states have a prevalence rate of prediabetes that is higher than that of the US rate (Table 5.3).

Because these data are based upon self-report and diagnosis of prediabetes, it can be assumed that actual rates of prediabetes are much higher. It is estimated that prediabetes is responsible for $44 billion in national health-care expenditures, primarily related to the association with cardiovascular disease, hypertension, retinopathy, and mortality. Obesity is the primary risk factor for prediabetes and its progression to type 2 diabetes. In all states in this region, obesity affects more than 26% of adults, while diabetes affects more than 9% of each states' population (CDC 2015). (Note: There are county-level stats that can be drilled down. There are some rural counties in west/central Florida and the outskirts of Tallahassee with diabetes prevalence rates that approach or exceed 15% (http://www.cdc.gov/diabetes/atlas/countydata/atlas.html).

The alarming public health burden of diabetes emphasizes the importance of better understanding metabolic syndrome given what is known of the increased risk of disease progression when certain conditions coexist. Several prominent organizations have put forth definitions regarding the criteria for clinical diagnosis of metabolic syndrome. A comprehensive review by Kaur (2014) states that most commonly used clinical criteria come from the World Health Organization (WHO), the European Group for the study of Insulin Resistance (EGIR), the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), the American Association of Clinical Endocrinologists (AACE), and the International Diabetes

Table 5.3 The age-adjusted rate of prediabetes by state

State	Age-adjusted prediabetes rate
United States	6.5
Florida	6.6
Georgia	6.7
South Carolina	6.5
North Carolina	6.7
Tennessee	14.1
Arkansas	5.4
Kentucky	8.2
Louisiana	8.0
Mississippi	6.2
Alabama	6.8

Source: Centers for Disease Control National Diabetes Surveillance System (http://gis.cdc.gov/grasp/diabetes/DiabetesAtlas.html)

Federation (IDF). These definitions share common features, including clinical measures for insulin resistance, body weight, lipid levels, blood pressure, and glucose. However, there are several differences in the parameters for these body measurements and laboratory tests (Kaur 2014).

The variability in the parameters of clinical measurements for defining metabolic syndrome has been described as potentially problematic for several reasons. One issue pertains to applicability across ethnic groups. The NCEP and WHO definitions have been considered as potentially problematic in this regard, particularly when attempting to determine obesity cutoff values. The relationship between body weight and waist circumference measures, and the risk of cardiovascular disease and type 2 diabetes, is not the same for all populations. As such, the IDF put forth criteria with specific ethnic/racial cutoff values to account for the different distributions of norms in distinct populations and nationalities. Additionally, the diagnostic criterion developed by NCEP, and later adopted by IDF, has been described as facilitating greater clinical and epidemiological applicability given that the measurements and lab results used are readily available to physicians. In the other three definitions, insulin resistance is a major focus, which is determined by a labor-intensive method primarily utilized in the research setting (Kaur 2014). Given that the differential parameters of clinical measurements used to diagnose metabolic syndrome can be problematic for the applicability of such definitions across provider settings and ethnic groups, it is important for the public health community to continue communication and collaboration to ensure that the predictive value of these definitions for the risk of developing chronic conditions.

While the lack of standardization in defining metabolic syndrome may present challenges, the association between the syndrome and risk for serious chronic conditions has been shown to exist, however defined, throughout the literature. In a study of metabolic syndrome and cardiovascular disease risk in Dutch men and women who did not have diabetes or a history of cardiovascular disease, four of these definitions were compared. The prevalence of metabolic syndrome was shown to vary based on the definition used. Using the NCEP, WHO, EGIR, and ACE definitions, the prevalence was 19%, 32%, 19%, and 41% in men and 26%, 26%, 17%, and 35% in women, respectively. However, results showed that for both men and women, metabolic syndrome was associated with an increased risk of cardiovascular morbidity and mortality, regardless of the definition used (Dekker et al. 2005).

In the epidemiology of cardiovascular diseases, metabolic syndrome can be viewed as an intermediate step in a pathway. For metabolic syndrome, type 2 diabetes, and cardiovascular diseases, many of the risk factors are the same. These conditions, however, often occur sequentially. Krickeberg et al. (2012) report that upward of 70% of type 2 diabetes patients die of cardiovascular diseases. Thus, interventions to halt the development or progression from one condition to the next can reduce the poly chronic conditions. Empirical evidence regarding the specificities associated with time and manifestation of these diseases is critically needed in order to design appropriate intervention strategies.

The development of serious health problems can be delayed or prevented through “aggressive lifestyle changes” by individuals who have metabolic syndrome or its components (Mayo Clinic 2017). For some patients, pharmacological treatments may be incorporated into the management of metabolic syndrome to reduce certain risk factors when lifestyle changes alone are not sufficient. Risk assessment is important given that the reduction of short-term risk and lifetime risk should be the goals of therapy (Kaur 2014). Intervening before chronic conditions have developed, and preventing the manifestation of subsequent comorbidity, requires preventive strategies at multiple levels.

5.4 Preventive Strategies of Poly Chronic Conditions

Health-care services are generally characterized by three different levels. The first level, primary care, describes entry into the health-care system through a patient visiting a medical care provider. Secondary care typically involves minor procedures or routine care and is provided in a hospital, in a nursing home, or by a home health agency. Tertiary care is the highest level, which may include advanced surgical procedures and care by specialists. Similarly, three levels of prevention have also emerged from this clinical model: primary prevention, secondary prevention, and tertiary prevention (Timmreck 1998). Given the complex and unique needs of patients with poly chronic conditions, multilevel prevention strategies may be employed to prevent the development or advancement of additional health conditions.

5.4.1 Primary Prevention

Primary prevention involves public education to raise awareness of chronic conditions and encourage lifestyle changes before illness has presented. A preventive model for improved outcome (O) or health-related quality of life with the population health intervention strategy coupled with changes in knowledge (K), motivation (M),

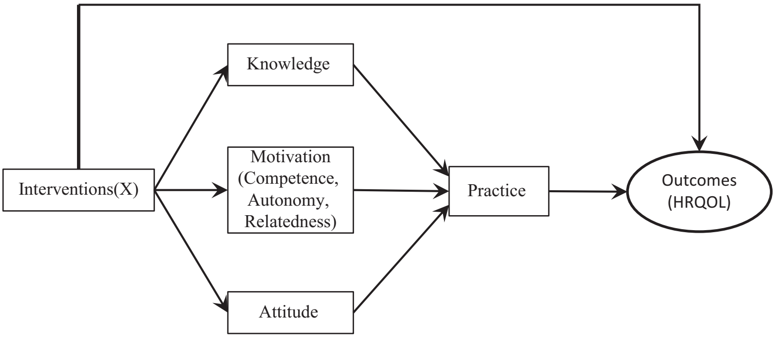

Fig. 5.1 The KMAP-O model: a theoretical preventive model

attitude (A), and practice (P) is proposed for the prevention of poly chronic conditions (Wan et al. 2017) (Fig. 5.1).

The motivation component of the KMAP-O model is based on self-determination theory (SDT; Deci and Ryan 1985, 2002), which has become extremely popular for understanding motivation and promoting well-being in health prevention, especially in the physical exercise domain (Frederick-Recascino 2004; Wilson et al. 2006). According to Deci and Ryan (2004), human motivations differ along a regular continuum ranging from fully constrained to fully self-determined, and self-determined motivation nurtures positive consequences including behavioral persistence and psychological and physical well-being. Underlying the self-determination theory is the core component of psychological needs. Unlike the traditional need theories that view psychological needs as motivating forces, such as personal desires and goals, Deci and Ryan (2002) argued that psychological needs represent the fundamental conditions that nourish growth, well-being, and health, thus providing a vital route for fostering interventions of health behaviors and promoting well-being. The psychological needs highlighted by the self-determination theory are the needs for competence, autonomy, and relatedness (Deci and Ryan 1985, 2002), which are critical motivations for successful intervention practice and adherence.

Competence refers to the efficacy of mastering challenging skills to effectively interact with the environment and perform tasks (White 1959). For health intervention specifically, it refers to confidence in one's own ability to practice interventions. One strategy for improving patients' competence is to develop an education component in the intervention and teach patients the behaviors that are needed for successful intervention and the basic principles of goal setting. Goal setting is an effective strategy and an important aspect of any health and wellness intervention (Conn et al. 2011). For example, setting process goals (e.g., maintaining a heart rate above 140 BPM for 30 min) yielded higher levels of interest and enjoyment and even exercise adherence than setting outcome goals (e.g., losing 10 pounds in 8 weeks) or no-goal control group (Wilson and Brookfield 2009).

Autonomy refers to the feeling of personal agency and a sense of internal locus of control (deCharms 1981). To apply this principle to the health intervention domain, we allow patients to choose the wellness goals that are ideally suited to their individualized needs. In addition, we also allow flexible schedules and tailor intervention activities according to each patient's ability level, preference, and lifestyle.

Finally, relatedness refers to a sense of meaningful connection to others in one's social environment (Baumeister and Leary 1995). In a study, providing a group network of social support to patients was expected to motivate intervention adherence and reinforce health behaviors (Williams et al. 2002). Previous research suggests that forming a social support group with individuals who are facing similar challenges and health problems can help group problem-solving and foster social reinforcement and encouragement. Indeed, this group-forming, social support strategy has been successfully applied to many health promotion and intervention such as pregnancy and HIV (Westdahl et al. 2007; Rich et al. 2012). In the context of chronic condition prevention, we could adopt social network techniques to understand the effect of relatedness and social support on the intervention practice adherence and outcome.

Several measurement instruments relevant to the KMAP-O model are suggested as follows:

(i) *Knowledge Scale.* Many disease-specific instruments are currently available. Useful information can be viewed on the website healthytutor.com. For instance, knowledge about hypertension and its prevention could rely on a respondent's responses to a multi-item scale of hypertensive knowledge; each response to an item could be given a score of 1 for a correct answer and 0 for an incorrect answer. A summative scale could be constructed by averaging the total correct score.

(ii) *Self-Determination Motivation Scale.* The self-determination motivation scale can be adapted from the Psychological Need Satisfaction in Exercise Scale originally developed by Wilson et al. (2006). This scale has three subscales, representing perceived competence, perceived autonomy, and perceived relatedness, respectively. Some sample items for the competence subscale include "I feel that I am able to complete exercises that are personally challenging" and "I feel confident in my ability to perform exercises that personally challenge me." Some sample items for the autonomy subscale include "I feel free to exercise in my own way" and "I feel free to make my own exercise program decisions." Some sample items for the relatedness subscale include "I feel attached to my exercise companions because they accept me for who I am" and "I feel like I share a common bond with people who are important to me when we exercise together."

(iii) *Attitudinal Scale.* Generally, attitude can be assessed in terms of cognition (aware or not aware), affect (like or dislike), and behavioral propensity (likely to act or not to act). Attitudes toward a given preventive effort can be measured by multiple relevant questions, using the Likert scale to sum the total-item scores together.

(iv) *Preventive Practice.* Actual behaviors or actions in a specific time frame (such as per week, month, quarter, or year) can be observed or gathered from a personal diary or self-reported responses to a series of questions on preventive actions or practices.

(v) *Outcome Assessment.* A series of health-related outcome measures can be collected. They may include (1) EuroQol Quality of Life Scale, (2) CES-Depression 10-Item Scale, (3) physical fatigue, (4) self-perceived health and weight, (5) adherence measures, (6) weight and height, (7) metabolic and non-invasive measures of body composition, (8) physical health, and (9) clinical lab tests such as metabolic syndrome or the A1C level.

The psychometric properties of each assessment instrument should be documented and empirically validated by the data, using both principal component factor analysis and confirmatory factor analysis. Multi-wave assessments should be made for each participant during the study period in each racial cohort; the stability of the scale or measurement over time can be examined by using four waves of data in growth curve modeling (Wan 2002).

5.4.2 Secondary Prevention

Secondary prevention involves early diagnosis, symptom management, and treatment for conditions before they manifest into chronic disease. For preventing the development of poly chronic conditions, it is imperative to investigate and understand the disease progression and its trajectory. Disease staging or transition from one to another chronic condition should be better explored from a large-scale epidemiological study. For instance, if we know the timeframe when obesity or hypertension may lead to the presence of other metabolic syndromes, the urgency for taking further preventive steps in achieving the goals of secondary prevention is better identified. Furthermore, the Taiwanese National Health Insurance implemented an incentive program (called the pay-for-performance) to offer intensive case management for diabetes and achieve an optimal level of glucose control. Consequently, it resulted in cost reduction for hospitalization and readmission.

5.4.3 Tertiary Prevention

Tertiary prevention involves strategies to keep conditions from progressing once a chronic disease has developed. Among patients with poly chronic conditions, the prevention of hospitalization is critical to improving health-care costs and outcomes. Analysis of patients who were hospitalized for potentially preventable acute and chronic conditions showed that multiple chronic conditions were present in more than 90% of patients hospitalized for ambulatory care sensitive chronic conditions and in approximately 80% of patients hospitalized for potentially preventable acute conditions (Skinner et al. 2016). Several chronic conditions such as heart failure, hypertension, COPD, asthma, diabetes, etc. are often considered ambulatory care sensitive conditions that should be properly treated or monitored through primary care. Hospital readmissions for these conditions should be preventable or avoided. Thus, the tertiary prevention of chronic conditions should go beyond the conventional approach to chronic disease care.

Evidence-based practice in chronic care has been well documented in recent publications of the *International Journal of Integrated Care*, particularly advocating the integration of formal care with informal care in a nonmedical model for long-term care patients in numerous European countries. These include the Netherlands' memorial care center, Swiss home care, Norway's personalized care, and Finland's chronic care. Innovative chronic care models with the assistive technology and health information technology for heart failure begin to emerge to encourage patient engagement and community participation in solving chronic care problems (Williams and Wan 2016). Concomitantly, medical professionals have broadened the medical perspective to include clinical case management or disease management strategies, coupled with mobile health technology that are geared to delay or postpone the presence of comorbidities or poly chronic conditions for targeted groups of patients with diabetes. In Taiwan, Hsu et al. (2015) targeted a group of obese diabetes patients whose body mass index was greater than 35 for bariatric surgery. They demonstrated a substantial beneficial effect of the procedure in a 5-year outcome study. Similarly, preventive strategies targeting for patients with high-risk factors such as high blood pressure, abnormal cholesterol level, and dyslipidemia could also reduce the preventable premature death from heart disease.

5.4.4 Multilevel Strategy

Prevention strategies that incorporate multiple levels can be employed for patients with chronic illnesses to prevent additional comorbidities. Patients with poly chronic conditions are likely to require multilevel preventive strategies given the complexity of their health status and health-care needs. For example, individuals who undergo particular screening tests and are identified as having metabolic syndrome can be introduced to behavioral interventions involving diet, exercise, weight management, and smoking cessation, which reduce the underlying risk factors for multiple chronic illnesses (Ryan et al. 2010). Furthermore, the likelihood of hospitalization or high utilization of health services among patients with poly chronic conditions can be reduced through interventions aimed at behavioral change and interventions to promote screening and symptom management.

5.5 Concluding Remarks

While the incidence of many chronic diseases generally can be attributed to the aging process and lifestyle, the causal or risk factors of chronic disease are impacted by multifaceted behavioral, environmental, biological/genetic, and social influences (Timmreck 1998). Applying fundamental epidemiologic principles to the study of poly chronic diseases provides the opportunity to identify the influential individual and contextual factors that need to be addressed in order to improve the health care and outcomes for patients with multiple chronic illnesses. One promising analytical strategy is to leverage the available massive data from varying sources, develop predictive analytical models, and formulate clinical and administrative decision support systems to improve patient-centered care and self-care of chronic disease.

Intervention strategies that incorporate the appropriate preventive care aspects are critical. Preventive efforts based on existing empirical evidence and the distinct needs of patients can be developed and implemented to slow the development of chronic disease. However, additional research using large, longitudinal data and transdisciplinary collaboration is needed to better understand the trajectory of disease development, its magnitude and impact, and the ways in which the health-care system can optimally serve patients with poly chronic conditions. Concerted efforts are needed to integrate population health programming with care management technologies through the investigation of social and individual determinants of health and the engagement of community participation in preventing poly chronic conditions.

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Chapter 6

Strategies to Modify the Risk for Heart Failure Readmission: A Systematic Review and Meta-analysis

Abstract Human factors play an important role in health-care outcomes of heart failure patients. A systematic review and meta-analysis of clinical trial studies on heart failure hospitalization may yield positive proofs of the beneficial effect of specific care management strategies.

We investigate how the eight guiding principles of choice, rest, environment, activity, trust, interpersonal relationships, outlook, and nutrition may reduce heart failure (HF) readmissions.

Appropriate keywords were identified related to the (1) independent variable of hospitalization and treatment, (2) moderating variable of care management principles, (3) dependent variable of readmission, and (4) disease of HF to conduct searches in nine databases on clinical trial studies. In the meta-analysis, data were collected from studies that measured HF readmission for individual patients. The results indicate that an intervention involving any human factor principles may nearly double an individual's probability of not being readmitted. Interventions with human factor principles reduce readmissions among HF patients. Overall, this review may help reconfigure the design, implementation, and evaluation of clinical practice for reducing HF readmissions in the future.

Keywords Heart failure readmission • Care management strategies • Moderating effects • Human factors in heart health care • Risk reduction approach • Meta-analysis

6.1 Introduction

Heart failure (HF) is a chronic and progressive condition in which the heart muscle is unable to pump enough blood to meet the body's need for blood and oxygen (American Heart Association 2015). Placement into class I, II, III, or IV of the New York Heart Association (NYHA) Functional Classification depends on the severity of patient symptoms and physical activity limitations (American Heart Association 2015). HF is a leading cause of hospitalization and health-care costs in the United States. Nearly 5.1 million Americans have been diagnosed with HF, and approximately half die within 5 years of diagnosis (Centers for Disease Control

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and Prevention website 2016; Go et al. 2013). The total costs of HF to the nation, in terms of direct medical costs and lost productivity, are estimated to be $32 billion annually. Congestive HF is the most common reason for readmission among Medicare fee-for-service patients (Jencks et al. 2009), and up to 25 percent of HF patients are readmitted within 30 days (Dharmarajan et al. 2013). An analysis of Medicare claim data from 2007 to 2009 showed that 35 percent of readmissions within 30 days were for HF (Dharmarajan et al. 2013). Section 3025 of the Affordable Care Act amended the Social Security Act to establish the Hospital Readmissions Reduction Program (HRRP), which requires the Centers for Medicare and Medicaid Services to decrease reimbursements to hospitals with excessive risk-standardized readmissions (Centers for Medicare and Medicaid Services website 2016). This program encourages hospitals to develop interventions to reduce readmission rates for HF patients. Increasingly, care management practices incorporate human factors that can influence the relationship between therapeutic interventions and patient outcomes.

In a search for the causal mechanisms for enhancing patient care outcomes, this investigation explored how scientific literature has documented the moderating influence of varying care management principles involving human factors on hospital outcomes of HF patients. A systematic review of intervention strategies was conducted, and a broad range of intervention types aimed at reducing HF readmissions was included. The selected intervention components included education and assessment, rest and relaxation, exercise, interpersonal relationships, outlook, and dietary recommendations. The systematic review and meta-analysis aimed to answer the following research questions:

1. Is there evidence that particular intervention components may modify the care management effects on HF readmission?
2. Does a single intervention component work more effectively than a combination of intervention components in care management for HF patients?
3. How can the knowledge gained from the systematic review and meta-analysis be applied in population health management for HF?

6.2 Materials and Methods

6.2.1 Data Sources and Searches

Appropriate keywords were identified related to (1) the independent variable of hospitalization and treatment, (2) the moderating variable of intervention components, (3) the dependent variable of readmission, and (4) the heart failure. Combinations with one keyword from each of the four categories (see Table 6.1) were used to conduct searches in nine databases: CINAHL, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, ERIC, MEDLINE, PubMed, PsycINFO, ScienceDirect, and Web of Science.

Table 6.1 List of keywords for database searches

Variable	Keywords
Heart failure	Heart failure
Intervention	Medicine, medication, hospital, inpatient, outpatient, health education, behavior modification, motivational interviewing
Outcome	Rehospitalization, readmission, health-related quality of life
Education/assessment	Internal-external control, choice behavior, responsibility, goal setting
Rest/relaxation	Relaxation, rest, sleep
Environment	Built environment, pollution
Exercise	Leisure activities, exercise, recreation, sports
Religion/spirituality	Trust, belief, higher power, religion, spirituality
Interpersonal relationships	Family relations, interpersonal relations, sibling relations, professional-family relations, professional-patient relations, social participation, social capital
Outlook	Mindfulness, control, self-efficacy, emotion*, optimism, stress*
Dietary	Food habits, meals, food preferences, food security

*Statistically significant at 0.05 or lower level

Although systematic reviews were not included in the meta-analysis, the Cochrane Database of Systematic Reviews was searched in case any similar studies existed.

6.2.2 *Study Selection, Data Extraction, and Quality Assessment*

Table 6.2 shows the inclusion and exclusion criteria in regard to population, interventions, outcomes, timing of outcomes, time period, settings, publication language, design, and publication format. Only studies associated with HF hospitalization and readmissions, published in English, Chinese, French, German, Italian, Portuguese, or Spanish between January 1, 1990, and August 31, 2015, were compiled.

Retrospective studies were excluded. Studies that evaluated interventions focused only on pharmaceuticals, surgical procedures, technology, or other therapeutic strategies, and not incorporating any of the selected human factors, were excluded. Each selected study was reviewed by a team of five graduate students with training in rating the quality. The detailed characteristics of cited studies are listed in Appendix 1.

6.2.3 *Data Synthesis and Analysis*

Studies focused on HF and other chronic illnesses and reported the number of readmissions for HF patients only if they met the inclusion criteria. All studies that reported the number of persons readmitted in each group were included in the meta-analysis. Although a study that only reported the total number of readmissions per group was included in the systematic review, it was not included in the

Table 6.2 Inclusion and exclusion criteria for studies of interventions in patients hospitalized for HF

Category	Inclusion criteria	Exclusion criteria
Population	Adults with heart failure	Children and adolescents
Interventions	Interventions that include one or more of the components listed	Interventions that do not incorporate one or more of the components listed
Outcomes	Readmission to hospital	Only a quality of life or functional status outcome with no mention of readmission to hospital
Timing of outcome	Outcomes occurring within 24 months of hospitalization	Outcomes occurring more than 24 months after hospitalization
Time period	Studies published from January 1, 1990 to August 31, 2015	Studies published before January 1, 1990, or after August 31, 2015
Settings	Interventions occurring during hospitalization before discharge; interventions occurring in an outpatient setting after discharge from hospital; interventions bridging the transition from inpatient to outpatient care	All other settings, such as discharge from hospital to a skilled nursing facility or rehabilitation center
Publication language	English, Chinese, French, German, Italian, Portuguese, Spanish	Any other languages
Design	Original research; randomized controlled trials (RCTs); nonrandomized controlled trials; prospective cohort studies with comparison group	Case reports; case-control studies; retrospective cohort studies
Publication format	Peer-reviewed articles in an academic journal	Books; book reviews; continuing education units (CEUs); conference abstracts; dissertations; nonsystematic reviews; systematic reviews; editorials; letters to the editor

meta-analysis. Additionally, studies in the systematic review could not be included in the meta-analysis if they evaluated multiple intervention groups and a control group rather than only one intervention group and one control group or if the study reported numbers for only composite outcomes, such as readmission and death.

In the Comprehensive Meta-Analysis software (Comprehensive meta-analysis website 2015), a mixed effect model was used to synthesize effect sizes from independent studies, which were also categorized into subgroups based on the moderator variable of intervention components. A random effect model was used to combine studies within each subgroup, and a fixed effect model was used to combine subgroups and yield the overall effect. The study-to-study variance was not assumed to be the same for all subgroups. This is the method used by Review Manager (RevMan) (Comprehensive meta-analysis website 2015). The odds ratio (OR) was represented by the odds of avoiding HF readmissions, given an exposure to an intervention involving one or more intervention components. A funnel plot of log odds ratio was created to test for publication bias.

6.3 Results of Systematic Review

A flow diagram of the systematic review of literature is shown in Fig. 6.1. The characteristics of the 113 included studies are shown in the Appendix. The interventions were grouped by components. Limited biases were introduced since only studies with proven quality were included. The empirical evidence provided by the systematic review is summarized in this section.

6.3.1 *Education and Assessment*

Eleven studies incorporated education and assessment (Bailón et al. 2007; Brotons et al. 2009; Cordisco et al. 1999; Domingues et al. 2011; Gambetta et al. 2007; Grundtvig et al. 2011; Hägglund et al. 2015; Hudson et al. 2005; Linden and Butterworth 2014; Miller and Cox 2005; Stewart et al. 1998). In eight of these studies, readmissions were significantly lowered. These interventions included:

- Patient education during hospitalization and post-discharge telemonitoring for reinforcement of education and assessment of patients (Hägglund et al. 2015) or post-discharge home visits and monthly calls for reinforcement, assessment, and medication compliance (Brotons et al. 2009)
- Phone calls after discharge for patient education, assessment of symptoms and compliance, and review of medication adherence (Hudson et al. 2005)
- Post-discharge patient education at outpatient clinics, assessment of symptoms, and compliance during clinic visits (Grundtvig et al. 2011) or during follow-up calls every 2–4 weeks (Bailón et al. 2007)
- Post-discharge assessments of medication adherence, symptoms/health, and compliance through a single home visit 1 week after discharge (Stewart et al. 1998), through daily telemonitoring and outpatient clinic visits every 1 to 2 weeks (Gambetta et al. 2007) and through a daily telemonitoring system (Cordisco et al. 1999)

6.3.2 *Exercise*

Four studies incorporated exercise (Belardinelli et al. 1999; Dracup et al. 2007; Evangelista et al. 2006; Zeitler et al. 2015). In all four studies, readmissions were significantly lowered. These interventions included:

- Home-based program of light aerobic exercise and resistance training with home visits by a nurse to assess adherence for 12 months (Dracup et al. 2007; Evangelista et al. 2006)
- Aerobic exercise training for 36 supervised sessions followed by home-based training (Zeitler et al. 2015)
- Exercise using a cycle ergometer two to three times per week for 1 year (Belardinelli et al. 1999)

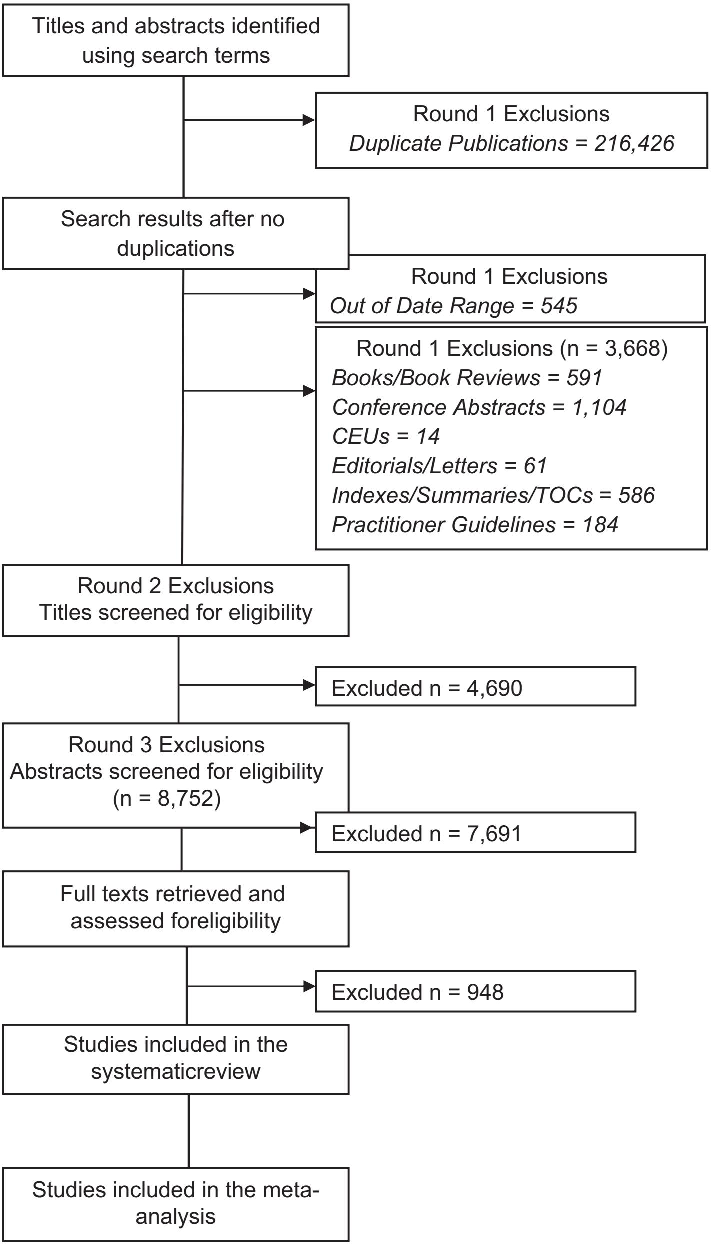

Fig. 6.1 Flow chart of the systematic review of literature

6.3.3 Interpersonal Relationships

Two studies incorporated interpersonal relationships (Heisler et al. 2013; Li et al. 2012). In these studies, readmissions were not significantly lowered.

6.3.4 Outlook

Two studies incorporated outlook (Dekker et al. 2012; Jayadevappa et al. 2007). In these studies, readmissions were not significantly lowered.

6.3.5 Dietary Recommendations

Three studies incorporated dietary recommendations (Albert et al. 2013; Parrinello et al. 2009; Paterna et al. 2009). In two of these studies, readmissions were significantly lowered. These interventions included:

- A comparison of two groups, one with a low-sodium diet and the other with a medium-sodium diet. Both groups had 1000 mL/d fluid restriction and a high diuretic dose. The group with the medium-sodium diet showed a significant reduction in readmissions (Parrinello et al. 2009).
- Eight different combinations of levels of fluid intake restriction, sodium intake, and diuretic dosages. A normal-sodium diet with high diuretic doses and fluid intake restriction was most effective in reducing readmissions (Paterna et al. 2009).

6.3.6 Education and Assessment Combined with Exercise

Two studies incorporated these two components (Kashem et al. 2008; Witham et al. 2005). In one of these studies, readmissions were significantly lowered. This intervention included:

- Patient education during hospitalization and post-discharge assessment of symptoms and compliance with emphasis on activity and treatment through Internet-based monitoring three times per week (Kashem et al. 2008)

6.3.7 Education and Assessment Combined with Interpersonal Relationships

Four studies incorporated these two components (Bull et al. 2000; Cline et al. 1998; Saleh et al. 2012; Wu et al. 2012). In two of these studies, readmissions were significantly lowered. This intervention included:

- Post-discharge education and counseling for patients and families to influence medication adherence through clinic visits and phone calls focused on incorporating significant others and building positive medication-taking behaviors (Wu et al. 2012).

6.3.8 Education and Assessment Combined with Outlook

One study incorporated these two components (Ekman et al. 2011). In this study, readmissions were not significantly lowered.

6.3.9 Education and Assessment Combined with Dietary Recommendations

Thirty studies incorporated these two components (Iraurgui et al. 2007; Benatar et al. 2003; Brandon et al. 2009; Chen et al. 2010; DeWalt et al. 2006; Dunagan et al. 2005; Falces et al. 2008; Gattis et al. 1999; Giordano et al. 2009; Goldberg et al. 2003; Ho et al. 2007; Jaarsma et al. 2008; Jurgens et al. 2013; Koelling et al. 2005; Korajkic et al. 2011; Lee et al. 2013; McDonald et al. 2002; Mejhert et al. 2004; Piepoli et al. 2006; Roig et al. 2006; Roth et al. 2004; Sales et al. 2013; Sethares and Elliott 2004; Shao and Yeh 2010; Sisk et al. 2006; Slater et al. 2008; Wang et al. 2014; West et al. 1997; Wheeler and Waterhouse 2006). In 16 of these studies, readmissions were significantly lowered. These interventions included:

- Patient education during hospitalization and weekly or biweekly phone calls post-discharge to reinforce education and assess symptoms, compliance (Slater et al. 2008; Wang et al. 2014), and medication adherence (Giordano et al. 2009; Sales et al. 2013)
- Diet and self-care education during hospitalization and reinforcement of education and assessment of symptoms and compliance after discharge through weekly calls for 2 weeks (Dunagan et al. 2005), weekly calls for 12 weeks and two clinic visits (McDonald et al. 2002), or calls and clinic visits tailored to individual patient needs (Piepoli et al. 2006)

- Diet, disease, and drug therapy education at discharge and after discharge on monthly phone calls, clinic assessments, and using a pill counter (Falces et al. 2008).
- Post-discharge phone calls weekly or biweekly for patient education (Brandon et al. 2009; Chen et al. 2010)
- Telemonitoring to assess diet, weight, symptoms (Roth et al. 2004), and medication adherence, along with home visits (Benatar et al. 2003)
- Patient education about symptoms and diet at discharge and after discharge over the phone, monthly home visits, and a daily diary for assessment of symptoms and compliance (Lee et al. 2013)
- Post-discharge patient education on HF and diet at outpatient clinics, assessment of symptoms and compliance during clinic visits, and monitoring diet and/or medication adherence on calls (Ho et al. 2007; West et al. 1997) or through the use of a diary and printed guide (Korajkic et al. 2011)

6.3.10 Rest and Relaxation Combined with Outlook

One study incorporated these two components (Jiang 2008). In this study, readmissions were significantly lowered. This intervention included:

- Relaxation therapy consisting of relaxation training and music therapy for 1 h daily and basic psychological care lasting 4 weeks (Jiang 2008)

6.3.11 Exercise Combined with Outlook

One study incorporated these two components (Tully et al. 2015). In this study, readmissions were not significantly lowered.

6.3.12 Education and Assessment Combined with Exercise and Interpersonal Relationships

One study incorporated these three components (Davidson et al. 2010). In this study, readmissions were significantly lowered. This intervention included:

- A cardiac rehabilitation program for 12 weeks with individualized exercise plans and group-based educational session for patients and families (Davidson et al. 2010)

6.3.13 Education and Assessment Combined with Exercise and Dietary Recommendations

Twenty-two studies incorporated these three components (Aguado et al. 2010; Anderson et al. 2005; Andryukhin et al. 2010; Dahl and Penque 2001; Doughty et al. 2002; Ferrante et al. 2010; Gámez-López et al. 2012; Gau et al. 2008; Hershberger et al. 2001; Houchen et al. 2012; Lee et al. 2014; Liou et al. 2015; Pugh et al. 2001; Riegel and Carlson 2004; Riegel et al. 2002; Smith et al. 2015; Stewart et al. 1999; Sun et al. 2013; Szkiladz et al. 2013; Tsuyuki et al. 2004; Vavouranakis et al. 2003; Wright et al. 2003). In 12 of these studies, readmissions were significantly lowered. These interventions included:

- Comprehensive patient education during hospitalization and a follow-up call 1 to 2 weeks after discharge (Gau et al. 2008) and at 90 days for high-risk patients (Dahl and Penque 2001)
- Patient education during hospitalization and post-discharge assessment of symptoms and compliance with emphasis on diet, activity, and treatment through biweekly phone calls (Ferrante et al. 2010)
- Comprehensive patient education during hospitalization and post-discharge reinforcement and assessment of symptoms and compliance emphasizing diet, activity, and treatment through home visits at least once weekly for 6 weeks (Anderson et al. 2005)
- Post-discharge clinic visits and phone calls at 6-month intervals to provide patient education and assess symptoms and compliance (Sun et al. 2013)
- Patient education post-discharge during two to five clinic visits and assessment of symptoms, compliance, and medication use through follow-up phone calls (Hershberger et al. 2001) or through the use of a diary and/or pill counter (Doughty et al. 2002), as well as motivational interviewing (Pugh et al. 2001), or during monthly home visits with follow-up phone calls every 10–15 days (Vavouranakis et al. 2003)
- One home visit during the first 2 weeks after discharge to provide patient education on self-management, diet, and physical activity and assess medication adherence and/or symptoms (Aguado et al. 2010) and follow-up phone calls at 3 and 6 months for assessment (Stewart et al. 1999)
- Education on self-care management, diet, and exercise delivered by a multidisciplinary team weekly for 6 weeks with a 1-h exercise component (Houchen et al. 2012)

6.3.14 Education and Assessment Combined with Interpersonal Relationships and Dietary Recommendations

Six studies incorporated these three components (Dracup et al. 2014; Cabezas et al. 2006; Howlett et al. 2009; Jaarsma et al. 1999; Naylor et al. 2004; Piamjariyakul et al. 2015). In four of these studies, readmissions were significantly lowered. These interventions included:

- Post-discharge education on diet and sodium restriction for patients and caregivers through weekly outpatient clinic visits (Howlett et al. 2009) or coaching phone calls (Piamjariyakul et al. 2015)
- Education on HF, diet, and drug therapy for patients and caregivers at discharge and post-discharge on monthly phone calls, clinic assessments, and medication checklist (Cabezas et al. 2006)
- Development of care plan and patient and caregiver education by multidisciplinary team during hospitalization and weekly home visits to reinforce education and assess symptoms and compliance for 9 weeks post-discharge (Naylor et al. 2004)

6.3.15 Education and Assessment Combined with Outlook and Dietary Recommendations

Two studies incorporated these three components (Jerant et al. 2001; Shao et al. 2013). In these studies, readmissions were not significantly lowered.

6.3.16 Education and Assessment Combined with Rest and Relaxation, Exercise, and Dietary Recommendations

One study incorporated the four components (Varma et al. 1999). In this study, readmissions were significantly lowered. This intervention included:

- Pharmaceutical care, education about self-care, drugs, and medication, and 1 month of self-monitoring diary cards to record medication use, physical activity, diet, and symptoms (Varma et al. 1999)

6.3.17 Education and Assessment Combined with Exercise, Interpersonal Relationships, and Dietary Recommendations

Eight studies incorporated these four components (Atienza et al. 2004; Fonarow et al. 1997; Holst et al. 2001; Kanoksilp et al. 2009; Morcillo et al. 2005; Ojeda et al. 2005; Wang et al. 2011; White and Hill 2014). In six of these studies, readmissions were significantly lowered. These interventions included:

- Educational programs in clinics for patients and families (Holst et al. 2001; Kanoksilp et al. 2009)

- Pre-discharge education on self-monitoring, diet, exercise, and medication and interview of patients and caregivers by nurse, and post-discharge outpatient clinic visits every 3 months to review performance and introduce strategies to improve treatment adherence and response (Atienza et al. 2004)
- Comprehensive patient education with families/caregivers during hospitalization and post-discharge reinforcement and assessment of symptoms and compliance emphasizing diet, activity, and treatment through clinic visits every 3 months (Wang et al. 2011) or clinic visits and phone calls every 2–8 weeks (Fonarow et al. 1997)
- Home visit once during the first month after discharge for education on self-management, diet, physical activity, and vaccinations for the patient and caregiver and pill organizers provided for medication adherence (Morcillo et al. 2005)

6.3.18 Education and Assessment Combined with Exercise, Outlook, and Dietary Recommendations

Three studies incorporated these four components (Davis et al. 2012; Delaney and Apostolidis 2010; Mao et al. 2015). In one of these studies, readmissions were significantly lowered. This intervention included:

- A multidisciplinary disease management program to provide in-person education to patients when enrolled in the intervention and through follow-up, which included outpatient clinic visits and monthly telephone calls and then visits every few months beginning at 6 months if patients had stabilized (Mao et al. 2015)

6.3.19 Education and Assessment Combined with Exercise, Interpersonal Relationships, Outlook, and Dietary Recommendations

Nine studies incorporated these five components (Byszewski et al. 2010; Domingo et al. 2011; Harrison et al. 2002; Löfvenmark et al. 2011; Otsu and Moriyama 2012; Rich et al. 1993, 1995; Stewart et al. 2012, 2014). In two of these studies, readmissions were significantly lowered. These interventions included:

- A telehealth system that combined self-monitoring and motivational support tools in addition to a comprehensive, multidisciplinary HF care program (Domingo et al. 2011)
- Patient education about HF, medication, diet, and activity during hospitalization, at discharge, or after discharge during home visits and phone calls, which also included assessment of diet, weight, and medication checklist (Rich et al. 1995)

6.3.20 *Education and Assessment Combined with Rest and Relaxation, Exercise, Interpersonal Relationships, Outlook, and Dietary Recommendations*

One study incorporated these six components (Sullivan et al. 2009). In this study, readmissions were not significantly lowered.

6.4 Results of Meta-analysis

A meta-analysis allowed for the combination of data from 67 studies to determine the impact of single or combined intervention components aiming to reduce HF readmissions. Studies included in the systematic review could not be included in the meta-analysis if only the total number of readmissions per group were reported, if multiple intervention groups were assessed, or if only composite outcomes were reported. Figure 6.2 shows the forest plot of the effect sizes and confidence intervals for each study in the fixed effect model and random effect model. In the mixed effect model, the overall odds of being readmitted were 1.79 times lower among participants of interventions that involved any of these intervention components. The funnel plot of log odds ratio was symmetrical, which indicates that publication bias was unlikely (Higgins and Green 2011).

6.5 Concluding Remarks

This analysis yielded robust results that are based on a systematic review and meta-analysis of published studies that evaluate interventions involving particular components aimed at reducing HF readmissions. Intervention strategies incorporating certain human factors or combinations of such factors have the potential to enhance therapeutic outcomes for HF patients following hospitalization. The implications of the key findings are as follows:

1. The independent and combined effects of education and assessment are the most beneficial strategies to yield a positive benefit to avoid or reduce readmissions of HF patients. A care management or disease management team could consider a person-centered approach to enhance individual choice or self-efficacy for the patients.
2. Exercise combined with education and assessment or rest and relaxation shows greater benefits than exercise alone. A clinical team could examine how activities were prescribed, implemented, and evaluated. Lack of adherence to or uncertainty about prescribed activities for the therapeutic outcomes may have prevented activities from demonstrating their beneficial effects on readmissions.

Group by Components	Study name	Statistics for each study		
		Odds ratio	Lower limit	Upper limit
1.00	Cordisco 1999	3.850	0.791	18.732
1.00	Domingues 2011	0.805	0.373	1.738
1.00	Gambetta 2007	5.461	3.006	9.921
1.00	Grundtvig 2011	17.235	14.000	21.217
1.00	Hagglund 2015	1.355	0.456	4.022
1.00	Linden 2014	0.702	0.387	1.275
1.00	Mendez Bailon 2007	3.146	1.209	8.189
1.00		2.654	0.763	9.239
2.00	Belardinelli 1999	3.600	1.183	10.952
2.00	Dracup 2007	1.122	0.613	2.055
2.00		1.824	0.591	5.624
3.00	Heisler 2013	1.127	0.697	1.824
3.00		1.127	0.697	1.824
4.00	Dekker 2012	1.059	0.187	5.985
4.00	Jayadevappa 2006	5.500	0.782	38.698
4.00		2.264	0.453	11.325
5.00	Jiang 2008	2.951	1.213	7.180
5.00		2.951	1.213	7.180
6.00	Kashem 2008	7.857	1.495	41.302
6.00	Witham 2005	1.904	0.512	7.085
6.00		3.520	0.889	13.942
7.00	DeWalt 2006	1.241	0.594	2.592
7.00	Dunagan 2005	2.016	1.035	3.930
7.00	Falces 2008	2.480	1.055	5.827
7.00	Gattis 1999	12.238	1.545	96.909
7.00	Giordano 2009	2.006	1.304	3.085
7.00	Jurgens 2013	0.550	0.224	1.349
7.00	Koelling 2005	2.261	1.161	4.406
7.00	Korajkic 2011	2.760	0.837	9.105
7.00	McDonald 2002	17.143	2.130	137.938
7.00	Mejhert 2004	0.959	0.471	1.951
7.00	Piepoli 2006	2.900	2.089	4.025
7.00	Sales 2013	2.017	0.639	6.365
7.00	Sethares 2004	2.160	0.704	6.626
7.00	Wheeler 2006	3.051	0.659	14.137
7.00		1.991	1.464	2.708
8.00	Bull 2000	1.723	0.275	10.796
8.00	Cline 1998	1.836	1.023	3.296
8.00	Saleh 2012	1.496	0.970	2.308
8.00		1.613	1.145	2.270
9.00	Ekman 2012	1.498	0.907	2.475
9.00		1.498	0.907	2.475
10.00	Davidson 2010	3.870	1.679	8.924
10.00		3.870	1.679	8.924
11.00	Atienza 2004	1.953	1.267	3.011
11.00	Kanoksilp 2009	2.698	1.148	6.341
11.00	Ojeda 2005	5.082	2.408	10.725
11.00	Wang 2011	5.609	1.075	29.274
11.00	White 2014	2.028	0.767	5.364
11.00		2.737	1.782	4.205
12.00	Harrison 2002	1.504	0.790	2.865
12.00	Lofvenmark 2011	2.259	1.074	4.751
12.00	Otsu 2012	0.326	0.013	8.217
12.00	Rich 1993	1.686	0.723	3.931
12.00	Rich 1995	3.087	1.772	5.380
12.00	Stewart 2012	1.107	0.669	1.832
12.00		1.749	1.174	2.605
13.00	Anderson 2005	6.156	2.192	17.292
13.00	Andryukhim 2010	2.424	0.670	8.769
13.00	Dahl 2001	1.843	0.928	3.660
13.00	Doughty 2002	4.327	2.192	8.543

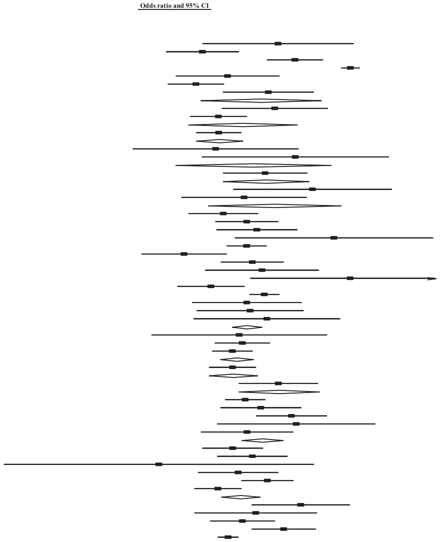

Fig. 6.2 Forest plot of odds ratios for HF readmission in included studies
Components: 1. Education/assessment; 2. Exercise; 3. Interpersonal relationships; 4. Outlook; 5. Rest/relaxation and outlook; 6. Education/assessment and exercise; 7. Education/assessment and dietary; 8. Education/assessment and interpersonal relationships; 9. Education/assessment and outlook; 10. Education/assessment, exercise, and interpersonal relationships; 11. Education/assessment, exercise, interpersonal relationships, and dietary; 12. Education/assessment, exercise, interpersonal relationships, outlook, and dietary; 13. Education/assessment, exercise, and dietary; 14. Education/assessment, exercise, outlook, and dietary; 15. Education/assessment, interpersonal relationships, and dietary; 16. Education/assessment, rest, exercise, and dietary; *Note*: Blank lines indicate subgroup summary for components

3. Nutrition combined with other intervention components reveals a clear positive effect. Dietary interventions should be combined with other strategies in order to maximize their benefit in the reduction of risk for HF readmissions.
4. Interventions with the aforementioned components increase the likelihood of not being readmitted to the hospital for HF. The meta-analysis results indicate that an intervention involving one or more of these components doubles an individual's probability of not being readmitted.

This study is not without limitations. Potential limitations include the risk of bias at the study level and the possibility of incomplete retrieval of studies that meet the criteria. Furthermore, consideration should be given to other human factors and information technology that may facilitate patient-provider communications and coordinated care for chronic conditions as effective care modalities are developed and implemented for HF care management. This study focused on therapeutic interventions that incorporated certain human factors; therefore, comparison of these interventions to those not incorporating human factors was beyond the scope of this analysis. Overall, this research may help reconfigure the design, implementation, and evaluation of clinical practice for reducing HF readmissions in the future.

Appendix 1: Characteristics of Included Studies

Authors	Year	Country	Sample (intervention)	Sample (control)	Setting	Timing[a]
Aguado et al.	2010	Spain	42	64	After discharge	24 months
Albert et al.	2013	US	20	26	After discharge	60 days
Aldamiz-Echevarria Iraúrgui et al.	2007	Spain	137	142	After discharge	12 months
Anderson et al.	2005	US	44	77	During hospitalizationDuring dischargeAfter discharge	6 months
Andryukhin et al.	2010	Russia	44	41	After discharge	6, 18 months
Atienza et al.	2004	Spain	164	174	During hospitalization	12 months
Belardinelli et al.	1999	US	50	49	After discharge	14 months
Benatar et al.	2003	US	108	108	After discharge	3 months
Brandon et al.	2009	US	10	10	After discharge	12 weeks
Brotons et al.	2009	Spain	144	139	After discharge	12 months
Bull et al.	2000	US	40	71	During hospitalizationAfter discharge	2 weeks, 2 months
Byszewski et al.	2010	Canada	45	46	After discharge	6 weeks
Chen et al.	2010	Taiwan	275	275	After discharge	6 months
Cline et al.	1998	Sweden	80	110	During hospitalizationAfter discharge	12 months
Cordisco et al.	1999	US	30	51	After discharge	1 year
Dahl and Penque	2001	US	381	203	During hospitalizationAfter discharge	90 days
Davidson et al.	2010	Australia	52	53	After discharge	12 months
Davis et al.	2012	US	63	62	During hospitalizationAfter discharge	30 days
Dekker et al.	2012	US	21	20	During hospitalizationAfter discharge	3 months
Delaney and Apostolidis	2010	US	12	12	After discharge	90 days
DeWalt et al.	2006	US	59	64	After discharge	12 months
Domingo et al.	2011	Spain	A = 48B = 44	N/A	After discharge	12 months
Domingues et al.	2011	Brazil	48	63	During hospitalizationAfter discharge	3 months

Authors	Year	Country	Sample (intervention)	Sample (control)	Setting	Timing[a]
Doughty et al.	2002	New Zealand	100	97	After discharge	12 months
Dracup et al.	2007	US	86	87	After discharge	3, 6, **12** months
Dracup et al.	2014	US	A = 200B = 193	209	After discharge	2 years
Dunagan et al.	2005	US	76	75	After discharge	**6**, 12 months
Ekman et al.	2011	Sweden	125	123	During hospitalization	6 months
Evangelista et al.	2006	US	48	51	After discharge	6 months
Falces et al.	2008	Spain	53	50	During discharge	**6**, 12 months
Ferrante et al.	2010	Argentina	760	758	After discharge	**1**, 3 years
Fonarow et al.	1997	US	214	N/A	During hospitalizationAfter discharge	6 months
Gambetta et al.	2007	US	158	124	After discharge	7 months
Gámez-López et al.	2012	Spain	A = 25B = 28C = 28	35	After discharge	10.8 ± 3.2 months
Gattis et al.	1999	US	90	91	After discharge	2, 12, **24** weeks
Gau et al.	2008	Taiwan, China	30	30	During hospitalizationAfter discharge	1 month
Giordano et al.	2009	Italy	230	230	During hospitalizationAfter discharge	12 months
Goldberg et al.	2003	US	138	142	During dischargeAfter discharge	6 months
Grundtvig et al.	2011	Norway	1169	N/A	After discharge	12 months
Hägglund et al.	2015	Sweden	32	40	After discharge	3 months
Harrison et al.	2002	Canada	92	100	After discharge	12 weeks
Heisler et al.	2013	US	135	131	During hospitalizationAfter discharge	12 months
Hershberger et al.	2001	US	108	N/A	After discharge	6 months
Ho et al.	2007	Taiwan	247	N/A	After discharge	139 ± 96 days
Holst et al.	2001	Australia	42	N/A	During hospitalizationAfter discharge	6 months
Houchen et al.	2012	UK	17	N/A	After discharge	12 months
Howlett et al.	2009	Canada	990	7741	After discharge	12 months
Hudson et al.	2005	US	91	N/A	After discharge	6 months
Jaarsma et al.	1999	Netherlands	84	95	During hospitalizationAfter discharge	9 months

Authors	Year	Country	Sample (intervention)	Sample (control)	Setting	Timing[a]
Jaarsma et al.	2008	Netherlands	A = 340B = 344	339	After discharge	18 months
Jayadevappa et al.	2007	US	13	10	After discharge	6 months
Jerant et al.	2001	US	A = 12B = 13	12	After discharge	6 months
Jiang	2008	China	101	89	During hospitalizationAfter discharge	6 months
Jurgens et al.	2013	US	48	51	During dischargeAfter discharge	90 days
Kanoksilp et al.	2009	Thailand	50	50	After discharge	12 months
Kashem et al.	2008	US	24	24	After discharge	12 months
Koelling et al.	2005	US	107	116	During discharge	180 days
Korajkic et al.	2011	Australia	35	35	After discharge	3 months
Lee et al.	2013	US	23	21	After discharge	3 months
Lee et al.	2014	US	473	475	During hospitalization	30 days
Li et al.	2012	US	202	205	During hospitalization	60 days
Linden and Butterworth	2014	US	128	129	During hospitalizationAfter discharge	**30**, 90 days
Liou et al.	2015	Taiwan	56	75	During hospitalizationAfter discharge	**30**, 90 days
Löfvenmark et al.	2011	Sweden	65	63	After discharge	18 months
López-Cabezas et al.	2006	Spain	70	64	During dischargeAfter discharge	12 months
Mao et al.	2015	Taiwan	174	175	After discharge	Median 2 years
McDonald et al.	2002	Ireland	51	47	During hospitalizationAfter discharge	3 months
Mejhert et al.	2004	Sweden	103	105	After discharge	18 months
Méndez Bailón et al.	2007	Spain	51	131	During discharge	90 days
Miller and Cox	2005	US	68	N/A	After discharge	90 days, 1 year
Morcillo et al.	2005	Spain	34	36	After discharge	6 months
Naylor et al.	2004	US	118	121	During hospitalizationAfter discharge	52 weeks
Ojeda et al.	2005	Spain	76	77	After discharge	16 ± 8 months
Otsu and Moriyama	2012	Japan	47	47	After discharge	**7–12**, 24 months
Parrinello et al.	2009	Italy	A = 87B = 86	N/A	After discharge	12 months

Authors	Year	Country	Sample (intervention)	Sample (control)	Setting	Timing[a]
Paterna et al.	2009	Italy	A = 52, B = 51, C = 51, D = 51, E = 52, F = 50, G = 52, H = 51	N/A	After discharge	6 months
Piamjariyakul et al.	2015	US	20	N/A	After discharge	6 months
Piepoli et al.	2006	Italy	509	N/A	After discharge	12 months
Pugh et al.	2001	US	27	31	During hospitalizationAfter discharge	12 months
Rich et al.	1993	US	63	35	During hospitalizationDuring dischargeAfter discharge	90 days
Rich et al.	1995	US	142	140	During hospitalizationDuring dischargeAfter discharge	90 days
Riegel et al.	2002	US	126	226	After discharge	**3**, 6 months
Riegel and Carlson	2004	US	45	43	After discharge	**30 days**, 3 months
Roig et al.	2006	Spain	61	N/A	After discharge	11 ± 10 months
Roth et al.	2004	Israel	118	N/A	After discharge	12 months
Saleh et al.	2012	US	173	160	During dischargeAfter discharge	12 months
Sales et al.	2013	US	70	67	During hospitalizationAfter discharge	30 days
Sethares and Elliott	2004	US	33	37	During hospitalizationAfter discharge	3 months
Shao and Yeh	2010	Taiwan, China	93	N/A	After discharge	1 month
Shao et al.	2013	Taiwan	47	46	After discharge	12 weeks
Sisk et al.	2006	US	203	203	After discharge	12 months
Slater et al.	2008	US	612	N/A	During hospitalizationAfter discharge	6 months
Smith et al.	2015	US	92	106	After discharge	12 months
Stewart et al.	1999	Australia	100	100	After discharge	6 months
Stewart et al.	1998	Australia	49	48	After discharge	6 months
Stewart et al.	2012	Australia	143	137	After discharge	18 months
Stewart et al.	2014	Australia	137	143	After discharge	12–18 months

Authors	Year	Country	Sample (intervention)	Sample (control)	Setting	Timing[a]
Sullivan et al.	2009	US	108	100	After discharge	12 months
Sun et al.	2013	China	433	288	After discharge	4 years
Szkiladz et al.	2013	US	86	94	During dischargeAfter discharge	30 days
Tsuyuki et al.	2004	Canada	140	136	During hospitalizationAfter discharge	6 months
Tully et al.	2015	Australia	A = 15B = 14	N/A	After discharge	6 months
Varma et al.	1999	UK	42	41	After discharge	12 months
Vavouranakis et al.	2003	Greece	28	N/A	After discharge	12 months
Wang et al.	2011	Taiwan, China	14	13	During hospitalizationAfter discharge	3 months
Wang et al.	2014	China	32	34	During hospitalizationAfter discharge	6 months
West et al.	1997	US	51	N/A	After discharge	94–182 days
Wheeler and Waterhouse	2006	US	20	20	After discharge	14 weeks
White and Hill	2014	US	59	N/A	During hospitalizationAfter discharge	2 months
Witham et al.	2005	UK	41	41	After discharge	6 months
Wright et al.	2003	New Zealand	100	97	After discharge	12 months
Wu et al.	2012	US	A = 27B = 27	28	After discharge	9 months
Zeitler et al.	2015	US	1159	1172	After discharge	Every 3 months for 2 years

[a] Timing in bold indicates outcome results used in meta-analysis

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Chapter 7
Contextual, Organizational, and Ecological Factors Influencing the Variations in Heart Failure Hospitalization in Rural Medicare Beneficiaries in Eight Southeastern States

Abstract This chapter reports contextual, organizational, and ecological factors influencing the variations in risk-adjusted hospitalization rates for heart failure (HF) of Medicare patients served by rural health clinics (RHCs) in the eight Southeastern states in the United States. We conducted a longitudinal analysis to show trends and patterns of RHC variations in the race-specific, risk-adjusted rates. There was a steady decline in HF hospital admission rates. A net-period effect of the Affordable Care Act on HF hospital admissions was also observed in both White and African-American groups. The results affirm the importance of considering county characteristics and organizational factors for African-American patients in accounting for the variability in HF hospital admissions. However, for the White patients, the variables measured at the organizational level (such as the dual-eligibility status of Medicare patients and the total FTEs employed by RHCs) were influential and could be considered in the formulation of hospital incentive payment formula in the future.

Keywords Rurality • Racial disparities • Heart failure hospitalization • ACA period effect • Ecological correlates • Rural health clinics • Ambulatory care sensitive condition

7.1 Introduction

Hospitalization for heart failure (HF) or congestive heart disease (CHD) has been identified as one of the major ambulatory care sensitive conditions in the effort of monitoring and improving chronic care. Health service utilization research suggests that differences in HF hospitalization rates cannot be adequately explained by race/ethnicity alone (Pappas et al. 1997; Wolinsky et al. 2010). Systematic review and analysis of racial disparities in use of health services and outcomes of heart health care are needed if the determinants of HF hospitalization are to be identified at both facility and ecological levels of analysis. Furthermore, longitudinal data are

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required if the causal relationship of the HF hospitalization rate to a complex set of contextual (county characteristic), organizational (clinic characteristic), and ecological (aggregate patient characteristic) factors at the rural health clinic (RHC) level is to be determined. The racial variability in HF hospitalizations should be investigated when the influence of other patient characteristics is being simultaneously controlled for in the analysis.

Careful inspection of empirical studies on HF hospitalizations suggests that multiple explanatory variables may directly and indirectly influence hospitalization rates. These factors are broadly classified into the societal and individual factors: (1) societal factors may include county-based contextual factors and organizational factors and (2) individual factors may include predisposing and demographic attributes, enabling factors such as dual-eligibility status and insurance coverage, and the need-for-care factors such as diagnostic conditions, severity of the illness, and prior hospitalization (Benbassat and Taragin 2000; Herrin et al. 2015; Jackson et al. 2013; Joynt et al. 2011a; Kulkarni et al. 2016; Wolinsky et al. 2010). Little is known about how the contextual (county), organizational (facility), and aggregate RHC patient characteristics or factors contribute to the variability in HF hospitalization when the influence of patient characteristics is being simultaneously controlled for in the investigation.

The Centers for Medicare and Medicaid Services (CMS) has started monitoring avoidable hospitalizations and readmissions by implementing a hospital readmissions reduction program to eliminate the hospital quality problem. In fact, it penalizes the reimbursements of hospital with high readmission rates for Medicare patients treated for congestive heart failure, acute myocardial infarction, or pneumonia. Beginning in October 2012, Medicare payments were to decrease by 1–2% in 2013 and by 3% in 2014 (Boccuti and Casillas 2015). Concomitantly, the enactment of the Patient Protection and Affordable Care Act (abbreviated as the ACA) on March 23, 2010, was expected to enhance patient-centric care and improve the delivery of ambulatory care and preventive services through the expansion of health insurance coverage for the uninsured. The ACA Section 3025 also solidifies the importance of reduction effort for ambulatory care sensitive conditions.

The rural health clinic (RHC) database for ambulatory care sensitive conditions, compiled from rural Medicare beneficiaries for the period of 7 years from 2007 through 2013 (including the pre-ACA period and the post-ACA period), offers a distinct opportunity to examine trends and patterns of racial disparities in hospitalization for HF in eight states of Region 4 (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee).

The twofold purpose of this investigation includes (1) to examine rural trends and patterns of crude- and race-specific risk-adjusted hospitalization rates for HF by state and year (before and after the ACA enactment) and (2) to investigate how contextual (county characteristic), organizational (clinic characteristic), and ecological (aggregate patient characteristic) factors may account for differential influences on the African-American and non-Hispanic White patients with HF. More specifically, three research questions relevant to hospitalization of rural Medicare patients for HF in rural areas of eight states are addressed in this empirical study when patient differences, with exception of race, are simultaneously controlled for through statistical risk adjustment:

1. Are there statistically significant differences in race-specific risk-adjusted HF hospitalization rates in the past 7 years (2007 through 2013) of RHC observation by state?
2. Can the variability in the rates for HF hospitalization be explained by rurality?
3. Have risk-adjusted hospitalization rates for HF patients served by RHCs decreased over the past 7 years? Can the change be reflected by the period effect attributable to the Affordable Care Act when other influential factors are simultaneously considered?

The pooled cross-sectional data from 2007 through 2013 for RHCs were aggregated from Medicare claim files of patients served by RHCs. Thus, RHC year is the unit of analysis, using multivariate modeling analytics to identify statistically significant factors influencing the racial variation in risk-adjusted hospitalization rates for African-American and non-Hispanic White HF patients. The identification of contributing factors to the high prevalence of hospitalization for HF by race may shed some light on potential policy development or interventions targeting the mutable county characteristics (e.g., state, rurality classification, poverty, demographic characteristics, health, professional resources distribution, etc.), clinic characteristics (e.g., provider status/ownership, staff size, and health system affiliation), and aggregated RHC patient characteristics (e.g., gender, age and dual-eligibility status, and ambulatory care service utilization).

7.2 Related Research

Hospitalization of HF or CHF, an ambulatory care sensitive condition or preventable hospitalization, is commonly considered as a measure of the lack of access to primary care in the community (Rosano et al. 2012; Saver et al. 2013; Will et al. 2012). However, the factors influencing health disparities, particularly in contrasting between non-Hispanic White and African-American populations residing in rural areas, are not well understood. The research literature on the explanatory factors or determinants of racial disparities can be grouped into three categories: the contextual, organizational, and patient population characteristics.

7.2.1 Contextual Determinants

Using 1995 through 2009 data from the National Hospital Discharge Survey, Will et al. (2012) analyzed the trends and showed that preventable HF hospitalization rates across time were higher in African-Americans than in Whites. Age- and gender-standardized rates for Whites showed a significant decline over time. African-American men aged 65 or older had no decrease in rates. Similarly, the rates for younger African-American males were on the rise for preventable HF hospitalizations. An analysis of readmission rates for CHF, using Medicare fee-for-service claims for 2007–2009, reported that the rate for HF was 24.8% (Jencks et al. 2009). However, no differences in HF rehospitalizations were observed for age, gender, and racial composition (Dharmarajan et al. 2013).

Health-care access to effective primary care is a key contributing factor to avoidable hospitalization (Laditka et al. 2009; Rosano et al. 2013). In a report on preventable hospitalizations, Nayar et al. (2012) also noted that rurality may have an impact on hospitalizations of ambulatory care sensitive conditions and that isolated rural or frontier communities may be at greater risk for preventable hospitalizations in Nebraska. Furthermore, the regional or state variation in access to primary care services also exists since health resources are inequitably distributed in the United States.

In identifying high-risk Veteran patients for early intervention to avoidable hospitalizations, Gao et al. (2014) suggested that a predictive model with predictor variables is more amenable to improve appropriate hospitalizations. They further advocated that the examination of accountable care organizations or primary care medical homes should be made in order to detect the beneficial effect of health-care policy changes in recent years. Under the impact of health-care reforms, it is reasonable to investigate a variety of federally initiated policies such as the quality improvement effort (Brennan 2014), the CMS Hospital Readmissions Reduction Program to penalize acute-care hospitals with a higher readmission rate for older adult patients, and the Affordable Care Act to improve insurance coverage for the uninsured and to emphasize primary and preventive care services for the elderly (Wan et al. 2015).

7.2.2 *Organizational Determinants*

The presence of primary care providers such as rural health clinics and community health centers in counties may help to reduce hospitalization rates for ambulatory care sensitive conditions (e.g., HF, diabetes, COPD, hypertension, etc.), particularly related to older adults (Probst et al. 2009). The physician supply was associated with the primary care system's performance in urban areas but not in rural areas (Laditka et al. 2005). Although an overall pattern of primary care availability is relatively comparable, the effect of primary care providers in varying sizes of rural areas has not been studied.

Adequate physician supply and equitable distribution of medical staff throughout all regions in all levels of health-care facilities are germane to ensure the quality and accessibility of needed health services. Thus, the structure of health-care organizations, irrespective of ambulatory care clinics and acute-care hospitals, may yield different effects on their performance. In a series of publications generated by the Rural Health Research Group at the University of Central Florida, investigators have consistently reported that provider-based rural health clinics outperformed their counterparts (independent rural health clinics) in a variety of areas such as productivity, cost efficiency, and quality as measured by readmissions (Wan et al. 2015; Ortiz et al. 2013; Agiro et al. 2012).

7.2.3 *Aggregate Patient Population Characteristics or Ecological Variables*

The aggregation of individual characteristics at the facility level constitutes ecological variables. For instance, prior research identifies the type of patients' diagnoses treated, dually eligible status, insurance coverage, race, socioeconomic status, and medical care needs accounted for the variability in health and hospital use (Chang et al. 2008; O'Neil et al. 2010; Wan 1989, 1995; Wan et al. 2015; Williams and Mohammed 2013; Wolinsky et al. 1989, 1995; Wolinsky and Johnson 1991). The presence or absence of these characteristics measured at the aggregate level or facility level may either facilitate or impede the use of health services, as predisposing factors to hospital utilization (Andersen and Newman 1973; Wan 1995). The health insurance coverage or dual-eligibility status of the elderly constitutes an enabling factor that influences the likelihood of having ambulatory care visits and hospitalizations. Similarly, Medicare beneficiaries with a usual source of care were also likely to use physician services and hospital care (Wan 1989). The need for care factors, such as the Charlson Index, severity of illness, and clinical diagnosis, may precipitate the individual to take health actions or seek care (Andersen and Newman 1973; Wan and Soifer 1974; Wolinsky and Coe 1984).

In summary, based on the cited literature, it is necessary to identify the relative influences of each component of the determinants in explaining racial disparities observed in the period of implementing health policy reforms such as ACA, CMS Hospital Readmission Reduction Program, and community-based care for chronic conditions. According to a recent report by the University of Washington Population Health Institute on county variations in health and health care in the United States, the four areas of contributing factors to the improvement of health care and health-care outcomes in the percentage distribution include (1) 10% related to physical environment and policy, (2) 20% related to clinical care and technology, (3) 30% related to personal behavioral factors, and (4) 40% related to social and economic factors (How Healthy is Your County 2017). This report points out strategic priorities for achieving population health by reducing health-care disparities and improving the quality of care in the US population. Furthermore, race-specific strategies must be developed and implemented when the underlying causes of racial disparities in health care are identified.

7.3 Analytical Framework

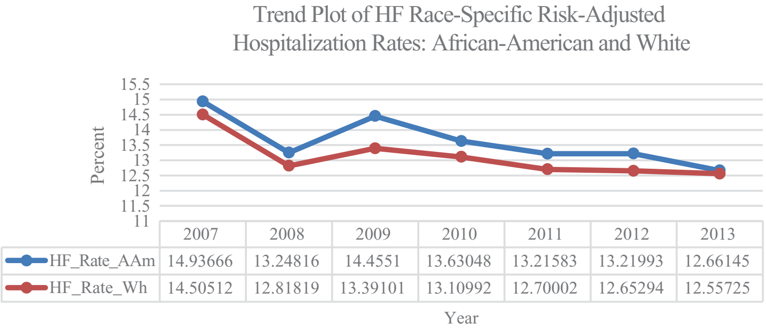
A behavioral system model developed by Andersen and Newman (1973) and adapted by Wan and Soifer (1974) with causal specifications of the determinants of health service use and outcomes is used in this investigation to explore the racial disparities in HF hospitalizations. It is posited that racial disparities in HF hospitalizations can be reduced with a better understanding of the determinants of adjusted admission rates, holding patient characteristics such as the severity of illness, comorbidity, age, gender, and socioeconomic status constant by means of risk adjustment.

The determinants of health-care use are generally classified into the predisposing, enabling, and need-for-care characteristics as shown in Fig. 7.1 in the behavioral system approach. Prior research assumes that the enabling and need-for-care factors are more dominant in influencing the variability in hospitalizations and outcomes than the predisposing factors. This study integrates the behavioral system approach with the ecological system framework. Personal factors such as age, gender, and the Charlson Morbidity Index were included in the computation of risk-adjusted rates for each of the racial group. Furthermore, the present study explores how the availability of rural health clinics, the ACA period effect, rurality, dual eligibility, and many aggregated patient and organizational characteristics at the RHC level may also influence the patterns and trends of risk-adjusted HF admission rates for the period of 2007 through 2013, while racial disparities are being examined.

7.4 Research Methodology

7.4.1 Design and Data Sources

We conducted a longitudinal analysis of hospital admissions based on administrative and claims data gathered from a variety of data sources compiled for CMS. HF admissions of rural Medicare patients (2007 through 2013) were captured in the



	2007	2008	2009	2010	2011	2012	2013
HF_Rate_AAm	14.93666	13.24816	14.4551	13.63048	13.21583	13.21993	12.66145
HF_Rate_Wh	14.50512	12.81819	13.39101	13.10992	12.70002	12.65294	12.55725

Fig. 7.1 Race-specific heart failure (HF) hospitalization rates (2007–2013) of rural Medicare beneficiaries served by rural health clinics in Region 4

CMS inpatient claim files of the Chronic Conditions Warehouse. The presence of hospital billing codes for admissions was coded as a hospitalized case (coded 1) or not-hospitalized case (coded 0).

The ICD-9-CM codes used to identify Medicare beneficiaries with HF are as follows: 39,891, 4280, 4281, 42,820, 42,821, 42,822, 42,823, 42,830, 42,831, 42,832, 42,833, 42,840, 42,841, 42,842, 42,843, and 4289. Also, discharge with a cardiac procedure is excluded. The admission rate for HF patients is computed by the total number of Medicare claims for admissions divided by the total number of hospital claims of patients served by each RHC per year. For each racial group, the risk adjustors for HF hospital admission risk-adjusted rate are patients' age, gender, and Charlson Comorbidity Index. The formulas used are as follows:

- **Crude hospital admission rate =** $\frac{\text{number of actual HF admissions}}{\text{number of RHC HF patients}}$
- **Risk-adjusted hospital admission rate =** $\frac{\text{number of adjusted HF admissions}}{\text{number of RHC HF patients}}$

Using logistic regression analysis of the Medicare claim file with the Charlson Index and other factors as risk adjusters (Wan et al. 2015) (including age, gender, and other personal factors), an expected number of admissions were calculated for each RHC per year by racial groups. The race-specific risk-adjusted admission rate was then calculated by using the expected number of HF admissions (the numerator) divided by the total number of HF patients in each RHC (the denominator).

Our analysis focuses on rural disparities in RHCs so that variations in the adjusted rate of admissions may be accounted for by the contextual, organizational, and ecological factors. Analyses present major characteristics of RHCs serving Medicare beneficiaries in several categories of rural areas as defined by Rural-Urban Community Area (RUCA) codes.[1] The rurality is classified into urbanized, large rural, small rural, and isolated rural areas. The total rural elderly studied ranged from 202,707 patients in 2007 to 270,769 patients in 2013. Excluding the missing cases for not having the total number of patients documented in the Medicare claim file, we retained 591 RHCs for this research.

7.4.2 *Measurements*

The contextual variables, derived from the Health Resources and Services Administration (HRSA) Area Resource File, include, for example, the percentage population in poverty, rurality (in four levels), racial composition, and state. In addition, a dichotomized predictor variable showing the potential period effect of

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[1] The RUCA is a classification scheme that uses the Bureau of Census Urbanized Area and Urban Cluster definitions in combination with work commuting information to characterize US Census tracts regarding their rural and urban status.

the ACA on RHC performance was created: before 2010 (2007 through 2009) coded 0 and after 2009 (2010 through 2013) coded 1.

The organizational factors included, for example, years of RHC certification, staff mix (a ratio of physician visits to the total number of health clinic visits), clinical staff size, provider-based or independent clinic, and ownership. Personal attributes of Medicare beneficiaries such as the size of patient population served, average age of patients, percent female patients, percent Hispanic patients, percent White patients, and percent dually eligible patients were considered as aggregated indicators or ecological factors of RHCs in this analysis. A summary of operational definitions of the study variables is presented in Appendix 1.

7.4.3 Analytical Methods

Three statistical methods were used to analyze the pooled data for the years 2007 to 2013; each was similar to a time series without using a panel group of RHCs in the longitudinal analysis. First, descriptive statistics were calculated to illustrate the general characteristics of the RHCs in Region 4. Significance tests, at the alpha level of 0.05, were performed when the analysis of variance for eight states for a given attribute or variable was appropriate. Second, correlation analysis of repeated measures of HF hospital admissions, as well as growth curve modeling of hospital admission rates, was performed for 2007 through 2013. This enabled us to ascertain if any serial correlations of the variables exist (Nagasako et al. 2014). Finally, regression of the dependent variable on selected predictors clustered into contextual, organizational, and ecological variables was analyzed by a generalized estimating equation (GEE) method, using the pooled data for all RHCs with complete information for the total number of patients served and readmissions (N = 3918 RHC years) and analyzed using the SAS Institute's GENMOD procedure.[2]

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[2] Generalized estimating equation method provides a semi-parametric approach to longitudinal analysis of categorical or continuous (repeated) measurements. GEEs were introduced by Liang and Zeger (1986) and expanded in a book by Diggle et al. (1994). The covariance structure does not need to be specified correctly to estimate regression coefficients and standard errors. The statistical assumptions are as follows: (1) the repeated measures or responses to be correlated or clustered, (2) covariates with a mixture of predictor variables and their interaction terms, (3) no requirement for equal variance or homogeneity of variance, (4) correlated errors assumed independent, (5) not required for multinormal distribution, and (6) a quasi-likelihood estimation rather than maximum likelihood estimation or ordinary least squares to estimate the parameters (Hardin and Hilbe 2012). The robustness of a GEE model is not determined by conventional goodness of fit statistics. However, an analog to Akaike's Information Criterion (AIC) such as QIC (quasi-likelihood under the independence model criterion) is used to assess the competing models for varying correlation structures. A marginal R-squared value can be computed to be used as a reference to the magnitude of the total variance explained by predictor variables in the equation (Hardin and Hilbe 2012; Zheng 2000).

Both time-constant and time-varying predictors were included. The reasons for performing GEE to identify the relevance of selected predictors in accounting for the variability in adjusted readmission rates are (1) a repeated measure of the risk-adjusted rate of each RHC for the 7 years was used as a dependent variable, (2) the predictor variables had many missing variables, (3) robust standard estimates were available for performing more consistent and accurate tests of statistical significance, and (4) quasi-likelihood information criterion [QIC] was available to reflect the relative quality of the proposed model in fitting the data. A detailed statistical description of the GEE used for this analysis is presented in the end of this chapter.

7.5 Research Results

7.5.1 RHC Year as the Unit of Analysis

There were 705 RHCs studied over a period of 7 years with 4935 RHC years. The total number and percentage distributions of RHCs included in the analysis are presented in Table 7.1. The White rural Medicare beneficiaries served by RHCs had a total of 3439 observations (accounting for 69.7% of Whites of the RHC years), African-American beneficiaries had a total of 2005 observations (40.6% of African-Americans of the RHC years), and Hispanics had only 75 observations (1.5% of the RHC years).

Table 7.1 The number of rural health clinics included in the period of 2007 through 2013 for computing race-specific risk-adjusted heart failure hospitalization rates

	Number and percentage distributions of rural health clinics (RHCs)					
	Included		Excluded		Total	
Race-specific group	N	%	N	%	N	%
Whites	3439	69.7	1496	30.3	4935	100
African-Americans	2005	40.6	2930	59.4	4935	100
Hispanics	75	1.5	4860	98.5	4935	100

In this report, the GEE model was performed by using SAS with the PROC GENMOD procedure. The model fitting and link function were based on the link function of identity (change nothing in a dependent variable) with an assumption of a normal distribution. The assumption on correlated errors between seven levels of time points or waves on a dependent variable was set to AR(1), which means the following:

We performed hierarchical regression of a continuous response variable on the contextual, organizational, and aggregate personal predictors separately and kept statistically significant variables for the final equation. When we included them together in the final model, we added additional fixed variables such as year (1–6), dummy variables for seven states (using Mississippi as a reference group), and rurality code (three dummy variables using RHC located in urbanized areas as a reference group). The backward selection criterion was used to enter the statistically significant predictors one by one at the alpha of 0.1.

7.5.2 State Variations in Race-Specific Risk-Adjusted Rates for HF Hospitalization

The one-way analysis of state variations in HF hospitalization was performed and showed the average rates of 13% for White, 14% for African-American, and 17% for Hispanic groups (Table 7.2). The state variations in the average rates were statistically significant. In the White group, the lowest rate was 12% in Alabama, and the highest rate was 14% in Mississippi and North Carolina. In the African-American group, the lowest rate was 12% in Georgia and South Carolina, and the highest rate was 16% in Tennessee. Relatively higher rates were observed in the Hispanic group (with the highest rate, 18% in Alabama).

7.5.3 Trends of Risk-Adjusted HF Hospitalization Rates in African-American and White American Medicare Patients Served by RHCs

Figure 7.1 presents a trend plot of the HF rates by year for two racial groups only since the observation units for the Hispanic group were very small for the trend analysis. In 2007, both African-American and White Medicare patients served by RHCs had a relatively higher rate, with 14.94% for African-Americans and 14.51% for White Americans. Both groups had a similar rate drop in 2008 and then saw a slight increase in 2009. Since 2010, the rates declined in both groups, with 12.55% for the African-American group and 12.66% for the White group. These trends reveal that the risk-adjusted HF hospitalization rates in the post-ACA period were

Table 7.2 Variations in race-specific heart failure hospitalization rates by state, 2007 through 2013

	Whites			African-Americans			Hispanics		
State	Mean	SD	F	Mean	SD	F	Mean	SD	F
AL	12%	0.034		14%	0.045		21%	.	
FL	13%	0.035		15%	0.047		17%	0.045	
GA	13%	0.039		12%	0.048		19%	0.006	
KY	13%	0.037		15%	0.055		–	–	
MS	14%	0.038		13%	0.041		19%	0.017	
NC	14%	0.040		14%	0.045		19%	0.009	
SC	13%	0.037		12%	0.040		19%	0.000	
TN	13%	0.038		16%	0.047		18%	.	
Total	13%	0.038		14%	0.046		17%	0.041	
ANOVA statistic			8.04[a]			18.25[a]			0.47

Note: [a]Statistically significant differences in four categories of rural classification at 0.05 or lower level much lower than these in the pre-ACA period. This is a crude measure of the ACA period effect on HF hospitalizations for rural Medicare patients served by RHCs. However, careful inspection of the net ACA period effect must be investigated by GEE so that repeated measures of the HF rate can be explained by varying predictor variables.

7.5.4 *Race-Specific Risk-Adjusted HF Hospitalization Rates by Rurality*

The variation in risk-adjusted HF hospitalization rates by rurality or rural classification was examined by one-way analysis of variance for 7 years. Table 7.3 shows that statistically significant differences in the adjusted rates for HF hospitalization were found in the African-American group, but not in the White or Hispanic group. The rates for African-Americans show that RHCs located in an urbanized and large rural areas had a slightly higher rate (14%) than RHCs located in both small and isolated rural areas (13%).

7.5.5 *Latent Growth Curve Modeling of Risk-Adjusted HF Hospitalization Rates (2007 Through 2013) for RHCs Serving White and African-American Medicare Patients*

Serial correlation is considered to be an important methodological problem that had to be addressed in this longitudinal analysis of RHC data for HF hospitalizations. The risk-adjusted HF hospitalization rates for the seven study years are positively and moderately related. The potential threat of auto-regression of the rates

Table 7.3 One-way analysis of variance in race-specific risk-adjusted HF hospitalization rates by rurality classification

	Whites			African-Americans			Hispanics		
Rurality	Mean	SD	F	Mean	SD	F	Mean	SD	F
Urban	13.4	0.041		14.1	0.046		17.5	0.18	
Large rural	13.2	0.039		14.2	0.045		16.9	0.17	
Small rural	13.1	0.035		13.3	0.046		18.7	0.19	
Isolated	12.9	0.038		13.5	0.046		18.2	0.18	
Total	13.1	0.038		13.6	0.046		17.4	0.17	
ANOVA statistic			2.38			4.95[a]			0.76

Note: [a]Statistically significant differences in four categories of rural classification at 0.05 or lower level

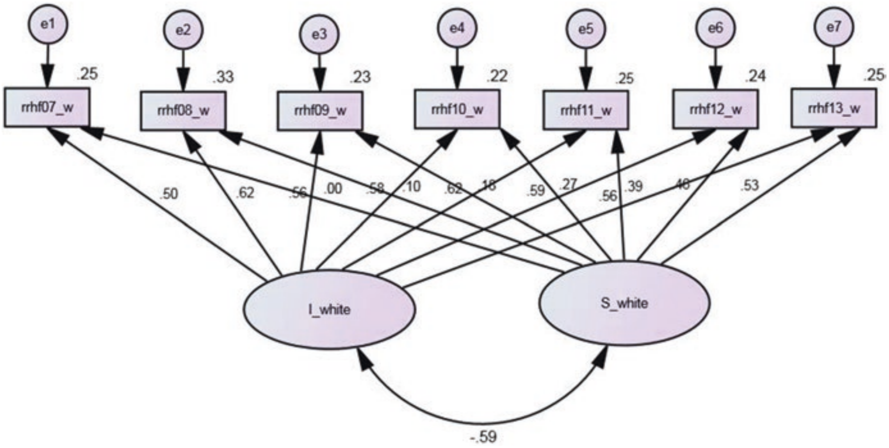

Fig. 7.2 The growth curve model of risk-adjusted heart failure hospitalization rates for White Medicare patients served by rural health clinics, 2007 through 2013

was further examined in latent growth curve modeling and analysis. Because the growth curve modeling requires a panel group of RHCs with the rates available for all 7 years, the analysis was performed for the White patient group only with 336 RHCs (Fig. 7.2).

Figure 7.2 shows a negative and statistically significant relationship between the two latent growth components, the intercept (I_rrhf) reflecting the initial status and the slope (Slope_rrhf) of yearly rates. A negative and statistically significant association of the two growth factors (intercept and slope) was found (−0.587). This suggests that the higher the HF hospital admission rate in a prior year, the slower the decline of hospitalizations in later years. This latent growth curve model fits the data for the White group very well with a chi-square value of 37.509, 18 degrees of freedom; NFI= 0.866, TLI = 0.879, CFI = 0.922, and RMSEA = 0.039. The relationship between each annual rate and the intercept is 0.496, 0.623, 0.564, 0.576, 0.616, 0.593, and 0.529 from 2007 through 2013, respectively. The relationship between each annual rate and the slope of the White group is 0.00, 0.098, 0.177, 0.270, 0.385, 0.464, and 0.529 for the respective years.

7.5.6 Generalized Estimating Equation (GEE) Analysis of Risk-Adjusted HF Hospitalization Rates for White and African-American Medicare Patients

GEE offers a unique perspective in the examination of repeated measures such as race-specific, risk-adjusted HF hospitalization rates of 2631 RHC years for White and 2005 RHC years for African-American patients. The analysis follows a two-step hierarchical regression: (1) the risk-adjusted rate, a continuous dependent variable, was regressed on each group of predictors such as the contextual, organizational, and aggregate patient attributes independently and (2) from each group of predictors, those that were statistically significant were combined in the second step of regression analysis using a backward selection method. Rurality was categorized into three dummy variables (large rural, small rural, and isolated rural areas with RHCs located in an urbanized area as a reference group) in the final regression equation. A pre-ACA year was coded 0, whereas a post-ACA year was coded 1. This dummy variable is treated as the ACA effect on the HF hospitalization rates. The results of substantively meaningful and statistically significant predictors for the risk-adjusted HF hospitalization rate for Whites and African-Americans are presented in Tables 7.4 and 7.5, respectively. For illustrative purposes, the relative importance of each predictor included in the analysis, we present only statistically significant standardized regression coefficients (parameter estimates) and relevant statistics in the table. A positive regression coefficient indicates that an increasing average-adjusted HF admission rate was observed. Similarly, a negative coefficient suggests that a declining average-adjusted HF hospitalization rate was observed for a given predictor variable. A marginal R^2 for the estimating equation was also computed to show the total variance in the HF hospitalization rates explained by all predictor variables included in the final model.

Table 7.4 reveals several interesting and statistically significant findings for White patients served by RHCs from the GEE analysis as follows: (1) the variable "ACA period" had an inverse relationship with the HF hospitalization rate for RHC patients, showing lower rates of the post-ACA period than the pre-ACA period; (2) the risk-adjusted HF hospitalization rates varied by the rurality classification, the RHCs located in small and remote areas having experienced a lower rate of HF admissions; (3) Alabama, Georgia, and South Carolina had lower rates than other southeastern states; (4) RHCs located in areas with a higher percentage of African-Americans had a higher adjusted rate of HF hospitalizations; (5) the percentage of dually eligible patients treated by RHCs were positively related to the risk-adjusted HF admission rate; and (6) RHCs with larger full-time equivalent (FTE) staffs were negatively related to the risk-adjusted HF admission rate. The total variance explained by the predictors shown by the marginal R-squared value is 4.77%.

For African-American patients served by RHCs, a total of 1542 RHC years with complete information for predictor variables was observed in Table 7.5. The statistically significant results are summarized in Table 7.5 as follows: (1) the post-ACA period had a lower risk-adjusted HF admission rates than the pre-ACA period; (2) no differences were found among four rural classifications; (3) higher rates were founded in Florida, Kentucky, and Tennessee, whereas lower rates were found in South Carolina; (4) RHCs with higher FTEs had a lower rate than those with lower FTEs; and (5) RHCs located in a higher concentration of poverty population had a higher HF admission rate. The total variance explained by the predictors was 10.52%.

Table 7.4 GEE results of predictors of risk-adjusted heart failure hospitalization rates for White Medicare patients in 2631 RHC years

Variables[a]	Estimate	Standard error	95% confidence limits		Z	P-value
ACA period effect	−0.1015	0.0193	−0.1393	−0.0636	−5.26	<0.0001
Rurality						
Urban (ref.)						
Large rural area	−0.0647	0.0358	−0.1350	0.0055	−1.81	0.0710
Small rural area	−0.0888	0.0371	−0.1615	−0.0160	−2.39	0.0167
Isolated	−0.0978	0.0373	−0.1709	−0.0246	−2.62	0.0088
State						
MS (ref.)						
AL	−0.1135	0.0277	−0.1678	−0.0592	−4.10	<0.0001
FL	−0.0812	0.0313	−0.1426	−0.0198	−2.59	0.0095
GA	−0.1193	0.0325	−0.1830	−0.0555	−3.67	0.0002
KY	−0.0737	0.0349	−0.1421	−0.0053	−2.11	0.0347
NC	−0.0012	0.0312	−0.0624	0.0600	−0.04	0.9691
SC	−0.0933	0.0284	−0.1491	−0.0376	−3.28	0.0010
TN	−0.0262	0.0272	−0.0796	0.0271	−0.96	0.3351
% of dually eligible patients	0.0617	0.0284	0.0060	0.1174	2.17	0.0298
Total FTEs	−0.0729	0.0204	−0.1130	−0.0329	−3.57	0.0004

Notes: QIC = 2633; QICu = 2645; marginal R-squared = 0.0477

[a] Statistically significant variables are in bold

Table 7.5 GEE results of predictors of risk-adjusted heart failure hospitalization rates for African-American Medicare patients in 1542 RHC years

Variables[a]	Estimate	Standard error	95% confidence limits		Z	P-value
ACA period effect	−0.0948	0.0239	−0.1418	−0.0479	−3.96	<0.0001
Rurality						
Urban (ref.)						
Large rural areas	0.0111	0.0429	−0.0730	0.0952	0.26	0.7951
Small rural areas	−0.0610	0.0492	−0.1574	0.0353	−1.24	0.2143
Isolated	−0.0231	0.0467	−0.1147	0.0685	−0.49	0.6215
State						
MS (ref.)						
AL	−0.0163	0.0353	−0.0855	0.0529	−0.46	0.6436
FL	0.0917	0.0318	0.0295	0.1540	2.89	0.0039
GA	−0.0559	0.0320	−0.1187	0.0068	−1.75	0.0808
KY	0.1080	0.0466	0.0167	0.1993	2.32	0.0204
NC	0.0055	0.0342	−0.0614	0.0724	0.16	0.8719
SC	−0.1139	0.0340	−0.1804	−0.0473	−3.35	0.0008
TN	0.1083	0.0290	0.0514	0.1653	3.73	0.0002
Total FTEs	−0.1013	0.0455	−0.1905	−0.0121	−2.23	0.0260
% in poverty	−0.1493	0.0323	−0.2125	−0.0860	−4.63	<0.0001

Notes: QIC = 1575; QICu = 1556; marginal R-squared = 0.1052

[a] Statistically significant variables are in bold

7.6 Implications and Discussion

The analysis of RHC data with 7 years of observation enables us to shed some light about the racial variability in risk-adjusted HF hospitalization rates in Region 4. The findings of this empirical study offer specific answers to each of the three research questions.

First, HF hospitalization rates decreased over the past years, particularly in 2012 and 2013. This changing pattern of HF hospital admission rates reflects the potential period effect attributable to the Affordable Care Act when the effects of personal risk factors for hospitalization were simultaneously controlled via risk adjustment. Both White and African-American adjusted rates of FH admission showed a steady increase from 2007 to 2008, although the speed of increase was relatively small. The latent growth curve model offered more substantive explanation regarding the nature of HF hospital admission rates. Because of the interdependence of the yearly rates, the change trajectories of HF hospitalizations had to be carefully considered in a thorough analysis of the contextual, organizational, and ecological predictors of the variation in HF admissions. Careful analysis of the predictor variables with the generalized estimating equation method revealed that a small amount of variance (marginal $R^2 = 0.0477$) in the risk-adjusted admission rates for Whites was accounted for by the predictor variables. In addition, the ACA period effect (with a relatively stronger regression coefficient of −0.091 relative to other predictors) on the White admission rates was also observed when other predictors were simultaneously considered; the post-ACA years had lower HF admission rates than the pre-ACA years. Because the decline in post-ACA years may be seen from multiple perspectives, system-based efforts to reduce HF admissions are likely, rather than just improvements in treatments for HF for both White and African-American patients. The community-based providers such as RHCs or community health centers may also focus on ways to lower admissions of their HF patients. Thus, RHC effort may have contributed to the decline in the risk-adjusted HF admission rates. Similarly, results in change trajectories of HF hospitalizations attributable to the positive ACA effect were found in the African-American group.

Second, the HF hospitalization rates did not vary significantly by categories of rurality in the African-American patient group for the 7 years observed, whereas the HF hospitalization rates for the White group were statistically significantly different in small and remote rural areas; for the White group, RHCs located in smaller or isolated rural areas appear to have had a slightly lower HF admission rate than large rural or urbanized areas.

Third, demographic and socioeconomic factors measured by the county-area characteristics and aggregate patient factors of RHCs appear to be relevant in explaining the variability in risk-adjusted HF hospitalization rates. More specifically, the percentage of the dually eligible reflects the relatively poor socioeconomic level and health status of Medicare patients served by RHCs. This variable was positively and statistically significantly associated with the HF admission rate: the larger the number of dually eligible patients, the higher the rate of HF admissions observed. It is interesting to note that the organizational attribute, such as the total FTEs of RHC visits, was negatively associated with the risk-adjusted rate for both White and African-American patients observed in multiple RHC years. For the African-American group, RHCs located in a higher rate of poverty population tended to have a lower risk-adjusted rate of HF hospitalizations.

The empirical findings presented are relatively robust, since GEE analysis of longitudinal data of RHC years included a risk-adjustment method to remove patient differences in RHCs. However, this study may be subject to a few limitations. First, the unit of analysis based on RHC year was measured by hospital admission claims of Medicare patients with HF. The measurement was based on episodes or events of interest. We cannot infer how the variability in hospital practices in RHC service areas may have contributed to the disparities in HF admissions. Second, the contextual, organizational, and ecological factors are those associated with RHCs, not hospitals. Our interest is to determine how the RHC and community area characteristics, reflecting the county, and aggregated RHC patient attributes, may account for the variability in admissions in multiple RHC years. Third, because the purpose of this investigation was to focus on the variability in the HF admission rates, identification of RHCs with substantially higher rates could portray the need for further enhancement of the ambulatory or primary care services needed for the specific groups of RHCs. We were unable to explore the full picture of regional variation in HF hospital admissions among RHCs in the United States because our data were restricted to the eight southeastern states in Region 4. Lastly, the supply-side variables, such as hospital market competition, travel distance from RHC to the nearest hospital, and types of hospital in the model, were not considered since RHC was the unit of analysis. Alternatively, a three-level multivariate analysis could be performed to include the interaction terms among patient-, hospital-, and community-level predictor variables in the analysis of HF hospital admissions. Furthermore, other efforts such as community support for fostering transitional care or post-acute care for HF through disease management or coordinated care may also be relevant to the declined trend of HF hospitalization.

This investigation has enlightened us about a statistically significant variability in hospital admission rates for HF by rurality for the White patients but not for the African-American Medicare patients. Future studies should address the variation in the stage of HF condition of RHC patients, using the American College of Cardiology's five classifications of HF severity. In addition, effectiveness in detecting the underlying causes or mechanisms for the disparities of HF hospital admissions and in implementing feasible organizational or community interventions should be further explored in future rural health research on HF.

7.7 Concluding Remarks

Our study offers robust evidence to show the relevance of contextual, organizational, and ecological factors, framed under the system framework, influencing the variations in HF hospitalization rates. The admission rates of rural Medicare beneficiaries varied by the ACA period and by state. There was a steady decline in HF hospital admissions of Medicare patients in the eight states from 2010 through 2013. A period effect of ACA on HF hospital admissions was observed in both White and African-American groups. The CMS Hospital Readmissions Reduction Program and other quality improvement initiatives, in addition to the ACA effect, may account for the declining rates. In order to disentangle the covariations or synergistic effects of both ACA and other policy interventions, researchers have to design and conduct thorough studies to investigate hospital practice variations in rural areas with multiple years.

This study contributes to the literature in the disparity research from the system perspective through the analysis of longitudinal data for HF hospitalizations. The results reveal that it is not a single operative factor alone influencing the variations in risk-adjusted HF admission rates, although race does play an important role (Williams and Mohammed 2013; Wolinsky et al. 1989). The general RHC structural characteristics such as facility age, ownership, and provider-based practice did not account for any statistically significant variability in the HF admission rates. The synergism of multiple contextual, staff size, and ecological (aggregated patient characteristics of RHCs) factors, as shown in this study, should be considered in the design and implementation of intervention studies such as using proper incentive plans or penalties to address the problem of HF hospital admissions through prevention and enhancement of HF management of rural Medicare beneficiaries. Our results also affirm the importance of considering county characteristic (percent poverty population) and RHC-based organizational factor (the total FTEs of RHC) for African-American patients in accounting for the variability in HF hospital admissions (Herrin et al. 2015). However, for the White patients, the variables measured at the organizational level such as the dual-eligibility status of Medicare patients and the total FTEs employed by RHCs should be considered in the formulation of hospital incentive payment formula in the future. The results of this study also reaffirm some of the current research literature (Gao et al. 2014; Jackson et al. 2013; Rosano et al. 2014). Furthermore, an evidence-based approach to guiding effective and efficient changes in HF admission practices, coupled with the use of community-based care modalities such as transitional care and mobile health-care management technologies, should be carefully formulated. Furthermore, intervention programs such as using telecardiology, communication systems, and HF disease management for reducing HF admissions and readmissions are needed (Riegel et al. 2002; Roth et al. 2004).

Appendix 1: The Study Variables and Their Operational Definitions

Variable	Codes	Operational definition
Contextual factors		
Older		Number of county population that is Medicare eligible (and age 65 and over)
Female		Number of county population that is female
Percent poverty population		Number of county population that is at 200% of poverty level
African-American		Number of county population that is African-American
Hispanic		Number of county population that is Hispanic
Native American		Number of county population that is Native American
White		Number of county population that is White
Rurality level	1: urban 2: large rural 3: small rural 4: isolated	Four categories based on RUCA code: urban, large rural, small rural, isolated Urban, 1.0, 1.1, 2.0, 2.1, 3.0, 4.1, 5.1, 7.1, 8.1, 10.1; large rural, 4.0, 4.2, 5.0, 5.2, 6.0, 6.1; small rural, 7.0, 7.2, 7.3, 7.4, 8.0, 8.2, 8.3, 8.4, 9.0, 9.1, 9.2; isolated, 10.0, 10.2, 10.3, 10.4, 10.5, 10.6
ACA period effect	0: before 2010 (2007 through 2009) 1: after 2010 (2010 through 2012)	The potential period effect of ACA on RHC performance
State		Region 4: seven dummy variables were created, using MS as a reference group; AL, FL, GA, KY, MS, NC, SC, TN
Organizational factors		
The years of RHC operation		Number of years Medicare certified for participation in RHC program
Staff mix and size		Number of physicians + PA + NP FTEs
Provider-based practice	1 = Provider-based RHC 0 = Independent RHC	RHC type
Ownership		Type of control of RHC according to 1 of 9 classifications (for provider type "12"—RHCs)
Personal factors		
Size of Medicare beneficiary population served		Total patients of RHC
Percent of female patients served		Number of patients aged 65 and older who are female (expressed as a percentage of total patients)
Percent of African-American patients served		Number of patients aged 65 and older who are African-American (expressed as a percentage of total patients)

Variable	Codes	Operational definition
Percent of Hispanic patients served		Number of patients aged 65 and older who are Hispanic (expressed as a percentage of total patients)
Percent of Native American patients served		Number of patients aged 65 and older who are Native American (expressed as a percentage of total patients)
Percent of White patients served		Number of patients aged 65 and older who are White (expressed as a percentage of total patients
Percent of patients dually eligible		Number of Medicare program beneficiaries with at least 3 dual eligible months within 1 year

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Part III

Implementing and Optimizing the Use of Health Information Technology in PHM Practice and Research

Chapter 8
Health Informatics Research and Innovations in Chronic Care Management: An Experimental Prospectus for Adopting Personal Health Records

Abstract This chapter focuses on the use of patient-centric care management technology, utilizing personal health record (PHR) as a facilitator for improving patient-provider communication, the continuity of care, medication management, and the adoption of health information technology in care management at community health centers. A randomized trial is proposed to evaluate how patient-centric care management technology may yield beneficial effects on a series of health-care outcome measures.

Keywords Personal health records • Health information technology • Patient-centric care • Complex factorial design • Randomized trial

8.1 Introduction

Patient safety and quality can be improved through proper design and implementation of an effective delivery system for patient-centered care. Little is known about an ideal care management technology that can be applied to community health centers or ambulatory care settings. Increased patient-clinician communication has shown to be associated with higher levels of patient satisfaction and perceived health outcomes (Glasgow et al. 2001; Ishikawa et al. 2005). The synergism of employing personal health record (PHR) and health information technology (HIT) in ambulatory care may play a pivotal role for enhancing collaborative patient care and increasing patient satisfaction, patient safety, and quality of care. To date there is little empirical evidence regarding the demonstrated value of the PHR, especially for underserved, minority, and older populations. It is also unclear if the PHR, augmented with a sound education training program, can reduce risks associated with medical errors in ambulatory care, improve patient-clinician communication, increase continuity of patient-centered care, and generate better proximal outcomes (patient and provider satisfaction) and improved distal outcomes (health-related quality of life and health status).

This chapter focuses on the use of patient-centric care management technology, utilizing PHR as a facilitator for improving patient-provider communication, the continuity of care, medication management, and the adoption of HIT in care

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management at community health centers. A randomized trial is proposed to evaluate how patient-centric care management technology may yield beneficial effects on a series of health-care outcome measures. Furthermore, this chapter will help address systemic barriers to HIT adoption in community health centers with disproportionately older, minority, and underserved populations.

More specifically, four aims are formulated as follows:

Aim 1 To identify the design and process components of a viable health informatics system to capture a commonly agreeable set of personal, health, and health-care variables clustered in a theoretically meaningful framework for constructing a data warehouse for research, education, and practice.

Aim 2 To evaluate the beneficial effects of PHR [electronic-based PHR and paper-based PHR] on ambulatory care outcomes measured by:

- Continuity of care
- Patient-clinician communication
- Patient and clinician satisfaction
- Adverse drug events detected by pharmacy consultation
- Use of health-care resources (patient visits, duplicate laboratory tests and imaging exams, emergency room visits (> 1 per 6 months), hospitalizations (>1 in previous 12 months)
- Health-related quality of life (HRQOL)
- Health status

Aim 3 To identify implementation barriers and facilitators for applying the PHR in the development of patient-centric care for the underserved patient population, specifically minority patients over 50 years of age, in community health centers.

Aim 4 To develop a dissemination and diffusion plan for implementing a patient-centric care management technology in ambulatory care settings.

8.2 Background and Significance

Following the publication of *Crossing the Quality Chasm* (Kohn et al. 2000), a blueprint for redesigning health care for the twenty-first century, patient-centered care became an indicator of quality care and patient safety. Defined as the patient's experience and the partnering of the clinician, patient-centered care is presumed to be enhanced by mechanisms that enhance patient-clinician communication (including the patient's caregiver or family) and patient safety. Patient-centered care is enhanced when the patient is included as a partner in their care (Ishikawa et al. 2005; Wagner et al. 2001a, b; Greenfield et al. 1985; Greenfield et al. 1988).

The adoption of personal health records is a patient-centered phenomenon (Noblin et al. 2012, 2013). The electronic personal health record (e-PHR) and the paper-based personal health record (p-PHR), when utilized, contain at a minimum a listing of patient allergies, clinical care providers, current medications, and current contact information. Several recent studies show that current medication records, a shared decision-making instrument, pro forma questions from patients, and electronic personal health records offer an improvement in patient-provider communication (Arar et al. 2005; Naik et al. 2005; Ross et al. 2004; Wang et al. 2004; Wells et al. 2004; Roblin et al. 2009). To date, the PHR in its electronic form or paper form has rarely been studied as a communication tool for improving patient safety and medication management, and there is little empirical data on the effectiveness of the PHR in either format with underserved patients in ambulatory care settings (Wang et al. 2004).

The significance of this PHR application project is exemplified by its conceptual, methodological, practical, and policy contributions for improving the patient safety and quality of ambulatory care, as follows.

8.2.1 Conceptual Formulation of Patient-Centric Care Management Technology

Digital health or m-health may change how population health is delivered and achieved. There is a critical need to conceptualize how patient-centric care modalities can be systematically formulated and evaluated. It is, therefore, important to explore the components that constitute an ideal patient-centric care management technology. The health IT applications for ambulatory care, using PHR, have the potential to enhance the continuity of care and the patient-clinician communication. The expected benefits may include improved patient-doctor relationships, enhanced physician knowledge of the patient status, increased patient adherence, avoided duplication of services and lab orders, improved patient safety, and reduced missed appointments.

The foundational principles of patient-centric care management rely on the improvement of interpersonal continuity of care and patient-physician communication. The Institute of Medicine (2000) has made continuity of care a primary goal of its comprehensive call for transforming the quality of care in the United States. In 2006, the American College of Physicians (ACP) established continuity of care as a central theme for restructuring or reengineering health care. Thus, it is imperative to establish scientific evidence in support of the need for expanding the PHR as part of the patient-centric care management technology.

8.2.2 Methodological Rigor and Measurement of Health-Care Outcomes

Health service research and evaluation are based on scientific principles (Wan 1995). The measurement issues pertaining to outcomes should be examined and validated. The temporal sequences of outcome-related measures should be clearly ascertained before one can draw any strong conclusion in regard to the effectiveness and efficacy of patient-centric care modalities. The evaluation of patient outcomes should delineate the causal sequelae of proximal and distal outcomes, using an experimental design. In addition, the study design should be able to tease out the main effects and interaction effects of intervention variables on outcome measures. A solidly designed investigation is capable of demonstrating how an ideal patient-centric care management technology can be implemented and evaluated by a rigorous experimental design.

8.2.3 Evidence-Based Knowledge and Best Practices in Patient-Centered Care

Over the past 20 years, concerted efforts have been made to design and implement the concept of patient-centered care through the use of care management technology. In recent years, there has been an explosion of evidence-based medicine/practice, as the direct result of several factors: the aging of the population, rising patient and professional expectations, the proliferation of new information technologies, the growth of disease management modeling, and the demand for better healing environments (Wan 2002). Massive amounts of clinical and administrative data have been gathered. Little has been done, however, to build the relational databases that can generate information for improving health-care processes and outcomes. Such systematic information is needed to build a repository of knowledge for use by policy decision-makers, providers, administrators, facility designers, researchers, and patients. Evidence-based knowledge gives users a competitive edge in making policy, clinical, administrative, and constructional decisions that improve personal and public health (Wan and Connell 2003). Furthermore, through using scientific principles in the demonstration projects, new knowledge can be gained from best practice modeling of the determinants and the consequences of care management interventions or patient-centric care strategies.

8.2.4 Population Health Policy Consideration

In a report to Congress, Public Health Service articulates that two major missions in public health are (1) to improve the quality of care and (2) to reduce health disparities. Innovative care strategies or policies are needed to provide guiding principles for reducing disparities in health care and health status, particularly related to ethnic minorities. This chapter will seek opportunities for identifying scientific evidence through systematic reviews on how HIT has affected population health and management around the globe.

8.3 Review of HIT Impacts on Population Health Management

Dorr et al. (2007) conducted a literature review of 109 articles on the impacts of HIT use in support of team-based chronic care and found that 67% of reviewed experimental studies had positive outcomes and 94% of observational studies also showed positive benefits of HIT. More specifically, they documented that the use of electronic medical record systems, computerized prompts, feedback and reports on population health management, electronic scheduling, and personal health records has yielded beneficial results. They also noted the barriers for hindering HIT applications related to costs, data privacy and security concerns, and failure to consider workflow (Dorr et al. 2007).

Williams and Wan (2016) examined the meaningful use of remote monitoring for heart patients served by a home health-care agency. They found the degree to which the information obtained from remote monitoring influenced change in readmission decisions. Hospital utilization was highly associated with nurses' clinical decisions to go to the hospital. They advocated that investments into remote monitoring technology should accompany strategies to enhance decision-making and align clinical decision-making with quality goals in practice.

Bauer et al. (2014) reviewed how collaborative or coordinative care could be enhanced by using mobile health technology. They articulated the need for integration through the principles of patient-centered care, evidence-based practice, measurement-based use, population-based care, and accountable care to improve quality. To leverage HIT in chronic disease care has potential to optimize the efficiency and quality in the process of transformation of innovative care delivery systems.

By using a cross-case comparison of five health informatics research projects, Unertl et al. (2015) identified specific advantages and challenges for integrating community-based participatory research and informatics approaches to improve the engagement of underserved populations. The use of PHR technology is an excellent mechanism for fostering the provider-patient interaction in the process of promoting population health.

8.4 Research Design and Evaluation

The Analytical Framework: Knowledge (K), Motivation (M), Attitude (A), Practice (P), and Outcome (O) Model

Figure 8.1 illustrates how patient care outcomes are directly responsive to the variation in preventive practice and indirectly influenced by varying levels of patient's knowledge, motivational and attitudinal changes via the preventive practice (Wan et al. 2017). In addition, the use of PHR as an intervention is expected to affect KMAP-O components directly.

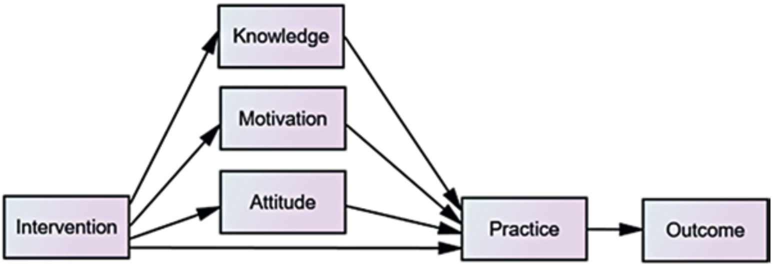

Fig. 8.1 The KMAP-O model

8.4.1 The Study Design: A Complex Factorial Design with Two Interventions

An evaluation research should be designed to assess the effects of the PHR format on health outcomes, continuity of care, patient-provider communication, patient safety specifically measured by medication interventions, sentinel events and adverse drug events (ADE), patient health outcomes, and patient and clinician satisfaction of ambulatory care patients. It is postulated that the three types of PHR interventions have different effects on patient health outcomes. The experimental design has two independent treatment variables and one interaction variable. Four community health centers will be randomized. The first intervention group is the application of electronic or digital PHR (e-PHR). The second intervention group is the application of paper-based PHR (p-PHR). The third intervention group is the combined application of both e-PHR and p-PHR. The fourth group is a control group (the usual care without the application of PHR and IT-based patient-centric care) (Table 8.1).

8.4.2 Measurement of the Study Variables

SF-12v2 Health Survey The SF-12v2 is a 12-item self-administered questionnaire tool which takes approximately 2–3 min to complete as a reliable measure of overall health status. It is the instrument of choice in population health surveys and has also been used extensively as a screening tool. The SF-12 measures eight scales: physical functioning, performance in physical role, performance in emotional role, vitality, social functioning, bodily pain, general health perceptions, and mental health. The results are generally displayed as either eight scales or two summary scales that capture physical and mental health. The questionnaires are widely used and have been found to be very useful in monitoring health outcomes in various disease and condition areas. The SF-12v2 Health Survey instrument is very sensitive to change.

Table 8.1 Intervention plan

Group	A (e-PHR)	B (p-PHR)
1	X	0
2	0	X
3	X	X
4 (control)	0	0

Note: X refers to the presence of an intervention, whereas 0 refers to the absence of an intervention

The Agency for Healthcare Research and Quality has developed a comprehensive survey instrument on patient's experience with providers and health-care systems. It is called the Consumer Assessment of Healthcare Providers and Systems (CAHPS). All data collected from the CAHPS® Clinician & Group Survey data could be shared with the National CAHPS Benchmarking Database (NCBD).

Health-Related Quality of Life (HRQOL) HRQOL can be measured using the WHOQOL-BREF. The World Health Organization Quality of Life (WHOQOL) project commenced in 1991. The 26-item WHOQOL-BREF assessment instrument was developed to measure quality of life for international cross-cultural populations. An individual's perceptions are assessed in the context of their culture and value systems, and their personal goals, standards, and concerns. Widely field-tested, the WHOQOL instruments were developed collaboratively in a number of centers worldwide. The domains measured by the WHOQOL-BREF instrument are physical health, psychological health, social relationships, and environment.

Patient-Centered Care Survey (PCCS) The PCCS is a survey of patient-provider communication with subscales such as the provider's responsiveness to patient inquiries, the patient's ability to understand how to perform self-care (knowledge), motivation to take actions, attitudes toward practice change, and actual behavioral change and practice in health promotion and disease prevention. We will use the Likert scale in the development and validation of the subscales, using both exploratory and confirmatory factor analyses.

8.4.3 Description of the Interventions. Experimental Protocol: Educational Training for the PHR

Educational training for the implementation of the p-PHR and e-PHR will be developed following an instructional analysis and a needs analysis of learners and context, including the special requirements for technology training of minority, older, and underserved patients. A focus group of patients will be recruited for the needs analysis prior to the development of the educational training program. Educational training will be developed for the physicians and clinic staff in use of the PHR as a communication tool. Specific training for the intervention will be developed utilizing social cognitive learning theory. Bandura's (1997, p. 10, 1986) social cognitive theory is the converging relationship between a learner's external environment, behavior, and personal factors (i.e., personal beliefs, characteristics, and experiences). The learner discovers that efficacy beliefs (one has the power to produce results), reality constructs, behavior, and environmental factors converge and influence his or her life. Perceptions and attitudes toward the subject matter to be taught influence the response of learners to the instruction, especially where technology is concerned (Bagozzi et al. 1992; Bandura 1982, 1989, 1993 1997; Compeau et al. 1999; Rogers and Mead 2004).

The Dick, Carey, and Carey Model of "The Systematic Design of Instruction" (2001) is widely used to develop instruction for business, government, and industry and allows for instructional analysis and needs analysis of learners and context, including the special requirements for technology training (Gustafson and Branch 2002). The Dick, Carey, and Carey Model allows for specific contextual training for older adult, underserved, and minority populations. Recent education and training literature indicates that age, gender, and cultural background are important considerations in designing training, especially if technology usage is involved (Ilie et al. 2005; Karavidas et al. 2005; Matanda et al. 2004; Morris and Venkatesh 2000; Richardson et al. 2005).

Physicians and staff in clinic settings will be trained in use of the randomized intervention assigned to their clinic, either the paper or electronic PHR, and use of the personal digital assistant (PDA). The clinic randomized to the e-PHR will receive a portable work station for use of the e-PHR if one is not available in the treatment room where patients will be seen.

- Patients with e-PHR: The patients bring their USB drive, and it is plugged into the PDA at each visit (or we use the wireless access to have the patient log in at the office and access their e-PHR online). The nursing assistant and/or physician review the medications with the patient. The CapMed Drug-to-Drug Interaction Checker is used to check for medication/safety problems. The medication list is updated on the patient's USB drive and on the PDA.
- Patients with p-PHR (paper-based personal health record): The patients bring their p-PHR record to the office visit. The nursing assistants scan the medication list and other changed information into a PDF which is downloaded to the PDA via the wireless network. The medications are reviewed by the physician with the patient.

E-PHR Patients Disease-specific education and links to http://medlineplus.gov/ or http://nihseniorhealth.gov will be put on the CapMed USB which utilizes the "Embedded Patient Education."

P-PHR Patients Disease-specific education will be printed out for patients from http://medlineplus.gov/ or http://nihseniorhealth.gov for the patients to take with them.

Important note: Both the e-PHR and p-PHR patients are given a few minutes to look over the information before they leave the physician's office, and the nursing assistants should assist the patients with questions.

8.4.4 Electronic PHR CapMed Personal Health Record

Since the inception of the CapMed Personal Health Record in 1996, it has been the company's goal to populate the PHR with existing electronic medical and health-care data. CapMed's team plays an active role on many different standards committees and interoperability initiatives with the goal of achieving full interoperability among health-care providers, payers, pharmacies, other sources of data, and the personal health record. The CapMed Web Server, as seen in Fig. 8.2, is built to facilitate exchange of standard data and integrate with online portals and other systems. The CapMed Personal Health Record is one of the few PHR systems able to support exchange of clinical data in the ASTM Continuity of Care Record format, the HL7 Clinical Document Architecture (CDA) of Care Record Summary format, and the harmonized ASTM/HL7 CDA Continuity of Care Document (CCD). Its interoperability module allows us to quickly translate and support other data formats, including proprietary data structures, as required.

8.4.5 Description of the Technical Architecture

As shown in Fig. 8.2, CapMed's technical architecture centers around the PHR users and the CapMed Web Server. Regardless of the PHR platform (online, secure desktop, or portable HealthKey), all communication between the PHR and external data sources is routed through the CapMed Web Server. This allows CapMed to implement new interfaces with standards-based data sources at the Web Server with little or no impact to the deployed PHR software. The CapMed Web Server is build based on service-oriented architecture (SOA) using the Microsoft .NET development environment.

8.4.6 Data Import/Export

The CapMed interoperability component supports the import and export of data to/from the PHR in many different formats and standards. As stated previously, its interoperability component supports the ASTM CCR and HL7 CDA and CCD standards. CapMed is continuously working to add additional standards, including NCPDP and X12 to its interoperability component. In addition to importing and exporting standards-based data, CapMed is positioned to support proprietary data formats, as is currently done with its interface to the MedicAlert Emergency Data Repository.

Aside from data standards and electronic transfer of discrete data, the CapMed PHR also supports saving the reports in PDF format, which can be transferred to medical providers and caregivers using a secure messaging center. CapMed is an

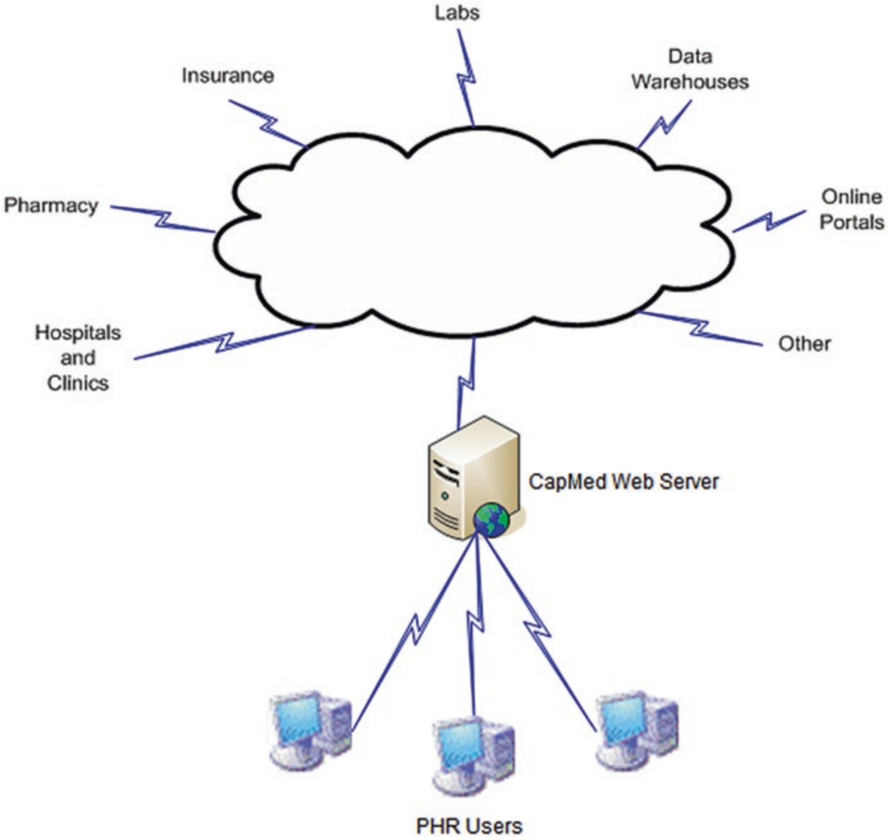

Fig. 8.2 CapMed interoperability overview

active member of the PDF for health-care working group that is defining the best practice guidelines for merging standards-based data into PDF form for both readability and transportability.

Finally, the CapMed PHR allows the import of virtually any electronic document into the PHR as an attachment. Thus, the patient can attach scanned copies of their medical records, results, bills, explanation of benefits, and more directly to their PHR.

8.4.7 Adherence to Technical Standards ASC X12, HL7, and CCR

CapMed supports the industry standards for storing and exchanging information and can exchange information with any application that supports these standards. The company plays an active role in creating the technology standards for patient-provider information exchange, and has been active in interoperability showcases using HL7 and CCR standards to demonstrate connectivity with more than 20 different EMR vendors. This interoperability component is designed to support quick integration of additional standards as well as custom solutions into CapMed's core technology.

The CapMed PHR includes a rich data definition and set of features that fully meet the AHIP standard for data in the Model Health Plan PHR, including the functional ability to auto-populate required information while allowing the consumer to self-enter any additional information into their PHR. In addition, the CapMed PHR provides a solution for full data portability between health plans at the patient's request.

8.4.8 Upload from Medical (Biometric) Devices

CapMed PHR provides mechanisms to upload results from home monitoring devices (glucose meters, scales, cholesterol meters, and blood pressure monitors) to the PHR for tracking, trending, and communication of results.

8.4.9 Images (e.g., Radiology)

CapMed PHR provides support for attaching external files such as images (X-rays, CT scans, EKGs, ultrasounds), scanned medical bills, birth certificates, copies of insurance cards, and any other pertinent information the user deems important.

8.4.10 Interface with EMR Applications

CapMed has been active in interoperability showcases using HL7 and CCR standards to demonstrate connectivity with more than 20 different EMR vendors using the IHE exchange and the patient as "chauffeur." To this point, CapMed has been the leading PHR vendor at the TEPR 2004 and 2006 CCR Interoperability Showcases; the HIMSS 2005, 2006, and 2007 IHE Interoperability Showcases; and the NCHICA 2006 IHE Interoperability Showcase. CapMed's ability to interoperate with multiple EMR vendors and other data sources such as insurance companies and pharmacies was instrumental in the ASTM judges' panel decision to name the CapMed PHR as the First-Place Personal Health Record in head-to-head competition at the TEPR conference May 21–24, 2006.

8.4.11 Flow for Participants in the Research Project

Physicians Project Confidentiality and Participation Agreement → Informed Consent → Pre Test → Training → Patient Office Visit → PCCS Communication Survey (repeated at each office visit) → Focus Group Debriefing

Clinic Staff Similar to physicians' model noted above, it will have the following steps:

Project Confidentiality and Participation Agreement → Training→ Participation in Project→ Focus Group Debriefing

Patient The steps are as follows: Informed Consent → Pre Test → Training → PHR Reminders → Office Visits (over 12 months) → PCCS Communication Survey (repeated at each office visit) → Post Tests → Focus Group Debriefing

The structural aspects are the organizational components: e-PHR, p-PHR, clinic staff (administrative, pharmaceutical consultant, nursing staff, and clinical/physician staff) and their educational levels and experience, and the PHR formats, both paper and electronic. The process components are the patient-physician processes, that is, the actual care delivered to the patients. This includes the assessment, planning, delivery (education and training of the patients), and evaluation of patient care outcomes.

8.4.12 Participants

The clinics should be randomly assigned to use one of four interventions: (1) e-PHR, (2) p-PHR, (3) e-PHR and p-PHR, and (4) waiting list/control group. (All participants will be offered training and a p-PHR at the end of the study.) All participants will be educated and assisted in use of the p-PHR and/or e-PHR or placed on the waiting list (control group). The control group will be offered training at the end of the intervention in use of the p-PHR and e-PHR.

8.4.13 Ambulatory Clinics as the Study Site

Multiple ambulatory care clinics could be selected from the community. Participants over age 60 in underserved areas are to be recruited to participate in a 12-month block randomized clinical trial of the personal e-PHR and p-PHR. The inclusion criteria should be specified and may include age, gender, health status, the general cognitive ability, etc.

8.4.14 Evaluation

This experimental project will generate rich data for outcome assessment and evaluation with multiple repeated measures suggested for the program evaluation. The difference-in-differences statistical analysis should be performed to examine the impact of using e-PHR and p-PHR. In addition, a logic model of program evaluation should be used to determine the effectiveness of the proposed intervention on the proximal (patient satisfaction), intermediate (usability of the PRG), and distal (HRQOL) outcomes.

8.4.15 Use of Decision Support Systems or Software in PHM

Many vendors and IT companies have developed a variety of decision support systems or software to enhance the usability of massive clinical and administrative health data from multiple sources. However, a comprehensive scope of PHM software is still yet to be developed. A useful guiding principle for selecting specific software or analytics was suggested by Sanders (2017) from the Health Catalyst Company (https://www.healthcatalyst.com/wp-content/uploads/2014/02/Population-Health-Management-v03-modified.pdf) that compares each company's product for 12 criteria of fully developed software. These criteria include (1) precise patient registries, (2) precise provider attribution, (3) precise numerators in the patient registries, (4) clinical and cost metrics, (5) basic clinical practice guidelines, (6) risk management outreach, (7) acquiring external data, (8) communication with patients, (9) educating and engaging patients, (10) complex clinical practice guidelines, (11) care team coordination, and (12) tracking specific outcomes. These criteria are helpful for assessing the maturity of PHM operations. Sanders advocates that criteria 1–6 are in the less advanced stage in comparison with criteria 7–12 in system functions and operations in using PHM software.

8.5 Human Subject Protection

8.5.1 Inclusion Criteria

For participation in the program, the following criteria are suggested: (1) age 60 years or older, (2) ambulatory patients who had one or more primary care visits in the past 12 months, (3) reside in the community, (4) have access to a telephone, (5) willing to attend training for the PHR, (6) at a minimum submit their p-PHR or e-PHR medication record for use as a patient-clinician communication tool for outpatient office visits and use the personal health record for 1 year, (7) willing to complete the measurement surveys, and (8) be randomly assigned to one of the four intervention/treatment conditions.

8.5.2 The Role of Health-Care Providers/Clinicians

The physicians will be participants in assessing the relative effectiveness of physician-patient communication following each patient visit.

8.5.3 Privacy and Security

Systems for the electronic health data exchange must protect the integrity, security, privacy, and confidentiality of an individual's information. All entities (partners in the study) that provide or manage personal health information, whether defined as covered entities under HIPAA, should follow the privacy and security rules that apply to HIPAA-covered entities.

8.5.4 Protection of Human Subjects

This is human subject research and meets the definition of clinical research. Data should be collected through intervention and interaction *with the individual throughout the project.* All identifiable PHI personal health information following initial collection will be retained in locked file cabinets or secure encrypted data files available only to the investigators and project manager.

8.5.5 Data Safety and Monitoring Plan

The risks of this study to subjects should be monitored and reviewed by a Data Safety and Monitoring Board (DSMB). This board will be composed of four or more professional persons who will meet a minimum of quarterly, more often if necessary via teleconference to:

1. Review the subject consent documents to ensure no coercion occurred, appropriate translations into the native language of the speaker were available, and post-consent testing occurred so that all subjects understood the consent process and the details of the study.
2. Review all adverse events (AEs). AEs will be categorized as related or unrelated. All related AEs will be reported as required by the University of Central Florida

Institutional Review Board (IRB). If deemed unrelated, the documentation will be retained as a part of the subject record. If deemed related, the board will investigate as appropriate. The results of the investigation should be included in the summary adverse event reports provided to the university IRB and project funding agency.

3. Monitor the use of the PHR technology and data collection to ensure the security and protections of subject data are considered at every step during the study. Any privacy violations or security lapses would be considered an adverse event. Recommendations will be made on any changes that may need to be made to assure that privacy and security issues are addressed during the trial.
4. Review a sample of raw data from the patient and clinician satisfaction and patient-clinician communication surveys for the potential for dissatisfaction with the experiment to result in negative patient care interactions.
5. Review selected protocols and results from the data cleaning and statistical analyses for accuracy and consistency.

8.5.6 Criteria for Termination of the Research Study

The Data Safety and Monitoring Board would suspend the study immediately if it were noticed that use of the PHR were resulting in statistically significant increases in the occurrence of adverse drug events or sentinel events.

8.5.7 Sustainability of the Intervention

Health educators, as part of the collaborative team, should continue to provide training in the use of the p-PHR and e-PHR as part of their community outreach.

8.6 Concluding Remarks

Implementation and evaluation of the use of PHR should be carried out simultaneously by a research team. The assessment of efficacy in the use of the proposed PHR intervention may shed some light about the barriers and advantages of offering PHR as part of the patient-centric activities to foster health behavioral changes and medical adherence that are critically needed for chronic disease management. The impetus for advocating this health informatics experiment in a population health management program is that it is believed it will induce more proactive responses to needed health actions and thus engender self-efficacy or self-care ability. Furthermore, research also suggests disparities in the use of PHR by racial and socioeconomic groups (Roblin et al. 2009). In order to fill the utilization gap, it is imperative to improve the accessibility to PHR at the population level.

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Chapter 9
Design of Integrated Care and Expansion of Health Insurance for the Underserved and Medically Indigent Population

Abstract The US health-care system fails to deliver integrated care through community health centers. The Medicaid crisis encountered by every state is pervasive and has adversely affected emergency departments' operation and function. The proposed managed care plan for Medicaid beneficiaries is an attempt to develop fundamental principles of reengineering or restructuring the community-based delivery system with applications of health information technology (HIT). This chapter illustrates important integrated care principles for restructuring community health centers to serve the underserved population in the United States. We present a schema for employing health-care information technologies in the design of a community-based delivery system. Based on the best practices of community health centers, we analyze the factors influencing their effectiveness and efficiency. The principles of an integrated care management plan are formulated. Expected outcomes of the HIT-based delivery system are discussed.

Keywords Indigent care • Medicaid • Health information technology • Community-based care • Integrated care • Community health center

9.1 Introduction

Despite becoming one of the five most globalized nations in the world in 2005 and ranked in the top seven for overall performance (U.S. News 2017), the United States fared far worse with regard to health rankings inside our borders and ranked 17th on the overall quality of life measure. Rated 37th in the quality of health care and 72nd in population health in the world, it is a common and growing fear that the US health-care system is unsafe. According to the seminal Institute of Medicine (IOM) reports *To Err is Human* and *Crossing the Quality Chasm*, this fear is grounded in fact (Briere 2001; Donaldson et al. 2000). These reports assert that the US health-care system is indeed unsafe and besieged with poor quality. Increases in complexity, poor system design, and underuse of information technology (IT) exacerbate these problems. In an attempt to restore integrity and excellence to the US health-care system, the IOM set forth six principles to guide future health-care system reform in *Crossing the Quality Chasm*: patient safety, effectiveness, efficiency,

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patient centeredness, timeliness, and equity (Briere 2001). These ideals are incorporated into this research.

While there have been significant improvements in patient safety using health information technology (HIT), alleviating critical symptoms of the larger health-care system failure requires more comprehensive, dynamic intervention (Enthoven and Tollen 2005; Shortell and Schmittdiel 2004). Advancing the protection of patient safety and, ultimately, health system safety requires attention to the broader scope of the root problem. This attention brings a renewed focus on better management and utilization of information and must be employed at the heart of patient-centered delivery of care. This expanded approach to HIT is known as knowledge management (Wan 2002). Knowledge management theory suggests that it is not enough to collect and control information and organize it for efficient recall and communication. Instead, knowledge management advocates the combination of technology-infused efficiency with timeliness, appropriateness, and effectiveness of health-care provision. This chapter illustrates an innovative idea of implementing health information technology-based knowledge management to a Medicaid managed care model for protection of both the economic and clinical safety of the program.

9.2 Background

Florida currently spends 15.5% of its state budget on Medicaid expenditures – a rate that threatens to climb to 50% in a few years if current growth remains unfettered. As the primary program for the uninsured, the underinsured, and the vulnerable, Medicaid is a critical program that Florida cannot afford to lose or even just maintain in its present condition. It is too early to understand how the mandatory privatization/capitation plan approved by the Florida legislature will impact program efficiency, effectiveness, equity, and quality of care. Every state in the union is struggling to protect their programs and their patients (Alker and Portelli 2004).

While cost constraints are necessary, reassessment of the care delivery strategy is also imperative to ensure long-term health-care economic safety for Medicaid. Knowledge management strategies incorporate tools that will improve quality, including improved communication between care providers, more readily accessible disease and wellness knowledge, availability of key pieces of information (such as the dose of a drug and its food, drug, and lifestyle interactions), prevention and screening reminders, and other types of decision support to promote accurate, appropriate health care.

Recent indictment of disease-specific patient safety is drawing attention to the broader problem of inadequate health system safety. This chapter builds on the success of HIT in protecting individual patient safety by expanding its application via a dynamic strategy of knowledge management to a state managed care Medicaid system.

We propose a pilot study to evaluate a new program called Integrated Care Management Plan (ICMP) that applies knowledge management (integration of health-care technologies and care management) in a rural community health center located in Hastings, FL. From our longitudinal analysis of 650 Community Health Centers (CHCs) and their performance in the United States, our research team has identified factors associated with higher CHC efficiency and clinical performance. From this study, hypotheses have been formulated as prescriptive models for achieving high performance in CHCs. The ability to identify and communicate those factors that influence health center clinical performance and economic safety will serve as a framework for a managed care model to serve state Medicaid subscribers.

9.3 Purpose

This chapter illustrates a strategy to restore the health-care economic safety of Medicaid managed care to good health via a knowledge management model grounded in innovative health-care information technology. A two-pronged approach to health-care economic safety is proposed:

1. Make use of Health Informatics Research Lab (HIRL) data to prescribe CHC best-performance practices based on research evidence.
2. Apply knowledge management to develop Medicaid managed care delivery model around benchmarks identified in step 1.

9.4 Principles of an Integrated Care Management Plan

The following nine principles are the basis for building an ideal knowledge management plan for Medicaid:

1. Patient-centric care management: A care management team should perform coordinated services that cover assessment, care planning, care evaluation, and outcome tracking. Efficiencies are gained where services are provided to groups of clients needing the same or similar benefits (education, exercise, etc.). Individual needs are assessed in the context of individual care and larger group care.
2. Comprehensive care: A full scope of both preventive and curative services should be provided. Both clinical and social services should be effectively coordinated and evaluated for improved outcomes. (Clients with diabetes reflect gains influenced by all members of the care team: podiatrist, nutritionist, provider, etc.)
3. Capitation: The monthly coverage for the health plan is based on capitation. Incentive plans for promoting quality of care can be built in the value-based payment system.

4. Technology use: Information and care technologies should be effectively used to enhance the delivery of high-quality and efficient services.
5. Volunteerism: Efforts should be made to recruit retired physicians and nurses to participate in the delivery of coordinated care.
6. Choice and engagement: A patient should be free to choose his or her caregiver from the health center. Patient engagement in the process and outcomes of care is an important step to build the trust with the health-care system.
7. Continuity of care: A regular source of care for the patient should be designated and coordinated. The patient is able to seek care from the same practitioner.
8. Accountability: Normative standards, such as Health Plan Employer Data and Information Set (HEDIS), should be communicated to the care team staff and measured in outcomes to benchmark the quality and efficiency of coordinated care. Incentives that reward evidence of applied accountability should be built into the practice.
9. Partnership: Strong partnerships among CHCs, acute care, subacute care, and long-term care facilities should be established to reduce fragmentation of services. In addition, the founding of or participation in an evidence-based public health system is vital (Fielding and Briss 2006; Tilson and Berkowitz 2006).

9.5 Managed Care Plan Objectives and Plan

9.5.1 Objectives

1. Analyze CHC data to determine factors contributing to improved performance as prescription for patient-centered care management and cost reduction without adversely affecting the quality of care via the following tasks to:
    - (a) Perform multivariate analysis to identify practices historically associated with improved performance indicated in the CHC data.
    - (b) Conduct sensitivity analysis to identify performance-determining practices with analytic tools and discrete-event model simulation and to inform protocol development, prioritization, and policy with cost-benefit evidence.
    - (c) Offer prescriptive performance-impact models derived from actuarial data, hypothesis testing, and practice evaluation.
    - (d) Use simulation or artificial intelligence to validate assertions and quantify expected results for applications of the derived models for health-care economic safety.
2. Use a fully HIPAA (Health Insurance Portability and Accountability Act)-compliant database to share demographic and basic information among primary care providers, subspecialists, emergency departments, and behavioral and social science providers by employing:
    - (a) Digital records wherever feasible as they are shareable, inherently searchable, and easily recompiled for decision support, public health monitoring and reporting, and feedback analysis

   (b) Non-digital documents scanned into the system and linked to a client record to establish an electronic document repository
   (c) Fingerprint identification and other confidentiality-defining technology to secure the system
   (d) An inventory of preventive services available to ensure the choice of a variety of decision support systems
   (e) An electronic referral/follow-up tracking system for follow-up, wellness, vaccinations, laboratory, and other continuity of care services
   (f) A formulary established for local primary health-care providers to be facilitated with HIT to ease publication, distribution, use, and evaluation to reduce error, promote safety, and limit waste

3. Establish a pharmacy system that is electronically connected to all providers through Medical Manager with a specialized prescription system module enabling to:

   (a) Support centralized purchasing of an inventory of drugs
   (b) Evaluate the pharmaceutical delivery system through the prescription system and a financial analysis module
   (c) Purchase pharmaceuticals for clients at an economy of scale to ensure lowest costs
   (d) Offer physicians and staff an automated prescription writing and distribution system that is fast and efficient
   (e) Provide geographic access to drugs for all patients without transportation, including home delivery
   (f) Establish an automated inventory and purchasing system to ensure the greatest operational efficiencies with resultant cost saving to the system

9.5.2 Plan

A two-pronged approach to remedy the HE safety ailment is proposed:

1. Make use of CHC data to prescribe best-performance practices based on research evidence.

Analysis of CHC data is planned to determine factors contributing to improved performance. Analysis will be in terms of cost, quality of care, and patient safety based on measured performance comparing intervention to controls. The results will thereby serve as sound evidence-based prescription for patient-centered care management and cost reduction without consequence to quality of care.

Multivariate analysis will be performed to identify practices historically associated with improved performance indicated in the CHC data. Sensitivity analysis will be performed on identified performance-determining practices with analytic tools and discrete-event model simulation to inform protocol development, prioritization, and policy with cost-benefit evidence. Prescriptive performance-impact models will be derived from actuarial data, hypothesis testing, and practice evaluation. Simulation will be used to validate assertions and quantify expected results for

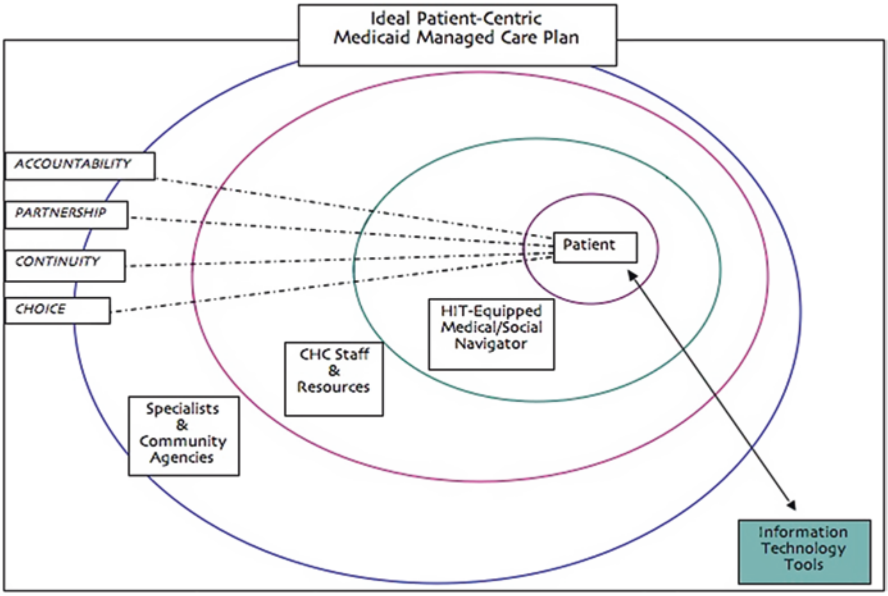

Fig. 9.1 ICMP-based care model

applications of the derived models for HE safety. At full maturity, the models may be employed dynamically in the delivery of care to provide high specificity optimization of performance tailored to unique parameter values for organizations with specific locations and contexts.

2. Apply knowledge management to develop health-care delivery model around benchmarks identified in step 1. (See model in Fig. 9.1.)

The most innovative, efficient health-care model money can buy is of no use if the quality of the care provided is inadequate to protect the people it was designed to help. With a nation of uninsured citizens often a paycheck away from losing their housing or their ability to meet their families' needs, it is imperative that an effective health-care model both prevent chronic disease onset and progression and minimize the financial and social impact of disease on individuals, families, organizations, and society.

By focusing on elements known to be strengths of community health centers, the ICMP model in Fig. 9.1 demonstrates a patient-centric care plan that recognizes the benefit of revolving service around the individual client's need. The patient is nestled in the field of their health-care advocate, a technologically well-connected medical-social navigator trained to guide them through their health-care choices and facilitate coordination (inside and out) of the care advised by the provider team. This advocate, the HIT-equipped medical-social navigator, is firmly seated between both the client's sphere and the realm of the health center, where they can coordinate care needs from appointments to group education to childcare referrals. The health

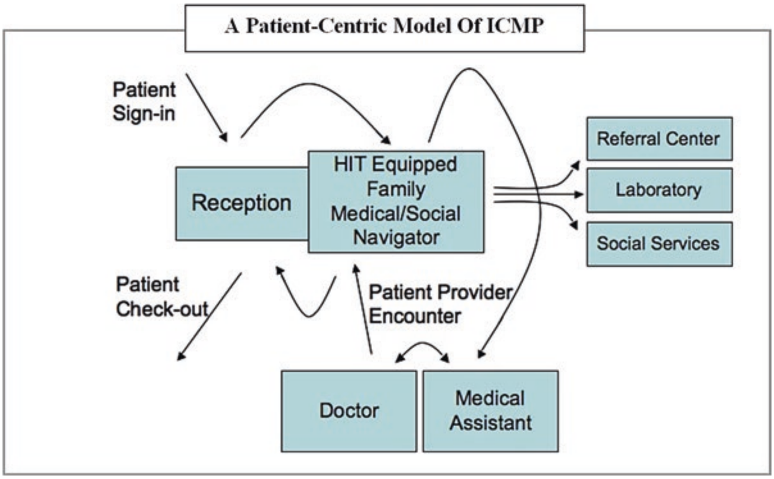

Fig. 9.2 ICMP-based care process

center staff and resources are encompassed by the larger community of specialists and other safety net agencies.

There are four common threads to this managed care plan that differentiate it from other private and Medicaid managed care products. All four characteristics are drawn from health center research that identified distinctions that influence a center's ability to provide higher quality health care to more satisfied clients. These factors, illustrated as running through each sphere of the model, include accountability, partnership, continuity, and choice.

The information technology tools that extend throughout all the model spheres are designed to develop, deploy, maintain, and evaluate this patient-centric managed care plan across risk pools. Service delivery will be improved via technology with the employment of information technologies such as expanded electronic medical records, Web-based access, digital record archiving, e-pharmacy, e-referrals, integrated billing, and posting. Technology will improve health-care outcomes through knowledge-based patient care management to improve client access to services, expanded provider linkages, reduced fragmentation, and improved system efficiencies. This ideal design based on a collection of successes may serve as a state/provincial model for Medicaid managed care (Fig. 9.2).

9.5.3 Expected Outcomes

Based on the criteria posited by the IOM, the following outcomes are expected:

1. **Patient-centered care:** The use of an electronic medical record system will minimize client frustration with the medical intake process. The same provider could see the patient at a satellite office, during a home visit, or in the hospital

and have immediate access to all the information to make assessments and recommend treatment. Medical records will not be "lost."

2. **Equitable care:** Through the uniform application of unbiased HIT, evidence-based medicine will reduce health-care disparities. Geographic access to drugs for all patients without transportation, including home delivery, is anticipated.
3. **Efficient care:** By avoiding duplication and waste, the program is expected to be **efficient**. To the degree that patient-centered records are complete, the program anticipates optimization of efficiency by avoiding redundancy. On-site wait time, telephone wait time, and refill and referral wait times will be reduced as a result of improved secure communication via email, instant messaging, and file sharing.
4. **Timely care:** By providing 24 h access to patient medical data, reduced documentation, transcription, and data entry, the program will provide timely care. During a life-threatening emergency, physicians or other medical persons will have **immediate** access to specific patient records that could help quickly decide among several methods of treatment, each with a set of pros and cons.
5. **Safe care:** Due to its point-of-service information availability of evidence-based **medicine**, the program will reduce prescription errors, increase preventive health services, avoid duplication of unnecessary and risky procedures, and therefore improve safety. Patient safety will be maintained and improved owing to better-attended patients through continuity of care and coherent care management.
6. **Quality care:** Losses to follow-up will be reduced by attention to outcomes and continuity of care by patient care management teams empowered by HIT. Clients will follow up on referrals for specialized treatment because it will not be an ongoing invasion of personal privacy from continual questioning about their medical history. Specialists will be more willing to participate in a system of care for the uninsured and underinsured because of reduced administrative and patient care costs. Unnecessary referral utilization will be reduced by evidence-based changes in delivery and elimination of unmerited practices.
7. **Population health management system:** The shift of a safety net function from emergency departments in acute care facilities to community health centers or community-based care has to be made. This shift has to be ensured by the sound practice of preventive-oriented personal and public health system (Marathe et al. 2007).

The planned pathway of the comprehensive strategy begins with the immediate rollout of feasible technology solutions, supplemented with and adapted by knowledge management techniques to ensure that the right people are receiving the right information at the right time via the right method to ensure the right plan, which can then be tracked and tailored as necessary. The feedback loop created by the ability to use current data to make safe clinical decisions and then track the outcomes of those decisions to continue to inform decision-making is the epicenter of knowledge management. The more innovative the technology applied, the more flexible and boundless the options to strengthen the efficiency and effectiveness of a health-care delivery system. An integrated care model fused with a technology-based, patient-centered delivery system is an innovative strategy to improve much needed access to comprehensive health services through community health centers for Medicaid beneficiaries. Its cost-effectiveness in the delivery of primary and preventive care can be realized by fostering the development and implementation of patient-centric care and integrating health and social services needed for the medically indigent who are likely afflicted by multiple chronic conditions.

9.6 Concluding Remarks

The US health-care system fails to deliver integrated care through community health centers. The Medicaid crisis encountered by every state is pervasive and has adversely affected emergency departments' operation and function. The proposed managed care plan for Medicaid beneficiaries is to attempt to develop fundamental principles of reengineering or restructuring the community-based delivery system with applications of health information technology (HIT).

This chapter illustrates important integrated care principles for structuring community health centers to serve the underserved population in the United States. We present a schema for employing health-care information technologies in the design of a community-based delivery system. Based on the best practices of community health centers, we have analyzed the factors influencing their effectiveness and efficiency. The principles of an integrated care management plan were formulated. Expected outcomes of the HIT-based delivery system were discussed.

An information-technology-based or smart delivery system in integrated care through community health centers is workable if population health and management, particularly related to the indigent or underserved patients, is set as a priority for health-care reforms and policy changes.

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Chapter 10
Reduction of Readmissions of Patients with Chronic Conditions: A Clinical Decision Support System Design for Care Management Interventions

Abstract When the population is aging in a fast track, it is imperative to take care of or manage chronic conditions. We should employ multiple strategies to optimize the best practical solutions for achieving high quality and low cost of care. This chapter offers an exciting opportunity to demonstrate the usefulness of a collaborative project for chronic care management and health promotion research. Building an effective and efficient PHM program for specific chronic diseases with a decision support system, particularly related to poly chronic conditions, will require a concerted effort in synchronizing multi-prone solutions and strategies for risk reduction or avoidance of rehospitalization through (1) advocating the delivery of patient-centric care and education, (2) integrating health information technologies to generate meaningful use and integrated informatics for enhancing clinical and administrative decisions, and (3) containing costs for care via the use of value-based payment system.

Keywords Population health management • Comparative effectiveness • Risk reduction • Rehospitalization • Decision support system • Health information technologies • Value-based approach • Artificial intelligence approach

10.1 Introduction

The prevalence rate of chronic conditions is positively associated with age. Repeated hospitalizations of some chronic conditions such as type 2 diabetes, COPD and asthma, heart failure, hypertension, and other heart conditions are generally considered ambulatory care sensitive conditions. In order to avoid or reduce the risk for being hospitalized or readmitted, both personal and contextual factors are important to be incorporated into care management plans by providers and caregivers. In fact, hospital readmissions associated with ambulatory care sensitive conditions are consistently identified as one of the major health-care issues in the effort of monitoring and improving the quality of care (Wan et al. 2017). High readmission rates have been attributable to the lack of transitional care, inadequate or poor access to primary care, and the provision of poor quality of hospital

T.T.H. Wan, *Population Health Management for Poly Chronic Conditions*,
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care (Golden et al. 2013; Jackson et al. 2013; Jencks et al. 2009; McCall et al. 2004; Mor and Besdine 2011).

Empirical studies suggest that personal attributes, diagnostic conditions, hospital transfer or discharge status, health-care system factors, and geographical distance to the focal hospital are potential risk factors for examining readmissions (Benbassat and Taragin 2000; Herrin et al. 2015; Jackson et al. 2013; Joynt et al. 2011b; Kulkarni et al. 2016; Marcantonio et al. 1999). Little is known about how the contextual (county characteristic), organizational (clinic characteristic), and ecological (aggregate patient characteristic) factors contribute to the variability in readmissions when the influence of patient characteristics is being simultaneously controlled for in the investigation.

According to Jencks et al. (2009), repeated hospitalization rates of Medicare patients for all conditions ranged from 19.6% (readmitted within 30 days of discharge from an acute-care hospital) to 34% (within 90 days of discharge). Hospital readmission rates for all conditions of Medicare beneficiaries were 19% from 2007 through 2011 and declined to 18.5% in 2012 as posted in MedicareCompare.gov. Brennan (2014) reported the cost estimate of repeated admissions at $25 billion per year. About $17.4 billion of the cost for readmissions is avoidable. The Centers for Medicare and Medicaid Services (CMS) has started monitoring avoidable hospitalizations and readmissions by implementing a hospital readmissions reduction program or a financial sanction plan to eliminate this hospital quality problem. In fact, it penalized hospital reimbursements with high readmission rates for Medicare patients treated for congestive heart failure, acute myocardial infarction, or pneumonia. Beginning October 2012, Medicare payments were to decrease by 1% to 2% in 2013 and by 3% in 2014. Beginning in October 2014, the readmission rate for Medicare patients with chronic obstructive pulmonary conditions also was monitored. Starting in 2015 the readmission rate for hip and knee replacements was included in the readmissions reduction program. Concomitantly, the enactment of the Patient Protection and Affordable Care Act (ACA) on March 23, 2010, was expected to enhance patient-centric care and improve the delivery of ambulatory care and prevention through the expansion of health insurance coverage for the uninsured. The ACA Section 3025 also solidifies the importance of readmission reduction effort.

Research literature suggests that the severity of illness and other personal characteristics may explain the differential rates in readmissions. Thus, risk adjustments for personal attributes and the severity of illness have to be considered when the independent effects or influences of the contextual, organizational, and ecological correlates of readmission rates are being investigated.

Four specific aims of this chapter are to (1) articulate the need for feasible strategies in reducing readmissions or avoidable hospitalization, (2) consider a multilevel or multitiered approach by combining person-centered and ecological-level interventions, (3) offer comparative strategies for action, and (4) search for the best and feasible practices in addressing human factors that may help reduce the risk for being readmitted for patients with specific chronic conditions.

10.2 Qualitative Aspects of Risk Reduction Strategies and Interventions in Population Health Management (PHM)

Communication channels between patients and their providers are essential to foster continued adherence to medical regimens, irrespective of the type of chronic conditions. Evidence has been documented that better therapeutic and self-reported outcomes are observed among patients who have direct communication with their providers via email, social media, or telecommunication networks. However, studies on the comparative results for having used a variety of communication channels or networks to achieve risk reduction or avoidance for readmissions have yet to be done, particularly in the use of clinical trial study design.

The PHM strategies reliant on the qualitative approach are generally found in the following four areas:

1. Risk Perception: Each individual's cognitive mapping of risk factors may operate on different levels of precision. However, patients are easily persuaded or motivated to focus on a variety of personal habits or lifestyles that may shift the relative risk for experiencing an adverse event or outcome.
2. Risk Differentiation: Through the partition of risk factors, patients may realize the need to categorize the risk propensities so that actions can be taken to avoid impeding an event or outcome. Thus, patients learn how to differentiate the relative risk for experiencing the odds of being readmitted if adequate evidence or information is readily available to them.
3. Risk Valuation: A value-based assessment may be undertaken by patients who are undergoing a choice of optimal solutions. Benefits vs costs for an action may be judged routinely by patients.
4. Value Optimization: The least effort principle is generally preferred so that the more efficient action or plan is selected after the risk valuation.

The success in PHM programming rests upon how the above qualitative aspects of risk reduction or avoidance are viewed by each patient. Thus, patient-centered care management has to take into account these relevant domains in human perceptions. Carefully designed PHM has to gather useful information that will help to achieve a better understanding of the variability in personal circumstances or situations. Exploratory research is needed to formalize the needs assessment before investigators can pursue the design and implement of psychometrically valid, reliable, and usable instruments for risk assessment.

10.3 Quantitative Aspects of Risk Reduction Strategies and Interventions in PHM

A scientific risk assessment is oriented toward the quantification of multiple and competing risk factors that may help signal the direction for early interventions, particularly related to the pattern detection of conditions that may accentuate the severity of illness and instigate the use of costly service modalities. Current developments in applying artificial intelligence or machine learning with "big" data have the potential to guide the formalization of preventive and prescriptive efforts in chronic disease prevention, treatment, and rehabilitation. Through research collaborations of scientists from clinical, population health, management, and biostatistical disciplines with multitiered strategies, many exciting population health management programs and services are evolving in the United States. Innovative PHM programs have been implemented, such as Philips Healthcare's align, engage, and integrate action plans for patient-centered population health, IBM's Watson Health, Optum Population Health's Infographic, and other private or commercial enterprises or services for reducing readmissions (Cognitive Healthcare Solutions 2017; Cortad et al. 2012; Proctor et al. 2016).

The quantification of risk reduction for hospital readmissions can be accomplished in three basic steps: (1) risk segmentation, (2) risk reduction, and (3) risk avoidance. The risk segmentation is derived from the identification of relatively homogenous subgroups via predictor tree analysis or automatic interaction detector analysis (Wan 2002). By employing a theoretically informed framework such as Andersen's behavioral system model, researchers can categorize predictor variables such as predisposing, enabling, and need-for-care factors in accounting for the variability in utilization behavior (e.g., hospitalization or readmission). Then, the patient population is segmented by the clusters of personal and contextual attributes so that the terminal subgroups show the homogeneity within the subgroup and the heterogeneity between the subgroups, using the automatic interaction detector analysis (Wan 2002) or predictor tree analysis (Sherrod 2002).

Risk reduction strategies may vary by the subgroups identified by the risk segmentation phase in the design of a PHM program. Personal choice is an important ingredient for a successfully executed program. In a previous chapter, we performed a systematic review and meta-analysis of selected human factors affecting the risk for heart failure hospitalization. How heart failure patients can lower their odds of readmissions is shown by selecting a single strategy or multiple combined strategies. The statistical algorithms for varying choices of strategies with the odds ratios for readmission are presented in the next section.

Risk avoidance is based on an optimization algorithm that will maximize the benefit for a specific action or procedure. In reality, if one can rely on empirical evidence observed or generated from a knowledge management tool in changing the odds, it will give the credence of a simulated result in decision-making. To achieve this goal, researchers have to collect more data and then validate the statistical model specified by a theoretical paradigm using multivariate modeling techniques, such as causal analysis or structural equation modeling (Wan 2002). How we can reach the ultimate goal of risk avoidance is rested on future research with a prospective or experimental study design.

10.4 Development and Implementation of a Clinical Decision Support System for Reducing Hospital Readmissions for Chronic Conditions: An Artificial Intelligence Approach

Artificial intelligence has been developed from a variety of scientific endeavors, evolving from data collection, statistical or mathematical modeling, causal analysis, simulation, predictive analytics design, and knowledge management applications. Data science has emerged as one of the main streams in Big Data exploration and mining. The scientific algorithms of data sciences could be based on three different approaches. The first approach is to gather new or existing research data under theoretical specifications and then validate the goodness of fit of the proposed model by the data available (Wan 2002). The second approach is to perform a systematic review and meta-analysis of scientific literature published in a variety of journals with specified selection criteria. A group of highly selected articles is assembled, analyzed, and validated with varying model assumptions. This enables the investigators to use the key parameters for estimating the odds ratios for single or multiple strategies for attaining desirable therapeutic or intervention goals. The third approach is to design a new web-designed data collection system in an interactive mode so that users can upload information pertinent to personal choices of behavioral change factors that enable them to reduce the odds for readmissions. Aided by the cloud-based information system, investigators could collect new information related to the proximal (short-term), intermediate, and distal (long-term) outcomes of the proposed intervention strategies of the potential users of this clinical decision support system. Ultimately, more refined algorithms for artificial intelligence to achieve an optimal solution (e.g., reducing the risk or odds for hospital readmissions) can be learned from this approach. Furthermore, the designed system could be expanded for global applications as well.

The following section is an example to illustrate the details for developing and implementing a clinical decision support system for reducing the risk of hospital readmissions for patients with heart failure.

10.4.1 Heart Failure Readmission Study: Preliminary Results with Logistic Regression

Human factors may modify the likelihood of hospital readmissions for heart failure (HF) patients. Based on the systematic review of the scientific studies on heart failure readmissions reviewed by our research team, meta-analysis of human factors influencing the likelihood of avoiding the hospital readmission rate for heart failure

Fig. 10.1 Examples of human factors modifying the risk for hospital readmissions of heart failure patients

was performed for a total of 113 studies. Logistic regression with multiple human factors influencing heart failure readmissions was performed, using the database created for the meta-analysis.

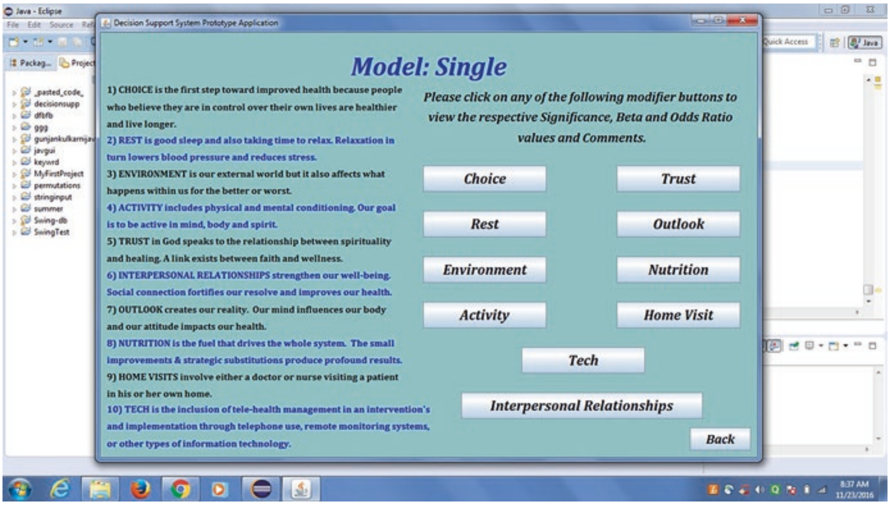
Figure 10.1 shows a few examples of human factors, as personal strategies in avoiding heart failure readmissions, such as dietary recommendations (nutrition), physical exercise (activity), outlook, education and assessment, interpersonal relationships, and rest and relaxation.

10.4.2 Main Effect Model

Figure 10.2 illustrates the main effect model with a single strategy used to avoid the odds of readmission for HF patients. The statistically significant level at 0.05 was used and guided by the selection of variables with a backward selection procedure (put all independent variables into the model and then delete the one with biggest p value, then rerun the model with the same selection criteria until all the independent variables in the model are significant) (Table 10.1).

Hypothesized main effect model: Statistically significant (event =“1”) for rest, interpersonal, and outlook (1).

Since the P-value is 0.59, larger than the significance level $\alpha = 0.05$, there is no evidence to reject the null hypothesis. Therefore, we cannot conclude that the intervention strategy under study is helpful to change the response or outcome variable.



1) CHOICE is the first step toward improved health because people who believe they are in control over their own lives are healthier and live longer.

2) REST is good sleep and also taking time to relax. Relaxation in turn lowers blood pressure and reduces stress.

3) ENVIRONMENT is our external world but it also affects what happens within us for the better or worst.

4) ACTIVITY includes physical and mental conditioning. Our goal is to be active in mind, body and spirit.

5) TRUST in God speaks to the relationship between spirituality and healing. A link exists between faith and wellness.

6) INTERPERSONAL RELATIONSHIPS strengthen our well-being. Social connection fortifies our resolve and improves our health.

7) OUTLOOK creates our reality. Our mind influences our body and our attitude impacts our health.

8) NUTRITION is the fuel that drives the whole system. The small improvements & strategic substitutions produce profound results.

9) HOME VISITS involve either a doctor or nurse visiting a patient in his or her own home.

10) TECH is the inclusion of tele-health management in an intervention's and implementation through telephone use, remote monitoring systems, or other types of information technology.

Please click on any of the following modifier buttons to view the respective Significance, Beta and Odds Ratio values and Comments.

Fig. 10.2 The main effect or single strategy selected by participants for risk reduction in HF readmissions

Table 10.1 Classification of human factors influencing the risk reduction likelihood based on the selected clinical trial studies on heart failure readmission ($N = 113$)

Principles\significant	1 (present)	0 (absent)	Sig. variable
Choice	102	13	
Rest	3	112	*
Environment	0	113	
Activity	44	71	
Trust	0	113	
Interpersonal	24	91	**
Outlook	18	97	**
Nutrition	68	47	

Note: ** p value <0.0001 and * p value <0.05

10.4.3 Interaction Effects

The interaction effect, according to our intervention summaries, was added into the logistic model (significant (event =“1”) =intervention) each time to see whether it is statistically significant (Table 10.2).

Then, all statistically significant interaction terms were added into the main effects model, (1) and backward selection was used to select the variables. The following is the final model with all statistically significant variables included:

Table 10.2 Statistical significance of various interaction effects on the risk reduction likelihood on heart failure readmission

Interactions	P-value	Significant
Activity*Choice	0.03	*
Activity*Outlook		**
Choice*Nutrition	0.25	
Choice*Outlook		**
Rest*Outlook	0.71	
Choice*Interpersonal		**
Activity*Choice*Nutrition	0.012	*
Choice*Interpersonal*Nutrition	0.0008	*
Choice*Interpersonal*Outlook		**
Choice*Nutrition*Outlook		**
Activity*Choice*Interpersonal*Nutrition		**
Activity*Choice*Rest*Nutrition	0.71	
Activity*Choice*Interpersonal*Nutrition*Outlook		**
Activity*Choice*Interpersonal*Nutrition*Outlook*Rest	0.98	

*Statistically significant at 0.05 or lower level.
**Statistically significant at 0.01 or lower level.

Table 10.3 Maximum likelihood estimates for statistically significant main effects and interaction effects, $N = 113$ studies

Analysis of maximum likelihood estimates								
Parameter				DF	Estimate	Standard error	Wald chi-square	Pr > ChiSq
Intercept				1	0.7958	0.0985	65.2970	<.0001
Rest	1			1	2.5609	0.5841	19.2242	<.0001
Interpersonal	1			1	−1.3838	0.2586	28.6308	<.0001
Outlook	1			1	−2.8529	0.5093	31.3815	<.0001
Activity*Outlook	1	1		1	−2.0542	0.7421	7.6617	0.0056
Choice*Activi*Nutrit	1	1	1	1	−0.5258	0.1723	9.3084	0.0023
Choice*Interp*Nutrit	1	1	1	1	1.9551	0.4310	20.5818	<.0001
Choice*Outloo*Nutrit	1	1	1	1	1.4500	0.6515	4.9536	0.0260

Sig (event =“1”) =Rest Interpersonal Outlook Activity*Outlook
Activity*Choice*Nutrition Choice*Interpersonal*Nutrition
Choice*Nutrition*Outlook (Tables 10.3 and 10.4)

The odds of reducing HF readmission with a “rest” intervention are about 13 times more than that without a rest intervention. For interactions, the odds of reducing HF readmission with Choice* Interpersonal Relationships*Nutrition and Choice*Outlook*Nutrition are about seven and four times more than that without those, respectively.

Table 10.5 shows the overall goodness of fit of the model. Since the *P*-value=0.835 is larger than the significance level $\alpha = 0.05$, we fail to reject the null hypothesis. Therefore, there is not enough evidence to conclude the effect of this intervention strategy on the outcome variable. From the final model, we can confidently say that the “rest intervention” can significantly reduce the HF readmission, and the odds of reducing HF

Table 10.4 Odds ratios (Part b) in risk reduction of heart failure readmission, $N = 113$ studies

Odds ratio estimates			
Effect	Point estimate	95% Wald confidence limits	
Rest 1 vs 0	12.948	4.121	40.680
Interpersonal 1 vs 0	0.251	0.151	0.416
Outlook 1 vs 0	0.058	0.021	0.156
AO 1 vs 0	0.128	0.030	0.549
ACN 1 vs 0	0.591	0.422	0.829
CIN 1 vs 0	7.065	3.036	16.441
CNO 1 vs 0	4.263	1.189	15.284

Table 10.5 Overall model fit statistics

Hosmer and Lemeshow goodness-of-fit test		
Chi-square	DF	Pr > ChiSq
2.1001	5	0.8351

readmission with such an intervention are about 13 times more than that without a rest intervention. However, "interpersonal relationships" and "outlook" interventions have no significant effect on HF readmission. Although we have no evidence to say that "choice" and "nutrition" are statistically significant in influencing HF readmission, respectively, both the combinations of Choice* Interpersonal Relationships*Nutrition and Choice*Outlook*Nutrition can significantly reduce HF readmission. The odds of reducing HF readmission with Choice* Interpersonal Relationships*Nutrition are about seven times more than without it, while the odds of reducing HF readmission with Choice*Outlook*Nutrition are about four times more than without it.

10.4.4 A Cloud-Based Data Design and Application

A data platform for collecting a user's selection of risk reduction strategies and their end results or outcomes can be formulated. It will serve as an option for compiling real-time data in a prospective design so that new information can be added to the existing data system for recalibrating the estimates of heart failure patients' risk reduction effort. Thus, validation of the predictive models with varying main effects and interaction effects of personal strategies can be made in the future. This approach offers the real test of the viability of a personal choice of varying noninvasive human intervention strategies.

10.4.5 Web-Based Data Security and Management Plan for the Interactive Data Collection Design

This section describes a proposed new data collection plan with a secure web-based architecture that is composed of the following components: secure data acquisition system, secure data warehouse management system, secure data storage system,

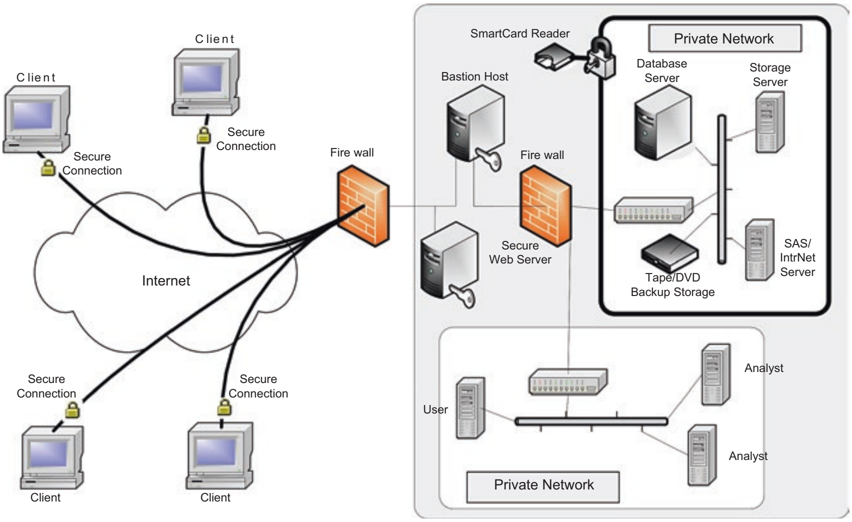


Fig. 10.3 Secure web-based infrastructure

data quality assurance system, and data analysis system. Under this architecture, personal and contextual data from multiple users of the clinical decision support system will be collected, stored, processed, and analyzed using secure web-based technologies. The procedures for handling these data will be based on the "health data safety monitoring and reporting" guidelines provided by the National Institutes of Health, since the data contain private and sensitive information.

Figure 10.3 illustrates the proposed web-based infrastructure. Geographically distributed client computers can send collected data or retrieve and analyze the stored data securely over unsecure Internet connections. Additional measures will be taken to protect the information. From the client computer to the front firewall, a secure network connection is established using virtual private network (VPN) technology based on IPSec. The client computers are authenticated, and all the network traffic is encrypted to protect information transmitted over the Internet. Firewalls consist of packet filtering routers that examine all the network packets and allow only authorized traffic. The firewalls protect and isolate the private networks behind the web server. Although firewalls can be either software based or hardware based, a hardware-based firewall is used since it provides higher performance under heavy network traffic. While IPSec provides security at the network protocol level, Secure Sockets Layer (SSL) provides additional security at the transport protocol level. Web traffic is secured by SSL to provide a reliable end-to-end secure communication channel. Even without IPSec, SSL could by itself provide enough security for the web connections from the client computers.

Providing VPN, SSL, and secure web servers requires the use of public and symmetric cryptography systems. In those systems, proper identification mechanisms are required for authentication and encryption, which are usually provided through a trusted third party certificate authority, such as VeriSign. These identifications are used for authentication among the servers and client computers. In the proposed architecture, two firewalls and a bastion computer in between will be included. This architecture provides tighter security than a single firewall. With a single firewall, once the firewall is compromised, network traffic from the outside can directly flow into the private networks. However, with our suggested configuration, the traffic that has penetrated the first firewall still needs to be authenticated and filtered by the bastion host and the second firewall.

This web-based architecture consists of four tiers—the client, secure web server, secure SAS/IntrNet server, and backend database and storage server. The clients connect to the secure web server over a secure network communication channel to access the data. However, the clients cannot directly access the data stored in the database and the storage server. Web-based services provide the user interface that processes the user requests, and then the web server contacts the database and storage servers that are protected within the private networks. In this way, the most important asset, the data, can be protected properly in the presence of potential system compromises. For example, the second firewall only allows packets from the secure web server and blocks out all other traffic. On the other hand, the data can be conveniently accessed by the analysts who function within the private network.

Security and privacy are two of the most critical aspects to be considered in this implementation of the new data collection system. However, reliability and dependability must be considered as well. Data stored on the database and the storage system can be compromised and damaged due to software and hardware failures. Redundant array of independent disk (RAID) systems spread information across several disks, using techniques such as disk striping (RAID Level 0) and disk mirroring (RAID Level 1) to achieve redundancy so that the storage system can tolerate failures. Under the protection of the secure infrastructure, there are five components: secure data acquisition system, secure data warehouse management system, data quality assurance system, secure data storage system, and data analysis system.

This system includes three servers, the secure web server, the secure temporary data storage server, and a SAS/IntrNet server. Sites and agencies can enter, view, validate, and modify data using this system through client computers. Data entering this system will be validated before being sent to the permanent storage server. All data entry, data viewing, validation, and modifications will be developed using state of the art SAS/IntrNet technology. The data entering form will be designed based on the study protocol that will be developed in the first 15 months of the study team. The components of this system will include web-based data entry systems, web-based data access system, and web-based reporting system. Providing security for the traffic collected and disseminated through servers requires huge additional computational overhead on the servers, since cryptography-based security mechanisms are based upon complex mathematical computation in key generation and encryption and decryption. This would impede the scalability of the servers. A dedicated hardware-based cryptographic coprocessor to mitigate this problem will be considered.

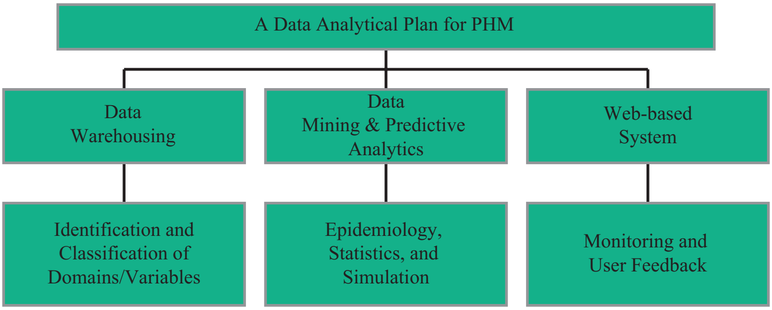


Fig. 10.4 A design of data analytical system for chronic conditions

Figure 10.4 presents a sketch with the data analytical system for a data warehouse (consisting of major conceptual domains populated with relevant variables for estimating the likelihood of reduction in the risk of being readmitted to a hospital), data mining and analysis, and a web-based interactive system. This enables us to build an upgraded predictive analytics for the clinical decision support system with new and enriched data from participants or users of the system.

10.5 Concluding Remarks

Implementation of a successful PHM program is a complex matter that requires transdisciplinary efforts of multiple scientists from different fields coupled with the use of health information technology and informatics.

Common challenges faced by the developers or innovators of integrated care are well documented in various research literature, including those encountered by EU-funded research projects on integrated care for vulnerable persons (Rutten-van Mölken 2017) and the assessment of care management for persons with complex multimorbidity (Tortajada et al. 2017). The research challenges include the lack of common language and understanding of research methodology, the difficulty in evaluating the effects of integrated care programs or patient care outcomes, the inadequate use of patient-reported outcome measures to reflect the improvement, the complexity of linking multiple data sources for program evaluation, the lack of clear evidence to guide the best practices with the assistance of decision support systems for coordinating and implementing integrated care, etc.

This chapter offers an exciting opportunity to demonstrate the usefulness of a collaborative project for chronic care management and health promotion research. Numerous lessons have been learned in the conduct of systematic review and meta-analysis of clinical studies to generate scientific evidence and avoid/reduce the risk for heart failure rehospitalization. Building an effective and efficient PHM program for specific chronic diseases, particularly related to poly chronic conditions, will require a concerted effort in synchronizing multi-prone solutions for risk reduction

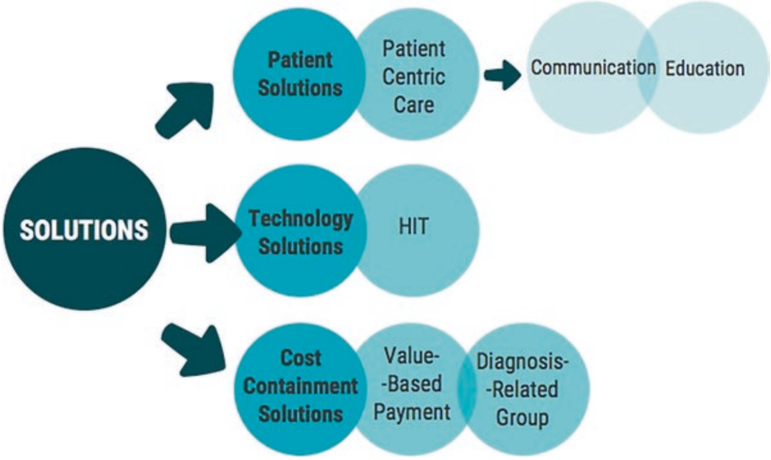


Fig. 10.5 Efforts in synchronizing multiple solutions to promote population health management

or avoidance of rehospitalization through (1) advocating the delivery of patient-centric care and education, (2) integrating health information technologies to generate meaningful use and integrated informatics for enhancing clinical and administrative decisions, and (3) containing costs for care via the use of value-based payment system (Fig. 10.5).

PHM research plays an important role in reshaping the human survival curve, or as James Fries called it, “the rectangular society as the result of compression of mortality in a graying world” (Fries and Crapo 1981). When the population is aging on a fast track, it is imperative to take care of or manage chronic conditions. We should employ multiple strategies to optimize the best and practical solutions for achieving high quality and low cost of care and advocate for the best practices in care management for multiple morbidity.

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Epilogue

Inspired by the need to understand how to improve population health management research and practice, we have conducted a thorough investigation on the structure-process-outcome aspects of the quality and efficiency of a continuum of care for chronic conditions. The use of an integrated theoretical perspective for population health problems enables us to transform broad ecological research on chronic disease, viewed from person-place-time dimensions of health disorders coupled with a person-centric emphasis for care management operations at the population level. This transdisciplinary view on care management strategies has instigated the conceptualization and empirical investigation of the predisposing, enabling, and need-for-care factors that are relevant to the improvement of administrative functions and patient-centered care modalities. This timely and thorough investigation on population health management has generated important information to enhance the integrity of integrated care policy on multimorbidities and poly chronic conditions.

The book has three component parts: trends and strategies of population health management, evidence-based approaches to population health management, and future MHP research and challenges for improving and optimizing population health management. Each component is illustrated by specific chapters with detailed empirical evidences as follows:

Part 1: Explore Trends and Strategies in PHM

PHM has evolved from an ecological health perspective cited in the population health literature to an integrated perspective with a population health (macro-) in combination with an individual health (micro-) view on the health of the population. Formally, PHM gears to the design and implementation of varying cost-containment strategies based on data-driven and empirically feasible policies, ranging from the prospective payment system (e.g., diagnostic-related grouping) to the value-based payment system (e.g., pay-for-performance). Evidence has shown that a single

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cost-containment strategy is not going to optimize the productivity and efficiency of a health-care system. On the contrary, it is achieved through the adoption of multiple change strategies, coupled with the collaborative governance of multiple private and public entities, and the joint effort of researchers and practitioners for optimization of population health solutions. The best practices in targeting the high cost and high vulnerability of specific patient population groups for care management interventions are guided by the predictive analytics and data-based information gathered from multiple sources.

Part 2: Identify Evidence-Based Approaches to PHM

Better management of population health programs requires precise and rigorous measurements or metrics. The identification of practical strategies for PHM could help improve care management and integration. Supplemented by the use of data analytics, predictive analytic software, and administrative and clinical decisions for performance improvement, hospitals and ambulatory care centers have collected and acquired necessary data to achieve optimal care and better outcomes. This phase of continuing investigation is very germane to the success of future PHM programming. However, little is known about the comparative effectiveness of varying clinical and administrative decision support systems available in enhancing quality and efficiency of hospital or health organizational performance in conducting PHM operations.

Part 3: Optimizing the Use of Health Information Technology in PHM Research

The dynamic nature and integrated mechanisms are described and supplemented by the systematic review and meta-analysis results of empirical studies. The transitional phases of PHM integration will be better understood if scientific studies with a randomized design are executed in the real world. Furthermore, a longitudinal design of the study of integration mechanisms via the use of decision support systems and care management technologies will yield insightful and meaningful information to guide the transitions and change trajectories of the PHM industry.

The book has traced the evidence for improved PHM programming and offered a guide to improved health-care policy reforms, particularly relevant to the structural integrity and quality improvement of the future PHM industry. Strong lessons are gained from collaborative learning with international scholars who are dedicated to population health management research and improvement throughout the world.

In conclusion, we are humbled by the vast amount of knowledge that exists and is gained from exchange with scientists in multiple disciplines. It is clear that no one can solve the global health problems without the assistance of care management technology and innovation. This book is only beginning to explore the possibility of establishing international collaboration to tackle the complexity of chronic disease etiologies and therapeutic mechanisms at the population level. The PHM programming can be reformulated via global health collaborative efforts as follows:

- Redesign care management approaches.
- Use experimental methods to design and implement intervention studies.
- Develop a systematic and tractable clinical case management strategy consisting of care needs assessment, care plan, care monitoring, and evaluation of outcomes.
- Perform comparative effectiveness analysis to support the value-added proposition in implementing and evaluating integrated chronic care management.
- Evaluate the efficacy or effectiveness of adopting decision support systems in improving care management and performance at the population level and enhancing self-care management at the patient level.
- Examine both provider-based and patient-based perspectives in quality improvement.

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