Chapter 14
Value-Based Health Care Supported by Data Science

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14.1 Introduction

The *value agenda* encompasses the overall vision for optimizing healthcare value for patients. *Value* in health care is traditionally defined as health outcomes (*quality* of care) achieved per dollar spent (*cost* of care) [1, 2]. The value agenda was originally developed in 2006 with six primary components, including measurement of outcomes and costs for every patient as the second step [1]. A seventh component was added to customize the agenda in certain contexts, for example, in the Netherlands, culture change and leadership are added to the agenda (Fig. 14.1) [3]. The primary aim overall is to crystallize a vision and direction towards true north in providing health care to patients, and set our collective sights on this goal. In its simplest definition, value is increased when there is more care quality for less cost. Optimizing outcomes that matter for patients means aligning medical and health care services, supportive services, process optimization efforts, health information technology, research and innovation. By increasing value, patients primarily benefit as the central stakeholder, which thereby benefits healthcare providers, insurers, and healthcare systems in terms of effectiveness compared to costs. With greater effectiveness per unit of cost achieved, healthcare costs may still continue to rise, albeit at a slowed rate [4, 5].

Regarding the first part of the value equation, quality measurement is easier said than done. Possibilities for measurements are virtually limitless, although in health care they have been derived traditionally from evidence-based clinical guidelines. Types of measurement frequently follow a Donabedian approach, first described in

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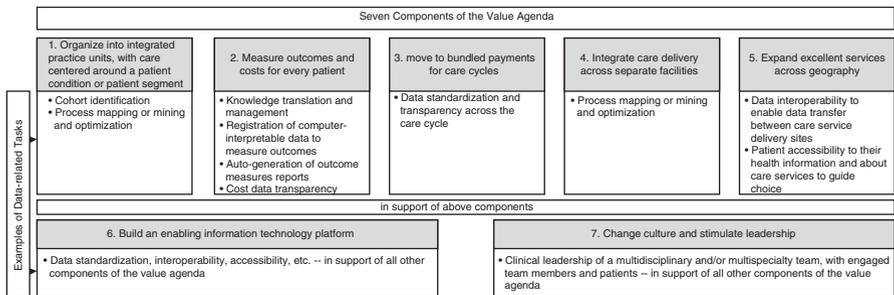e-mail: t.leung@maastrichtuniversity.nl; g.van.merode@mumc.nl

Seven Components of the Value Agenda				
1. Organize into integrated practice units, with care centered around a patient condition or patient segment	**2. Measure outcomes and costs for every patient**	**3. move to bundled payments for care cycles**	**4. Integrate care delivery across separate facilities**	**5. Expand excellent services across geography**
• Cohort identification • Process mapping or mining and optimization	• Knowledge translation and management • Registration of computer-interpretable data to measure outcomes • Auto-generation of outcome measures reports • Cost data transparency	• Data standardization and transparency across the care cycle	• Process mapping or mining and optimization	• Data interoperability to enable data transfer between care service delivery sites • Patient accessibility to their health information and about care services to guide choice

(left margin, rotated: Examples of Data-related Tasks)

in support of above components	
6. Build an enabling information technology platform	**7. Change culture and stimulate leadership**
• Data standardization, interoperability, accessibility, etc. -- in support of all other components of the value agenda	• Clinical leadership of a multidisciplinary and/or multispecialty team, with engaged team members and patients -- in support of all other components of the value agenda

Fig. 14.1 Components of the Value agenda, with associated examples of data related tasks. Components 6 and 7 are supportive of all other components. (Adapted from *Redefining Health Care: Creating Value-Based Competition on Results* and *The Value Agenda for The Netherlands: A Call for Action* [1])

1988, in which measures are classified in three categories: structures, processes, and outcomes [6]. *Structural measures* refer to supporting structures that enable care provision (e.g. having point-of-care hemoglobin A1c, or HbA1c, testing available in an outpatient clinic where patients seek management care for diabetes mellitus type 2). *Process measures* refer to processes of care (e.g. measurement of HbA1c every 3 months while actively managing medication doses for a patient with diabetes) [7]. *Outcome measures* include health status, clinical measures (e.g. HbA1c was at goal less than 7% for a healthy adult less than 65 years old), patient-reported outcomes (e.g. perceived diabetes control), patient experience (e.g. feeling engaged in decision making), and quality of life. However, even in 2016, outcome measurements were not measured as frequently as they should be; at that time, an analysis of 1,958 measures from the U.S. National Quality Measurement Clearinghouse, a registry of measurements from various quality reporting organizations, showed that only 7% of the measures were actually outcomes and less than 2% were patient-reported outcomes [8]. This is the result of interpreting quality of care as compliance with evidence-based guidelines, which emphasized process measurement, rather than outcome measurement and their improvement.

In the second part of the value equation, namely cost, the aim is to best estimate costs in order to reform healthcare financing, which is complicated and can vary widely by country. Uniformly, costs attributable to health care are rising and consuming a growing proportion of each developed country's gross domestic product. The United States is the most costly healthcare system globally, spending about 17.9% of the GDP on health care, which is nearly 5% higher than the next highest spending country, with a projected increase of 5.5% per year towards USD$5.7 trillion by 2026 [9]. Primary drivers for persistently rising costs include prices of labor and goods, such as medications and devices, and administrative costs [10]. The value agenda aims to clearly define and focus on optimizing *healthcare value* to "solve the cost crisis" [11].

This chapter focuses on components of the value agenda pertaining to measuring outcomes and costs, which is founded on building supportive information

> **Box 14.1 Measuring Outcomes and Costs for Every Patient Is a Big Data Challenge**
> The tasks of performing outcome and cost measurement involve working with big data and its 5 V's: we aim to derive *value* from healthcare services provided (and data are our means of measurement), large *volumes* of data are generated with high *velocity* and are also inherently of high *variety*, ideally with high *veracity*. Beyond the complex healthcare data ecosystem, human components and interactions with information systems inherently require work with data in a sociotechnical context. That is, local organizational behavior and culture, as well as leadership and social aspects of a healthcare organization are significant determinants of the design, implementation and effectiveness of information systems.

technology (IT) systems and stimulating leadership and culture change (Box 14.1). Offering a circumspect perspective on healthcare value, the chapter leaves the reader with key points to remember and for further dialogue about healthcare value and its role in healthcare transformation.

14.2 Measuring Outcomes

The first consideration in measuring healthcare value is outcome measurement, which is costly and complex. In one study, measuring outcomes cost medical practices an estimated USD$15.4 billion annually, and more than 15 h per physician per week, in only four common U.S. specialties, general medicine, family medicine, cardiology and orthopedics [12]. In this survey, much of the burden of time and cost was attributed to perform five activities that totalled 15.1 total hours of effort (physicians and staff time) per week per physician: entering information into the medical record (12.5 h including 2.3 h of physician time), reviewing quality reports from external entities (0.5 h), tracking quality measure specifications (0.7 h), developing and implementing data collection processes (0.8 h), and collecting and transmitting data (0.7 h).

The paradigm of outcome measurement often takes a highly deterministic and also biomedical approach, being frequently condition-specific and multi-dimensional [2]. That is, cohort identification is frequently done on the basis of a population with a specific medical condition and health status. Then, measurement of care quality at the levels of each patient and for the population of all patients with the same condition can be done. Translating knowledge about clinical and diagnostic criteria for a condition into a computable format is currently a necessary step to be able to perform cohort identification (Box 14.2a). In Chap. 3, data standards in healthcare are governed by principles that apply to language: *syntax* (the rules and structure of sentences, consisting of a combi-

nation of symbols, used to communicate), *semantics* (the relationship between symbols in a sentence), and *pragmatics* (the situational context of the symbols). These principles are important in translating from the language of clinical diagnosis from a practice guideline, for example, to computer-interpretable language.

Cohort identification may also use other types of data, such as service utilization or cost data (Box 14.2b). With only limited access to one's own population data to a detailed enough degree, or with adequate customizability, quality of care per physician can be difficult to track and improve. Cohort identification supports population health management, as well as potential research activities including, for example, facilitating clinical trials recruitment and collecting outcomes data and other measurements need for a clinical trial.

Box 14.2 Cohort Identification

(a) *By disease:* The majority of current cohort identification systems in practice rely upon deterministic methods, such as identifying all patients registered in an electronic health record (EHR) as having a certain diagnosis code, or patients who may meet a certain laboratory or other criteria that serves as a surrogate for the presence of the diagnosis. For example, a patient with a provider-registered diagnosis code in the EHR of diabetes mellitus type 2 is a patient with diabetes, or a patient with a HbA1c $\geq 6.5\%$ (48 mmol/mol) may also be included in this cohort [13]; therefore, outcome measures applicable to diabetes would be expected to apply to these patients. Consideration should be given to patient attribution, meaning that such patients should be attributed to the physician providing diabetes care. For example, a patient may have a HbA1c that meets diagnostic criteria from 18 months ago but without further follow up due to moving out of the area or changing providers or healthcare systems. Another approach to cohort identification is *electronic phenotyping*, which is a statistical learning approach to identify patients with a condition of interest or a certain phenotype [14]. This approach is potentially time-saving and less labor-intensive than rule-based approaches, however, is not yet routinely implemented in clinical practice. Predictive modeling and machine learning techniques, discussed in Chap. 8, can be applied to warehoused clinical data to perform the cohort identification task using such statistical approaches.

(b) *By service utilization:* Another way to group patients, or identify the patient segment in value agenda terms, is to examine individual patients' service utilization or use of high-cost services. This method has also been called *hotspotting* [15]. In the U.S., this approach is based upon data that show that a large proportion of healthcare costs are incurred by a small proportion of patients. Data on health service utilization can be used to identify *super-utilizers*, or patients who disproportionately utilize high-

cost services, such as emergency room visits and hospitalizations, or have high care needs. A typical approach to assessing patients' service utilization is to perform an analysis of claims data, which usually also includes certain demographic, geographic and health data. For example, one study of Camden health centers in New Jersey, where the hotspotting approach originated from, utilized hospital claims data from three facilities to perform a cluster analysis and classify pediatric patients into five subgroups of risk according to their asthma-related emergency department visits and hospitalizations [16]. The aim of this classification was to identify cohorts and potentially guide interventions tailored to each subgroup to optimally reduce asthma-related hospitalizations. More generally, cohort identification based on service utilization aims to guide the design of multidisciplinary and community-based services, self-management support, and health care that can address medical and non-medical needs of patients, thereby reducing the need to utilize higher-cost services. These are ways to integrate care delivery and expand excellent service across geography, according to the value agenda summarized in Fig. 14.1. In another study, patients were identified by their provider as a patient with high-frequency healthcare system access or complex unresolved needs; these patients were then referred to a complex care center within the organization [17]. At this center, a root cause analysis was performed at the level of the patient by multidisciplinary team led by a master's trained clinical nurse leader in order to discover root causes of patient instability. A combination of EHR data, insurance data, housing and employment information, institutional policies, and other information sources was used in this thematic analysis of determinants of patients' service utilization.

In recent years, there is a greater shift towards measuring what matters to patients. *Patient-reported outcomes*, which aim to be both evidence-based and patient-centered, offer an opportunity to engage the patient in measuring what matters to them, but also requires robust and lengthy processes to develop, validate, and also implement them in a non-invasive manner [18]. Typically, there is an evidence basis that guides the development of patient-reported outcomes and their validation [19]. *Patient-reported outcome measures* (PROMs) are the tools, such as surveys or questionnaires, used to collect patient-reported outcomes. One international initiative to develop standardized patient outcome measures, the International Consortium of Healthcare Outcomes Measurement (ICHOM), is a large, multi-institutional effort that draws from international registries and provider best practices to implement PROMs in alignment with the value agenda [20]. *Patient-reported experience measures* (PREMs), including patient satisfaction, are intended to ensure accountability for healthcare service provision that is appropriate, equitable, accessible, affordable, appropriate, and efficient [21]. Consumer Assessment of Healthcare Providers and Systems surveys, first devel-

oped in 1995 in the U.S. [22], and the Dutch Consumer Quality Index, which is disease- and provider-specific and also assesses patient priorities [23], are patient-directed questionnaires that measure PREMs.

As already noted, outcome measurement is complex, easily extending well beyond the structure-process-outcomes approach. Scientific literature, medical knowledge, clinical practice guidelines, and outcome measurement specifications are constantly evolving, resulting in rapidly growing volume and variety of data and information. For example,evidence-based clinical outcomes often are derived from the results of randomized control trial results, if available. Otherwise, outcomes may originate from other study types or expert consensus, and then selected and synthesized into clinical practice guidelines, with an indeterminate timeline or process for revision as new scientific and medical knowledge becomes available.

When a single disease clinical guideline is implemented, the quantity of data and information needed to adhere to guideline recommendations is enormous. For example, consider a guideline update on early management of acute ischemic stroke published in 2018, in which 217 recommendations were made, citing 421 published references [24, 25]. Clinical comorbidities may further complicate translation and implementation of such guidelines; for example, a guideline on transient ischemic attack recommends aspirin to prevent ischemic stroke, but in a patient with peptic ulcer disease, this guideline recommends avoiding aspirin, which is a conflict between two concurrently applied guidelines. This clinical scenario is one example of a use case in which each clinical guideline was transformed into a computer-interpretable format, then conflicts were resolved using a computational method of conflict resolution [26, 27]. As a result, accurate quality measurement that adequately accounts for such cases can become challenging.

Overall, the measurement of high-value health care should be able to account for clinical complexity, social determinants of health, and patient preferences. Multimorbidity is a classic example of *clinical complexity* (Box 14.3). In this case, the clinical complexity of multiple comorbid conditions arises from the numerous possible combinations of disease and types of relationships (e.g. chronology, etiologic association, or dominance) [28, 29]; furthermore, these relationships may change in strength or association over time, as can their associated treatment recommendations and the potential synergies and conflicts between them. In settings involving clinical complexity, risk adjustment through case mix indices or comorbidity indices, such as the Charlson Index [30], can be applied, although the latter are more often used in clinical research rather than implemented in outcome measurements.

The simplest approaches to account for clinical complexity can be designed as alerts in an electronic health record (EHR) to allow for exclusion of a particular patient from a cohort; for example, if a patient has an incurable and terminal illness, an EHR may allow for this patient to be easily identified in a manner that would acknowledge that even though she may meet eligibility criteria for certain preventive services, such as cancer screening, these would be low-value services in this patient context. Knowledge management, discussed later in this chapter, and dealing with alert fatigue, discussed in Chap. 11 on clinical deci-

Box 14.3 The Challenge of Multimorbidity

Multimorbidity, or the presence of multiple comorbid conditions in a patient, is increasingly recognized as a clinical condition, yet remains difficult to characterize due to significant heterogeneity. Further, generalizability of the results of clinical trials, a traditional manner of evidence generation and the basis of clinical practice guidelines on single conditions, may be difficult, as 81% of randomized control trials exclude patients with multimorbidity [31]. In fact, application of single-disease guidelines to patients with multimorbidity can increase treatment and self-management complexity, risk of interactions between guideline recommendations, potential adverse events, hospitalization and poorer health outcomes [32–35]. Consequently, quality measurement in the setting of multimorbidity is challenging—multimorbidity is not simply a count of conditions [36] and co-occurring conditions can be interrelated in a variety of ways [33], even in chronology [28, 37]. Intelligent information systems, given reliable data, could better be able to handle the complexity and probabilistic nature of potential outcomes for patients with multimorbidity, and thereby measure care quality in a more nuanced manner representative of the population.

sion support, become relevant in crafting an appropriate approach to developing and managing such alerts.

Social determinants of health are also important contextual factors in determining an outcome even if not explicitly measured. Moving away from solely a biomedical approach to medicine, a *biopsychosocial model* of medicine, first introduced by psychiatrist George Engel in 1977, centralizes the important roles of social, psychological and behavioral determinants of health [38]. Numerous social determinants of health are now known, including sociodemographic factors (e.g. race, ethnicity, employment, food and housing insecurity), psychological factors (e.g. health literacy, psychological assets such as self-efficacy and patient engagement or activation), behavioral factors (e.g. physical activity, tobacco use and exposure, alcohol use, and dietary patterns), individual-level social relationships and living conditions (e.g. social isolation), and neighborhoods (e.g. neighborhood compositional characteristics) [39]. However, few are documented and in fact a subset of sociodemographic characteristics and social determinants in the behavioral domain are typically the most commonly documented in a structured manner in EHRs [39].

Additional determinants are usually not documented in a structured format that could enable cohort identification or other data analytical activities that would be supportive of a value agenda. For example, adverse childhood experiences, such as psychological, physical or sexual abuse, or exposure to violence against their mother (the original 1998 study did not investigate exposure to violence against all types of parents), can be important determinants and risk factors for certain mental health and chronic diseases [40]. Other patient characteristics that could be important determinants of health, such as positive intimate partner violence screening or

undocumented migrant status, may be purposefully left undocumented by clinicians in the electronic health record due to potential legal and social consequences.

Finally, patient preferences are essential to consider in shared decision making, as is a frank discussion of uncertainty in medicine. A probabilistic approach is often more appropriate approach to decision-making than a deterministic one, but such interpretation may be challenging to communicate and dependent on clinician knowledge and skills or numeracy (or numerical literacy) of the patient. Further, service overutilization, waste, and poorer patient outcomes can result from a compulsion to "do something" [41]. Outcome measures should appropriately consider a variety of influencing factors, which may be difficult to measure or may not be formally registered in an electronic record or information system, to provide the best representation of true outcomes for a given patient or population.

14.3   Measuring Cost

Beyond the complexities of measuring outcomes, cost is also challenging to estimate accurately. *Costing analyses* are conducted to estimate the cost of providing healthcare services. While there are many costing analysis methods, a popular approach coupled with the value-based healthcare framework is *time-driven activity-based costing* (TDABC). Traditional activity-based costing is typically isolated to an individual department, which becomes inadequate for cost estimation that involves further complexity, such as across multiple departments involved in a care pathway [11, 42].

The TDABC approach accounts for the cost of a particular supply per unit time; for example, the cost of 1 h of a neurosurgeon's time differs greatly from the cost of 1 h of a physician assistant's time. Redistributing certain responsibilities appropriately within the scope of each clinician's practice (also known as working at the top of one's license) becomes a potential opportunity for reducing cost, and is therefore a value-added change. Objects may also be time-dependent, for example, there is also a cost per hour of usage for an operating room. A shorter operating time that offers similar outcomes as longer operating times would also be value-added. In TDABC, the intent is to capture all costs incurred by the institution to provide care services in an entire care pathway, including costs of equipment, information technology, space, human labor in the form of health professionals, and additional supportive services (Fig. 14.2). The methodology specifically distinguishes between these costs versus other costs, such as prices charged to insurers or patients for services rendered and reimbursed costs for those services.

Expert interviews, focus groups, process mapping and mining, or event log data can be combined with accurate financial data, including itemized prices and labor costs (including benefits) to appropriately estimate true costs. Such approaches are intended to map the care pathway and value streams, highlighting key processes for
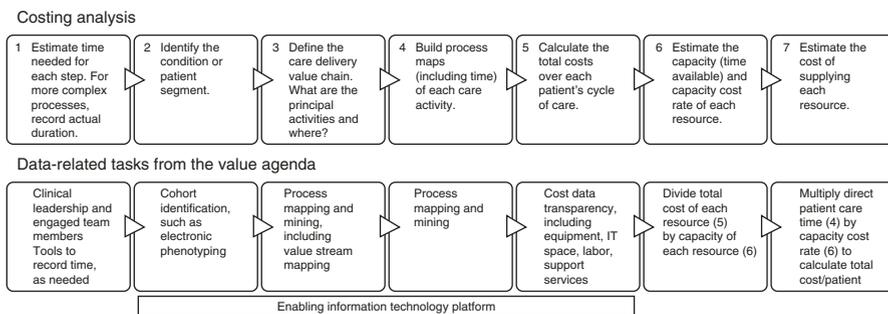
Costing analysis

Data-related tasks from the value agenda

Fig. 14.2 Steps involved in time-driven activity-based costing (TDABC) costing analysis and associated examples of data-related tasks. (Adapted from Kaplan and Porter [11])

improvement and points of care as well as care inefficiencies. Process mining and event logs were described in Chap. 13 on Operational Excellence. Further description of how to perform a costing analysis, such as TDABC, is beyond the scope of this chapter and additional reading is supplied in the references at the end of this chapter.

14.4 Creating Value Through Innovation

With the foundation laid for measuring outcomes and costs, increasing value can follow. Innovation is a key component of healthcare transformation centered on increasing value for patients. A broad definition of innovation would encompass several domains, including the development and implementation of new information technologies that enable remote disease monitoring or self-management care, as well as service delivery innovation or re-design that integrates traditionally disparate services in a manner that increases value for patients. Further, device and information technology innovations (e.g. tools based on predictive analytic or machine learning technologies and artificial intelligence) can drive added value in health care.

E-Health is defined as any activity in which an electronic means is used to deliver information, resources and services related to health; domains include EHRs, telehealth, mobile health (e.g. wearables, remote monitoring or connected devices, and app), and health-related use of e-Learning, social media, and health analytics [43]. With the explosive growth of e-Health, more technologies and platforms offer greater opportunities for data collection, management and processing. Information technology should be designed in support of increasing healthcare value for patients by enabling data capture and consumption in a manner that allows for outcomes and cost measurement, but e-health is not mandatory to increase value (Box 14.4).

Box 14.4 Innovation and Value in Care for Specific Populations

(a) *A role for technology:* Inflammatory bowel disease is a chronic condition that, with adherence to appropriate medications and close monitoring of response to therapies, can prevent disease complications and improve long-term outcomes. At Maastricht University Medical Center, a multidisciplinary clinical research group developed MijnIBDcoach, a software platform that enables home monitoring and patient-provider communication about health status, tracking and response to disease activity, medication adherence, side effects, nutrition, fatigue, quality of life, life events, and behavioral health such as stress and anxiety levels [44]. For example, alerts were created to notify the care team of indicators for a possible disease flare; and during a disease flare, the platform allowed for intensified home monitoring. E-learning is also available to educate and engage patients in their care. In a randomized controlled trial, patients in the intervention group had a statistically significantly lower mean number of outpatient office visits and mean number of hospitalizations compared to patients who received standard of care [45]. Patients with the intervention also demonstrated improved patient-reported outcomes, as measured by the My IBD At Home questionnaire, and quality of life, as measured by the Short Inflammatory Bowel Disease Questionnaire, although both without statistical significance. This intervention demonstrates potential added value to health care services offered for a specific patient population, enabled by information and communication technologies.

(b) *Technology not required:* Oak Street Health offers innovative primary care service delivery in Chicago in a unique model that draws upon community features, providing medical and non-medical services to an elderly population of patients in order to keep patients "happy, healthy, and out of the hospital" [46]. Instead of a traditional fee-for-service model, the Oak Street business model is globally capitated, which means the practice has financial responsibility for the entirety of their patients' care. This results in allocations of financial resources towards prevention and out-of-hospital management services, including in-house care management and longer primary care visits. Added-value services can even include transportation between home and primary care visits. Team-based primary care is also coupled with patient classification into four risk-based cohorts, or tiers, with re-evaluation as patients may transition between tiers throughout the course of their care; these tiers guide primary care visit cadence and allocation of care management resources. While not studied in a randomized control trial, Oak Street Health has a high Net Promoter Score, a summary metric for patient satisfaction; achieved a 5-star rating in Healthcare Effectiveness Data and Information Set (HEDIS) metrics, which are sets of quality and performance measures utilized by more than 90% of American health care plans; and reduced hospitalizations in their population by 40%, compared to geographically matched cohorts with similar health insurance coverage. In this case, innovation in the form of service delivery and design with appropriate financial incentives drives increased healthcare value for patients.

14.5 Increasing Value in a Learning Health System

Regardless of approach, robust measurement of outcomes and costs of care services depend on access to accurate health, administrative, and cost data. Traditional sources of data, for example, scientific literature and clinical guidelines, and administrative data, such as financial, insurance or claims data, continue to be important data sources in medicine. An *evidence-based medicine* approach [47] remains the current and more accepted driver of clinical and medical evidence generation to support synthesis into clinical practice guideline recommendations and best practices. However, studies have estimated that the time for transfer from research to practice is 17 years [48, 49]. Further, established medical practices may need to undergo reversal due to new evidence and medical knowledge discoveries, yet this also can be a slow process [50, 51].

This paradigm is evolving. A *data-driven medicine*, or practice-based evidence [52–54], approach is a newer paradigm that has become possible in light of the massive amounts of data now available for knowledge discovery. Together, evidence-based medicine and practice-based evidence could also be framed in the context of the *learning health system*, in which rapid translation of knowledge from "bench to bedside" can drive healthcare reform centered on increased value [55–59]. A learning health system embodies a virtuous cycle in which new scientific knowledge can translate into high-value healthcare practices and personalized patient services, additional knowledge from clinical practice can be gained from EHR and other patient data streams, which further enables scientific inquiry and so on. Additionally, the learning health system would also include infrastructure and policies supportive of secondary uses of EHR and other patient data, without undue burden on clinicians, such as basic and clinical research, public health surveillance and management, quality improvement, and safety monitoring [60].

A related framework is *network medicine*, in which the network concept in medicine can reveal a surprising number of connections between diseases [61]. Further, these diseases can vary in the types and strengths of their relationships to one another, as well as with other things in the world in which we live. The concept of clinical complexity was introduced earlier, highlighted in the context of multimorbidity. Clinical complexity is subsumed under the broader framework of complex systems and network medicine. That is, medical knowledge, the practice of medicine and delivery of healthcare are best understood as dynamic networks, components of a whole, which constantly evolves and adapts to change: these are social, technological, metabolic or molecular, and disease networks [62]. *Network-based thinking* addresses the complex relationships between human health or disease and all else, such as, for example, genetics, social determinants of health and other influencing characteristics of a patient, and environmental factors. With deeper understanding of the local components and their interactions, is it then possible to understand how the whole complex system works in a way that is greater than a sum of each of its parts [63].

In the social network of medicine, physicians and other professionals are enabled to provide patient-centered continuous care, within an ecosystem of care that supports high-value care provision to patients with appropriate outcomes and cost mea-

surements [64]. Medical specialists of the future would function collaboratively within this network of care, which is centered around the patient [65]. Care is enabled by technology and patient engagement, and their health beliefs and preferences are accounted for in care management decisions. The technological network of medicine includes information technologies and infrastructure, as well as new medical technologies in general, which enable patient-centered healthcare service delivery. This could include, for example, clinical decision support systems, e-health technologies, and virtual networks or services. Information technologies should also enable knowledge discovery and management. Metabolic and molecular networks relate to systems biology and human disease, such as drug discovery and disease classification, and increasing scientific knowledge and innovation [62]. A disease network involves understanding disease relationships, clinical complexity and multimorbidity [62, 66].

In the world of complex systems in which we live and deliver or receive health care, data science drives the aim which we seek to achieve: the creation of learning healthcare systems that optimize patient value with available resources.

14.6 Sociotechnical Considerations

As noted, outcome measurement should account for clinical complexity, social determinants of health, and patient preferences. Much of this work could be enabled by data management infrastructure and policies designed to address the needs of patients, clinicians, researchers and innovators [67]. Education also plays an important role in developing a capable workforce to function in a redesigned healthcare system. A *sociotechnical approach* to health information technology has been developed that provides better context for health IT and therefore also health data [68, 69], are an important consideration in a learning health system that aims to increase healthcare value for patients. The sociotechnical approach to health IT systems consists of eight interdependent dimensions to address challenges involves in design, development, implementation, use, and evaluation of health IT (Box 14.5) [68]. All eight dimensions are relevant to the value agenda, but the organizational features, particularly culture and policies, include leadership, resource allocation of capital budgets, IT-related policies and procedures, and other core elements without which the value agenda would fail.

Box 14.5 Eight Dimensions of a Sociotechnical Approach to IT Systems

Hardware and software	Workflow and communication
Clinical content	Internal organizational features
Human computer interface	External rules and regulations
People	System measurement and monitoring

Table 14.1 Components of knowledge management for clinical information systems

Knowledge management component	Definition	Clinical example
Knowledge asset management	A set of processes for creating (knowledge creation), validating, updating, and deploying knowledge	A healthcare organization's clinical decision support committee evaluates and implements a proposed guideline-based alert from a medical director of the urgent care clinic. The proposal aims to reduce unnecessary radiologic imaging for uncomplicated low back pain. A timeline for future review is established.
Knowledge application	The art of leveraging knowledge at the right places in workflow to achieve a strategic objective	The guideline-based alert is activated when a clinician places an order for radiologic imaging concurrently with a diagnostic code for low back pain. The alert asks focused questions to help guide appropriate use, and includes an infobutton for the clinician to access optional additional continuing education.
Knowledge discovery	The process of analyzing data for the purpose of understanding performance, reporting, predicting, and/ or harvesting new knowledge	A periodic report is produced for review, identifying the cohort of patients with diagnostic codes for low back pain. The report includes responses to the focused questions in the alert and number of completed imaging studies to determine appropriate use. The urgent care medical director is involved in the review.

Adapted from Glaser and Hongsermeier [73]

Each healthcare setting and institution may employ different knowledge management processes, which can have a several potential consequences in implementing the value agenda. For example, due to localized organizational structures and cultures, information systems, and processes, guideline-based care and outcome measurement for a condition can vary in their implementations, even though they may draw from exactly the same source guideline. *Knowledge management* is a process that involves the capture, storage and sharing of intellectual assets, thereby enabling knowledge access and reuse, potentially reducing costs, and allowing for company growth [70]. When applied to clinical information systems, knowledge management is subdivided into a three-part repeating cycle: *knowledge asset management*, *knowledge application*, and *knowledge discovery* (Table 14.1) [71]. *Knowledge creation* is a subcomponent of knowledge asset management and arises from social practices and social interactions, such as dialogue [72]. In healthcare settings, one common example is a clinical decision support committee where knowledge is created, applied, and managed, although the possibilities for knowledge creation are indefinite within formal and informal healthcare organizational structures.

As an example of knowledge management between and within healthcare organizations, a quality improvement collaborative (QIC) is an organizational model used to perform large-scale performance improvements and disseminate them efficiently. The QIC supports healthcare improvement efforts primarily by providing process

redesign educational material and guides, enabling knowledge sharing between participant institutions, and providing support in the form of an external change agent. While these are considered strengths of a QIC approach, when evaluated in a set of Dutch hospitals, the standardized process redesign approach from QIC was difficult to localize [74]. Aligning various interests in existing clinical departmental structures was in some cases prohibitive to change. Knowledge sharing across participating institutions was not as fruitful as anticipated due to variations in patient populations and processes targeted for improvement, as well as differences in local processes and structures. Revisiting data standardization principles of syntax, semantics, and pragmatics, these also apply to the management of knowledge; in other words, even with the syntax and semantics provided by the QIC to guide process redesign, the lack of pragmatics—or poorly matching processes or patient selection between organizations—knowledge sharing could not be achieved [75, 76]. Lastly, in the QIC evaluation, participants reported insufficiently enabling health information technologies to generate outcome data as well as intermediate and process measures [74].

Finally, education is also essential as healthcare delivery evolves. To promote future adoption and integration of the value agenda and related frameworks, organizations are responsible for continuing education of their existing workforce. Undergraduate and graduate medical education integrating these concepts may also be needed to develop future generations of healthcare professionals from early stages in their careers. Informatics education and an introduction to data science for clinicians, as this book aims to accomplish, benefit future clinician executives or managers, as well as front-line clinicians. One such example of informatics education integrated into medical school, residency and clinical informatics fellowship are curricula designed, implemented and evaluated at Oregon Health Sciences University in the United States [77–79].

14.7   Further Considerations in Measuring Value

The value agenda describes an overarching framework for re-strategizing and reforming healthcare. While aspirational in setting a vision and direction towards true north in patient care, further considerations about its context in the art and science of medicine remain. Some are more directly related to data-dependent components of a healthcare system than others.

First, outcome measures may not align fully with one another in the care of the whole patient, rather than from the perspective of a single condition or segment of a patient population. For example, there may be circumstances in which improving a patient experience measure does not align with improving outcome measures; if patient experience measures consists of a rating based in part on a patient's ease of access to care, then reducing speed of access to care—any care—is incentivized. Then, to optimize access, on-demand care services are developed and offered in a manner that is not well-integrated with an established healthcare system: a patient may utilize telemedicine urgent care that is distinct from her primary care practitioner, leading to

overall care fragmentation. On-demand services, while desirable by patients, could lead to decreased quality of care, increased overutilization and inappropriate variability in care, worse health outcomes, and increased service utilization [80, 81].

Also, social and political issues may influence the implementability of the value agenda and should be considered and potentially addressed in parallel to the value-based efforts of an individual healthcare system. For example, vaccinations can be considered a high-value care service due to their high effectiveness in a population in preventing infectious diseases with high morbidity and mortality. Reducing vaccine-preventable disease could be best supported by government-sponsored public health initiatives targeted towards educating the general public and providing vaccinations at low or no cost. However, vaccination policies and rates are variable attributable to the push and pull of individual choice versus social or public benefits—a frequently highly personal belief or opinion. As an example, pediatric vaccination is recommended and available free of charge in the Netherlands, but is not mandatory. In recent years, Dutch vaccination rates continue to decline [82, 83] and are also accompanied by outbreaks of vaccine-preventable illnesses such as measles [84]. Nonetheless, prevention of disease would seem to be a care service of the highest value, yet is not fully accepted in any society [83].

Next, humanistic clinical practice is immeasurable yet highly desirable in certain if not all patient care situations and is, arguably, a key element in certain clinical situations that is not accounted for explicitly in the traditional value definition. *Humanism* is demonstrated in the healthcare professional's attitude and actions that show respect for a patient's values and concerns, particularly their social, psychological and spiritual life domains [85]. While the value agenda may implicitly integrate humanism into standard practice and trait of added-value activities, leading to improved patient outcomes and experiences, this may devalue the central importance of humanism in medicine [86]. Related to this, healthcare value may be difficult to measure in certain situations, such as palliative and end-of-life care contexts [87, 88]. Patient preferences, including possible preferences to withhold aggressive care, could mean clinical deterioration or poorer outcomes, which should not lead to reduced healthcare value as it could in a traditional definition of value.

Additionally, there are other frameworks not accounted for in the value agenda, despite their growing acceptance, such as The Quadruple Aim, which includes clinician well-being as a fourth aim of quality improvement [89]. Clinician *burnout*, characterized by depersonalization, emotional exhaustion, and lack of personal accomplishment, has been connected to high costs related to turnover among physicians and loss of productivity due to physicians dropping out of the workforce [90]. Increasing research on the growing administrative burdens on physicians and other healthcare professionals, including excessive data registration workload that are driven by the needs of the value agenda, especially with respect to outcome measurement, are among key contributors to reduced clinician well-being and reduced quality of care provided [91–94]. Further, no outcome or cost measures in the value agenda account for physician and healthcare professional well-being, mental and physical health, and other unmeasured factors that are foundational for the potential success of implementing the value agenda [93].

Key Points to Remember

1. The *value agenda* involves measuring outcomes that matter and costs of care to achieve the most optimal outcomes per dollar spent. The primary aim overall is to describe a vision and direction towards true north in providing health care to patients.
2. Outcome measurement is costly and complex, and measures are most often condition-specific and multidimensional. Examples include patient-reported outcomes and patient reported experience measures.
3. *Costing analyses* are conducted to estimate the cost of providing health-care services, and one popular approach coupled with the value-based healthcare framework is *time-driven activity-based costing*.
4. Innovation is a key component of driving transformation towards high-value health care; importantly, innovation can involve technology, such as e-health, but can also involve novel service delivery design.
5. The *learning health system* and *network-based thinking* are frameworks that are complementary to the value agenda and important for current and future clinicians to learn as clinical medicine evolves to involve growing amounts of data, knowledge, and information.

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