A Design Framework for Tool Support of Performance Management for Clinical Practice

PILAR MATA

Thesis submitted to the University of Ottawa
in partial Fulfillment of the requirements for the
Doctorate in Philosophy degree in Digital Transformation and Innovation

uOttawa

School of Electrical Engineering and Computer Science
Faculty of Engineering
University of Ottawa

Abstract

Performance management is essential to any organization that wants to monitor progress towards strategic goals and proactively address gaps identified during the implementation of the strategy. Healthcare organizations have implemented tool support for performance management in response to increasing demand for accountability and transparency on quality of care indicators or to promote continuous improvements in quality of care. However, there is little guidance in the literature and the industry on how to operationalize a performance management strategy for clinical practice with appropriate tool support.

In this thesis we propose a framework for design of tool support for performance management of clinical practice. The framework includes: a Conceptual Model of the relevant entities and actors for performance management of clinical practice; a Performance Management Participation View of what tool-supported tasks performed by what actors in what processes are needed to enact performance management for the clinical practice; a Performance Measurement View of what clinical practice goals are measured by what indicators in which tool-supported tasks for the clinical practice; and a Tool Support Design Methodology for the design, implementation and validation of tools to support performance management of the clinical practice.

The research methodology followed for this thesis was design science research. The framework was developed and evaluated iteratively in a series of three case studies conducted in collaboration with three sets of health care professionals responsible for

clinical practice in these areas: resident training, discharge management, and care of frail patients in a long term care residence.

Acknowledgements

First, I would like to thank my supervisor Dr. Liam Peyton, who has been a true coach during my studies. With a pragmatic and empathic approach, you have effectively guided this work to its culmination. Your patience, time, guidance, knowledge, valuable discussions, and continued support have made this research an enriching academic experience. Thank you for all your support!

Second, I would like to thank my family immensely. To Daniel, my husband, for always being by my side and for always believing that I can achieve everything. For easing the load when I required time to work on my thesis. To my children, Isabella and Tomas, for being my source of inspiration! The enthusiasm, joy, and support that you give us every day, give incredible meaning to all we do! I dedicate this work to you! Thanks for everything!

Third, I would like to thank my parents, for always being present and for supporting me without any conditions and in everything I do! Thanks for being a great example to me.

Also, I would also like to thank Dr. Craig Kuziemsky and Dr. Doug Archibald, for your valuable contributions to this research and for always be ready to give feedback and offer your help. To Dr. Chantal Backmand, Dr. Viner, Dr. Wooltorton, Enrique Soto, Danielle Sinden, Andrea Liu, and Daniela Acosta. For your time commitment participating in our case studies and for providing valuable feedback about your experiences using our framework. Thank you!

Finally, I would like to thank the University of Ottawa and the Ontario Graduate Scholarship Program for their financial support during my studies.

Thank you All!

Table of Contents

List of Figures

List of Tables

List of Acronyms

Acronym	Definition
BA	Business Analytics
BI	Business Intelligence
BSC	Balanced Scorecard
BSPS	Balanced Scorecard Public Sector
CDMF	Clinical Decision-Making Framework
CBME	Competency Based Medical Education
CoE	Centre of Excellence
CPL	Clinical Practice Level
DSR	Design Science Research
eHealth	Electronic Health
EHR	Electronic Health Record
EMR	Electronic Medical Records
EPA	Entrustable Professional Activities
HIS	Health Information Systems
IT	Information Technology
KPI	Key Performance Indicators
mHealth	Mobile Health
OM	Outcome Measures
PM	Performance Management
PMS	Performance Management System
PT	Physical Therapist
RPP	Resident Practice Profile

Chapter 1. Introduction

1.1. Motivation

Healthcare is a complex interaction of organizations, people, processes, and technologies. As care is provided, patients navigate a complex system where vast amounts of data are generated, collected and reported, every day, by health care providers and stakeholders (e.g. providers, patients, health plans, regulatory agencies, clinics). Performance management is essential to understand how well individuals, departments, organizations, or groups of organizations are doing against a set of established goals and to promote improvements in the system. The overarching role of a performance measurement system in healthcare must be to provide information to enhance decisions made by its stakeholders (Smith, Mossialos, and Papanicolas 2008) and support performance management. A frequent maxim in management is that 'what gets measured gets attention'. The healthcare system is data rich but the challenge is how to transform the vast amounts of data into actionable insights and usable information (Acito and Khatri 2014)

There have been some performance management initiatives reported in the literature for healthcare system. The Balanced Scorecard for Ontario's acute care hospitals (Ontario. Ministry of Health and Long-Term Care; University of Toronto; Canadian Institute for Health Information; Ontario Hospital Association 2006) uses five dimensions for ranking and comparing performance across hospitals in the region. These dimensions

include; System Integration and Change, Women's Health Perspective, Clinical Utilization and Outcomes, Patient Satisfaction, and Financial Performance and Condition.

The 'Hospital Report Card: Ontario 2009' (Esmail and Hazel 2009), published by The Fraser Institute, describe the use of the Canadian Institute for Health Information's Discharge Abstract Database to generate indicators for acute-care hospitals in Ontario. The report includes quality and patient safety indicators such as; death rates, volumes of procedures, rates of adverse events, and utilization rates for hospitals in Ontario.

In June 2008, The Sunnybrook Hospital in Ontario published its Balanced Scorecard & Patient Safety Indicators. The Balanced Scorecard included dimensions of patient care quality, research and education, and sustainability and accountability. The scorecard was published in an effort to increase transparency for the community (Sunnybrook 2018)

Wachtel, Hartford, & Hughes (1999) developed a Balanced Scorecard for the University of Colorado Health Sciences Center Burn Center. Their Balanced Scorecard targeted individual and collective efforts of the burn team and progress towards achievement of the vision.

In the United States and the United Kingdom, reporting is perceived as a critical factor for improving accountability and quality in the health care system (Marshall et al. 2003). The authors reviewed implementations of healthcare quality reports (also called report cards, profile cards, quality assessment reports, league tables) in these countries and reported that despite the importance of these, it is often challenging to engage stakeholders

in these initiatives. For example, some physicians and hospitals with poor performance in the United States try to discredit the data and distrust the results.

At the operationalization level, implementing performance management initiatives in the healthcare industry has its own challenges. First, there are interoperability challenges related to implementing information technologies (Kuziemsky and Peyton 2016). In many instances, given the complexity of health care systems, a single technological solution or single vendor cannot provide all the functionalities required for performance management of health care (Gaynor et al. 2014). Therefore, it is important to consider interoperability aspects in technology implementations. Secondly, it is important to conceptualize the aggregation or disaggregation of the different healthcare systems components – agents, recipients, mode of intervention, and outcomes –its dynamics and impact on outcomes (Mitchell, Ferketich & Jennings 1998). From a technology implementation perspective, understanding the structure, dynamics, and interdependencies between the main elements of the health care system is important to determine how technologies can be used (Reid et al. 2005).

Finally, healthcare delivery is evolving from the care provided by single organizations (e.g. hospitals) to care provided by an integrated network of healthcare providers in the community (e.g. hospitals, outpatient care, home care, nursing homes). The level of complexity of these networks of care results in challenges to traditional approaches to design and implement performance measuring systems (Curtright, Stolp-Smith, and Edell 2000)

1.2. Problem Statement

Traditionally, clinicians and administrators designing tool support for performance management of any aspect of health care try to use information which they can extract from electronic health records, or to design ad-hoc data collection tools to generate ad-hoc reports which they need to monitor a clinical practice. This approach often proves to be more troublesome than helpful, as there is a disconnect between information that is actually needed, consistency and quality of data sources used for reports, consistency in how the information is communicated to stakeholders, and ultimately, the relevance of the information clinicians and administrators use to manage performance in health care.

In addition, it can be challenging to understand the complete context of a clinical practice when designing tool support for performance management. In previous work we developed a clinical performance monitoring app (Mata et al. 2015) that was enthusiastically received during user acceptance testing, but whose use was discontinued later when it failed to effectively support the overall performance management of the clinical practice. This thesis sought to understand and address that failure (and is discussed as a case study in section 6.1).

Health organizations can be seen as complex systems. Relationships between its parts are dynamic and continuously shifting, thus generating always changing results (Anderson et al. 2005). Issues with personnel, information, and processes can lead to gaps in data for decision-making processes in healthcare (Foshay and Kuziemsky 2014). Therefore, for effective design of tool support for performance management of the clinical practice, we believe there is a need for a framework that first allows understanding and

modeling of a clinical practice as a whole complex system of actors, processes, tasks, and data flows and that incorporates elements of measurement (goals and indicators) for different user contexts (Kuziemsky et al. 2014) to guide the effective design of tool support.

1.3. Contributions

This thesis proposes a design framework for tool support of performance management for clinical practice. The framework includes:

a. A Conceptual Model of the relevant entities and actors for performance management of clinical practice.
b. A Performance Management Participation View of what tool-supported tasks performed by what actors in what processes are needed to enact performance management for the clinical practice.
c. A Performance Measurement View of what clinical practice goals are measured by what indicators in which tool-supported tasks for the clinical practice.
d. A Tool Support Design Methodology for the design, implementation and validation of tools for performance management of the clinical practice.

The framework provides a systematic and structured approach, guided by a set of tables and diagrams, to help understand the complexity of clinical practice. It provides a sequence of steps for defining and validating how performance management of a clinical practice is operationalized with tool support.

Below, we list publications that have been presented in relation to this work.

1. P. Mata, C. Kuziemsky, L.Peyton, "A Framework for Performance Management of Clinical Practice", HEALTHINF 2019, Prague, Czech Republic, February, 2019

2. Mata Pilar, Kuziemsky Craig, Peyton Liam. A Framework for Performance Management of Clinical Practice. Poster presented at the 11th Annual Engineering and Computer Science Graduate Poster Competition, Faculty of Engineering, University of Ottawa, 2019. Award: Best overall female presenter.
3. Mata Pilar, Kuziemsky Craig, Peyton Liam. A Framework for Performance Management of Healthcare processes. Poster presented at MDII & Create-Best Research Poster Day, 2018.
4. Mata Pilar, Peyton Liam. Designing Support Tools for Performance Monitoring of Healthcare Processes. Poster presented at 10th Annual Engineering and Computer Science Graduate Poster Competition. Faculty of Engineering, University of Ottawa, 2018. Award: Third place.
5. P. Mata, A. Baarah, C. Kuziemsky, L. Peyton, “An Application Meta-model for Community Care”, Software Engineering in Health Care. Editors M. Huhn and L. Williams. Springer International Publishing, pp 162-177, 2017. ISBN 978-3-319-63193-6
6. Mata Pilar, Peyton Liam. A Development Methodology for a Stroke Rehabilitation Monitoring Application. Poster presented at MDII & Create-Best Research Poster Day, 2017 and 2016 Engineering and Computer Science Graduate Poster Competition. Award: Second Place.

7. P. Mata, C. Kuziemsky, L.Peyton, "A Development Methodology for a Stroke Rehabilitation Monitoring Applications ", HEALTHINF 2016, Rome, Italy, January, 2016

1.4. Thesis Organization

This thesis is organized as follows; In Chapter 2, we defined key concepts that set the context for the study and we reviewed related works for performance management of healthcare processes and organizations.

In Chapter 3, we describe the research methodology for this thesis. We define research questions, main research philosophies we identified with and our approach to research. Then, in the research design, we provide a detailed description of how we structured our research, and we end the chapter by describing the methods we use for data collection and data analysis.

In Chapter 4, we define key terminology related to our framework, describe current practice, and identify the main shortcomings of related works for designing tool support of performance management for healthcare processes. Then, we delimit gaps our performance framework will address. Lastly, we provide a list of detailed evaluation criteria for the evaluation of our framework against related works and, to validate the relevance of these criteria across the three case studies.

In Chapter 5 we present our framework for performance management of healthcare processes.

In Chapter 6, we describe the three case studies we used to evaluate our framework and review the main results and findings for each.

In Chapter 7, we document results from the evaluation of our framework. We first report results and insights gathered from review and feedback sessions with the case study stakeholders, then we evaluate our framework using the evaluation criteria defined in Chapter 4 across the three case studies. Next, we compared our framework against the current practice and related works using the evaluation criteria. Finally, we declare threats to the validity of this research, and limitations, and assumptions.

Finally, in Chapter 8, we summarize the main findings of this research and propose areas for future work.

Chapter 2. Background and Related Works

In this chapter, we define key concepts that set the background for this thesis. The chapter is organized into four sections. First, we review the definition of performance management and review key terminology related to performance management. Understanding what performance management involves and its main components is fundamental to determine what elements need to be incorporated when designing and integrating tool support to operationalize performance management. Second, we delve into the specifics of performance management in healthcare. Understanding healthcare systems' unique characteristics and challenges related to performance management allow us to focus on distinctive healthcare aspects that need to be considered to design and integrate tool support. Third, we review what tools are available for performance management of healthcare processes to determine what can be leveraged and what gap needs to be addressed. Lastly, we review related works where different approaches are taken to implement performance management in healthcare to determine what is available for integrating tool support of performance management for clinical practice, to what extent and what areas remain to be addressed.

2.1. Performance Management

In this section, conceptual definitions relevant to frame the thesis are provided: what is performance management, common approaches to performance management, differences between performance management and performance measurement, and how systems and frameworks are used to support performance management.

2.1.1 **Performance Management**

Management as defined by the Oxford dictionary is “the process of dealing with or controlling things or people”. In the business context, performance management involves systematic planning, execution, monitoring, and evaluation of goals derived from the business strategy with the purpose of improving business effectiveness (Dresner 2008). Performance management is a continuous process. It requires close collaboration of all stakeholders – managers and employees – for the definition of measures and actions to achieve strategic goals set for individuals, departments, or organizational units (Dresner 2008).

In its traditional form, performance management reviews are typically done ex-post. The review process is often time-consuming and leaves little or no room for collaboration and innovation. It frequently emphasizes the financial perspective, in the form of financial rewards and punishments, hoping to correct current performance by holding people accountable for past performance (Cappelli and Tavis 2016).

While the financial perspective continues to be the main focus in performance management systems, the link between organizational learning and the effectiveness of organizations has been well discussed in the literature. However, little progress has been made to integrate the competitive advantage learning brings to organizations with measures and rewards used in performance management systems other than financial rewards (Rowland and Hall 2014). Typically, outcome-based measures, widely recognized as unreliable or irrelevant, continue to be used in performance management systems, and rewards for meeting these measures are often financial rewards. While this continues to be

the case, some progress has been made for using quality measures (Inamdar, Kaplan, and Reynolds 2002), but how to measure the impact of these in a system or what reward mechanisms to use are still not clear (Rowland and Hall 2014). The authors argue that in order to foster learning organizations, performance measurement systems must incorporate and encourage behaviors that contribute to the success of the organization.

2.1.2 Indicators

Key Performance indicators (KPIs) "measure the business health of the enterprise and ensure that all individuals at all levels are 'marching in step' to the same goals and strategies" (Bauer 2004). KPIs guide decision-making aligned with strategic goals (Brooks 2005). Metrics instead are measurements taken at a specific point in time, and help actors understand the impact of past decisions. While performance indicators are used to measure processes (what is done), outcome measures or metrics are used to measure what the result of a process is (Davies and Lampel 1998).

KPIs are "quantifiable and strategic measurements that reflect an organization's critical success factors. These measures help organizations define and track progress toward organizational goals, using a closely related set of operational metrics for each and every strategic initiative" (Brooks 2005).

2.1.3 Performance Measurement

Performance measurement refers to the use of a multi-dimensional set of performance measures, which may include; financial and non-financial measures, internal and external measures of performance, or lag measures (measures of what has been achieved) and leading measures (to help predict the future) (Bourne et al. 2003).

Performance measurement is “the process of quantifying action, where measurement is the process of quantification and action leads to performance” (Neely, Gregory, and Platts 2005). A performance measurement system can be defined as the collection of measures that quantifies both effectiveness and efficiency of actions (Neely, Gregory, and Platts 2005).

The difference between a performance measurement systems and a performance management systems is that the latter uses the results from a performance measurement system to perform continuous evaluations and for the redefinition of a strategy or processes (Voelker, Rakich, and French 2001), while the focus of a performance measurement system is to quantify actions. Quantifying actions on its own cannot be used to redefine the strategy or a process.

2.1.4 **Performance Management Systems**

Performance Management Systems are defined by (Ferreira and Otley 2009) as “the evolving formal and informal mechanisms, processes, systems, and networks used by organizations for conveying the key objectives and goals elicited by management, for assisting the strategic process and ongoing management through analysis, planning, measurement, control, rewarding, and broadly managing performance, and for supporting and facilitating organizational learning and change”. It is a philosophy supported by performance measurement (Lebas 1995).

Performance Management (PM) frameworks, in many cases, are used to translate the organization strategy into performance measurements to achieve strategic alignment within the organization. A framework is used as a tool to depict relationships between

various descriptive categories, e.g. concepts, constructs, or variables that are believed to explain a certain phenomenon. They represent a structure, overview, system, or plan (Nilsen 2015). PM Frameworks can be used to measure and manage the performance of individuals, departments, processes, programs, or organizations. Some examples of performance management frameworks include the Balanced Scorecard (Robert S Kaplan and Norton 1992), Strategy Maps (R. S. Kaplan et al. 2004), Balanced Scorecards in Healthcare (Voelker, Rakich, and French 2001) decision-making frameworks for selecting outcome measures (Neely et al. 2000), and Competency Based Medical Education frameworks (Frank et al. 2010).

The Balanced Scorecard (BSC) was designed by Kaplan and Norton to provide a more balanced approach to performance management of business organizations and to not limit measurements exclusively to financial indicators (Esmail and Hazel 2009; Wongrassamee, Simmons, and Gardiner 2003; Robert S Kaplan and Norton 1992). The aim was to provide top executives with a balanced view of their business measures, from different perspectives simultaneously, and with a limited set of measurements that were considered to be the most critical to the organization (Robert S Kaplan and Norton 1992).

The balanced scorecard complements the financial perspective with three additional operational perspectives so executives can answer the following questions; 'How do customers see us?' (Customer satisfaction perspective), 'What we must excel at?' (Internal perspective), 'Can we continue to improve and create value?' (Innovation and learning perspective), 'How do we look to shareholders?' (Financial perspective) (Robert S Kaplan and Norton 1992). The BSC helps organizations to overcome three key issues; "effective

organizational performance measurement, the rise of intangible assets, and the challenge of implementing strategy" (Niven 2012). Figure 1 depicts the four perspectives of the Balanced Score Card.

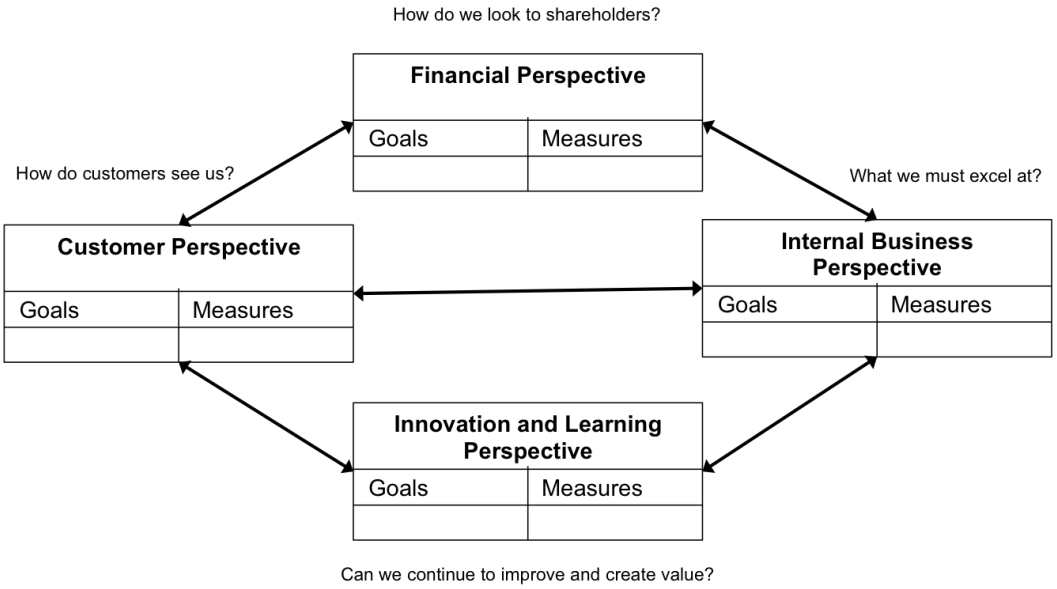


Figure 1: Balanced Scorecard (Kaplan & Norton, 1992)

The financial perspective measures past performance while the other three perspectives measure the organization drivers for future success. A limited number of indicators, four to five per perspective (a total of fifteen to twenty indicators), is key for successful implementation of the BSC. A small but relevant number of measurements foster transparency in the organization and allows external observers to see through the organization's strategy (Wongrassamee, Simmons, and Gardiner 2003). Objectives are used to translate the strategy into measurable actions within each performance perspective, and measures are defined and tied to objectives.

The BSC can be used as a communication tool, measurement system, or strategic management system (Niven 2012). It can be a tool for implementing a strategy or for the development of a strategy. It provides a balanced approach that promotes dialogue between different stakeholders to gain consensus on common goals and critical factors for success (Voelker, Rakich, and French 2001). A BSC promotes organization excellence by balancing the accomplishment of all functions within whole systems and not in isolation to detriment of other functions of the system.

Implementations of the Balanced Scorecard can be broad, including not only corporate or strategic business units, but can also be implemented at departmental and individual levels. Each product strategy, market situation or business environment will require the development of a customized scorecard that fits the mission, strategy, culture, and technology of the organization (Wongrassamee, Simmons, and Gardiner 2003). Finally, while the BSC was originally developed for the private sector, it can be used for both For-Profit organizations and Not-for-Profit organizations, e.g. healthcare (Voelker, Rakich, and French 2001).

2.2. Healthcare Performance Management

This section provides an overview of performance management in healthcare: concepts, how it is approached, main drivers to performance management and how it is measured. We then drill down into healthcare processes and what characterized them. We describe the importance of healthcare interoperability and the importance of contexts of use to design and implement technologies for performance management in healthcare. We end this section with a review of different healthcare performance indicators and the

importance of visualizing healthcare as a whole system for effective performance measurement.

2.2.1 Healthcare Performance Management

The World Health Organization (WHO) defines quality of care as "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes. It is based on evidence-based professional knowledge and is critical for achieving universal health coverage" (World Health Organization n.d.). The WHO recognizes quality of care can be defined in many different ways and acknowledges a growing agreement in core dimensions of quality of care namely; effectiveness, safety, and people centeredness and that health services must be timely, equitable, integrated and efficient in order to realize quality of care.

In the last few decades, there has been increasing pressure on healthcare organizations to improve quality of care. (Shortell et al. 1995) defines continuous quality improvement (CQI) or total quality management (TQM) as the adoption of the philosophy, approach, and tools used in quality control, with a focus to control increasing costs while improving quality. The key elements of CQI / TQM are continuous improvement, client focus, structured processes, and wide participation of the organization with the goal of understanding and improving processes and systems rather than correcting errors after-the-fact (Shortell et al. 1995). In the context of the health industry, QI is defined as "a distinct management process and set of tools and techniques that are coordinated to ensure that departments consistently meet their communities' health needs and strive to improve the health status of their populations." (Riley et al. 2010).

The process of improving quality can be seen as a continuous process and quality management can therefore be defined "as directing (managing) the whole (total) production process to produce an excellent (quality) product or service" with a focus on the product and the worker (Nixon 2006). In order to move an organization towards QI, performance management models must be implemented (Riley et al. 2010).

In healthcare, Performance Management is typically perceived as the “external judgment of the quality of care based on performance monitoring data followed by a system of reward and punishment” (Lilford et al. 2004). It can refer to performance management of an entire healthcare organization (e.g. hospital), a department within a healthcare organization, a specific health care process, or an individual (e.g. care provider, or patient).

Performance management of healthcare systems can be approached in two ways. Firstly, management can be driven by the measurement of outcomes of care. In many cases, this measurement serves only one function – regulatory, clinical or diagnostic (Inamdar, Kaplan, and Reynolds 2002). Outcome measures are numerical values that themselves, lack context, thus fail to explain the causes behind an outcome. Some examples of outcome measures include patient satisfaction, mortality rates, and morbidity rates. When outcome measures are used alone for performance management, they often produce fear and anxiety amongst healthcare management (Lilford et al. 2004).

Secondly, healthcare performance management can be seen at the process level, with a focus on improving processes that in turn, will impact outcomes of care (Goddard et al. 2002). The aim is to identify the root cause of issues to take timely actions to address the issue. Some examples of process performance management include monitoring a

patient from diagnosis to end of treatment, training of medical residents, stroke rehabilitation, and management of frailty patients.

Exclusive use of one type of performance indicators may not be sufficient for measuring the quality of care. (Mant 2001) suggest that, as the perspective for which the measure will be used broadens (e.g. comparing performance between two countries), the use of outcome indicators becomes more relevant. On the other hand, as the perspective gets narrower (e.g. measuring individuals' performance), process measures become more useful. According to the author, outcome measures are often not enough to determine differences in care quality unless appropriate measures are taken to ensure data reliability (e.g. number of patients, standards for data collection, case mix adjustments). Conversely, process measures are straightforward to interpret and often more useful to determine when and where remedial actions need to be taken for a poor performing indicator, but process indicators are only relevant if they are linked to an outcome (Mant 2001).

The approach of reward and punishment (blame culture) based mainly on outcome measures has proven (in many cases) to be counterproductive for patient safety. Instead, the literature suggests adopting an approach based on patient safety culture and understanding factors that impact patient safety - organizational support structures, organizational learning, and teamwork and collaboration (Goh, Chan, and Kuziemsky 2013). (Goh, Chan, and Kuziemsky 2013) propose a framework that integrates all these factors and defines the relationships between them to measure the impact on patient safety indicators and employee outcomes (macro-level outcomes). Their work suggests an understanding of these relationships would enable the development of health information

technology to support safe patient care delivered by organizations that promote organizational learning and teamwork and collaboration.

Finally, healthcare systems are complex and involve multiple interdependent and interacting parts (Kuziemsky 2016; Reid et al. 2005). As defined by (Kannampallil et al. 2011), complexity is measured by "the interrelatedness of components of a system", or the influence each component has on other components of the system. This notion of interrelatedness – degree and number of relationships between components - is even more important than the number of components included in a system. Two important properties of complex systems are the non-decomposability and non-linear behavior (Kannampallil et al. 2011). It is important to understand that due to the nature of interrelationships of components in complex system, it is not possible to understand each component in isolation (Kannampallil et al. 2011). It is also important to understand the non-linearity of relationships of complex systems, identify relationships that can have an impact on an outcome, regardless of whether it is small or large, and be able to measure whether a small event generates a larger outcome or a larger event generates a smaller outcome (Anderson et al. 2005). By being able to identify the right components and cause-effect relationships between them, one can take the appropriate actions to effectively understand complex systems (Anderson et al. 2005; Kannampallil et al. 2011) and design effective performance management systems for healthcare.

2.2.2 **Healthcare Processes**

Organizations carry out a number of activities with the purpose of producing an outcome. Outcomes could be the product a company produce or services such as healthcare

services. Business processes are the links that connect the different parts of an organization to produce an outcome and deliver services to customers (Jeston and Nelis 2008). A business process is the "key instrument to organizing these activities and to improving the understanding of their relationships" (Weske 2012).

Business processes cycles can go from days to months to complete and a system thinking approach is needed to effectively manage processes. System thinking provides structure, and consistency to management efforts (Jeston and Nelis 2008). It provides structure to define a plan, define what is needed to execute the plan (e.g. process, project, or tasks), and define steps for measuring outcomes over time until the plan is completed. This process can trigger process improvements or changes to the plan (Jeston and Nelis 2008).

In the particular case of healthcare, processes can be classified as: clinical processes and organizational or administrative processes (Lvaro Rebuge et al. 2012). Clinical processes are directly linked to patients, involve understanding patient specific information and medical knowledge for making decisions about treatments. Organizational or administrative processes are designed to support clinical processes in general, are not related to specific medical conditions, and support coordination of different people and units that provide care (Lvaro Rebuge et al. 2012). The authors characterized healthcare processes as; highly dynamic, highly complex, multi-disciplinary and ad-hoc.

The dynamic nature of healthcare processes is due among other reasons to; constant changes in technology developments to support care delivery, introduction of new drugs, new treatments, introduction of new clinical knowledge, or new administrative processes

(Lvaro Rebuge et al. 2012). Factors that increase complexity of healthcare processes include availability of large amounts of data (in variety and formats) for medical decisions (Esmail and Hazel 2009; Lvaro Rebuge et al. 2012), individual experience of care providers that impact decision making processes, and sometimes the unpredictability of clinical decisions (Lvaro Rebuge et al. 2012). The healthcare system is also moving towards a more collaborative approach where care is delivered by a distributed a network of healthcare providers. This fact introduces challenges related to management of different organizational cultures, skill levels and knowledge (Kuziemsky 2016; Lvaro Rebuge et al. 2012). Finally, healthcare processes are often ad-hoc due to the collaborative nature of clinical processes and the autonomy participants (clinicians) have to make their own decisions based on their skillsets and knowledge (Lvaro Rebuge et al. 2012).

2.2.3 **Healthcare Interoperability**

Healthcare interoperability is defined as the flow, integration and use of information between technologies, processes, people and data in the provision of health care services to patients regardless of the location where care is provided (Mouttham et al. 2012).

Technologies to support technical interoperability, standards to support semantic interoperability, and research to overcome issues with care process interoperability (Benson 2012) indicate that organizations do not operate in 'silos.' There is a need to coordinate data exchanges (Marcotte et al. 2015). Data generated in healthcare processes needs to be exchanged seamlessly and understood in the same way across different organizations (internally and externally) (Gaynor et al. 2014). For this thesis, and strictly in what it relates to performance management systems, the concept of interoperability is

important to ensure the coordination and flows of information for indicators within a whole performance management system, so that indicators are understood and measured unequivocally within the system.

Interoperability can be grouped, at a high level, into three main interdependent categories: technical, semantic and processes interoperability, all needed to achieve business benefits (Benson 2012).

Technical interoperability refers to the exchange of information between two systems regardless of the domain - the ability to move data from system A to system B without caring about the meaning of what is being exchanged (Benson 2012). Technologies that support these type of interoperability include, Extensible Markup Language (XML), web Service and Oriented Architectures (SOA) (Sadeghi, Benyoucef, and Kuziemsky 2012; Gaynor et al. 2014).

Semantic interoperability is defined as the ability of sender and receiver to understand the same data in the same way, so data is shared, interpreted, and used without ambiguity (Benson 2012). Standards developed to support these type of interoperability include, amongst others, HL7 (Sadeghi, Benyoucef, and Kuziemsky 2012), medical term models such as Systematic Nomenclature of Medicine-Clinical Terms SNOMED-CT, Logical Observation Identifiers for laboratory tests and other logical observations LOINC (Dixon, Vreeman, and Grannis 2014), International Classification of Disease ICD-9/10, Digital Imaging and Communication in Medicine (DICOM) for transmission of medical images, RXNorm for normalized names of clinical drugs and, Continuity of Care document (CCD) for defining data within EHR (Gaynor et al. 2014).

Process interoperability is achieved when there is a common understanding between human beings in a network, business systems interoperate, and work processes are coordinated (Benson 2012). This type of interoperability embraces one of the key dimensions in healthcare delivery: the interpersonal nature of care delivery, often ignored during the design of healthcare systems (Avison and Young 2007).

Recent research shows advancements towards enabling healthcare interoperability. (Gaynor et al. 2014) developed a methodology for designing modular systems, with a focus on semantic interoperability. These systems are composed of several interoperable modules (applications) designed for a single organization or for a functional area of a clinical setting. They acknowledge in their work that, given the complexity of healthcare systems (even within a single hospital) a single vendor cannot have best solutions for all hospitals functions; therefore, they identified a need for modularity to allow providers select the best of breed solutions and make all these various applications interoperate with each other.

(Mouttham et al. 2012) research focus is on systems design for multidisciplinary teams, proposing an ontology and clinical information system architecture for collaborative care delivery. The aim of their work is to facilitate the conceptual analysis of interoperability requirements and facilitate design and evaluation of technologies to support collaborative processes.

(Benson 2012) proposes the use of standards (unambiguous way of defining a transaction in detail) as the recommended approach to link multiple domains. Standards address semantic interoperability, providing unified messages regardless of the language and/or notation used by a system. The Office of the National Coordinator for Health IT

(ONC), in a separate attempt to improving care transitions by using standards, is working on a standardized vocabulary and transport of clinical information “to achieve secure transmission of and access to information by patients and their health-care providers” (Marcotte et al. 2015). The aim is to extract, from EHRs from different vendors, a set of key clinical information to be transferred to care providers at each transition to ensure timely and effective transfer of information between providers (Marcotte et al. 2015).

2.2.4 **Context of Use**

(Kuziemsky et al. 2014) highlights the importance of understanding the health system as a "whole system" and incorporating all levels of the system for the design and implementation of technologies. It is not only necessary to understand the different contexts in which users and processes operate to effectively satisfy different information needs, but it is also necessary to avoid unintended consequences in the delivery of care. Effectiveness in the use of data in a health care system results from the intersection of the context of use, the tasks, and users. The authors define this space as the "digital persona". Understanding the digital personas when designing and implementing technologies is key to define the information needs and provide meaningful data. The author situates the "digital persona" at three different contexts of use - micro, meso, and macro. At the micro-level, the author groups patients and service providers. At the meso level is the group that integrates and coordinate processes that occur at the micro level (intra or inter-organizational). Finally, the macro level group users and processes that regulate the health care system, such as the World Health Organization (Kuziemsky et al. 2014).

(Reid et al. 2005) proposed a four-level model for understanding the health care system. The model is used to explain the structure, dynamics, and interdependencies between the main elements of the health care system and how these elements impact the way information technologies can be used. The four levels include; 1. The patient, 2. The care team, 3. The organization, and 4. The political and economic environment. The authors describe the four levels as follows:

Patients represent the first level of the system. Recent policy changes place patients in an active and central role within the health care system. As such, patients are expected to be agents of change in the system, by demanding better care, effectiveness, and efficiency in care delivery, actively participating in decisions related to their care, which requires interaction with other levels of the system. However, patients do not always have the appropriate tools to assume this role.

Service providers and care teams represent the second level of the model. Service providers and the care team are made up of a group of people who provide direct care to the patient, their families, and caregivers. It is still common to find service providers that act independently, and do not have the necessary tools to facilitate exchanges of information with patients and with other service providers.

Health organizations represent the third level of the health system model. This level typically coordinates activities of care teams, supports care units, and manages the allocation of resources. One of the main challenges that health organizations face is to manage care teams and doctors who function independently. In many cases, organizations

do not have the necessary tools to facilitate and remove barriers between doctors and management teams.

Finally, the last level of (Reid et al. 2005) health system model is the political and economic environment made up of regulatory and financing agencies whose policies have a direct impact on health organizations and consequently at other levels of the system.

(Reid et al. 2005) describe the current health system as a "cottage industry" in which each element of the system acts autonomously, or in "silos", and coordination between different units of the health system or standardization of processes is typically not sought. This lack of coordination between different units and processes is not only observed for inter-organizational processes but it also affects intra-organizational processes. The authors argue that to achieve maximum performance in the health care system, a different approach is necessary. They suggest there should be a change from a system that operates in “silos” to a system where there is coordination between all parts across all system levels. That the impact one unit has on the other units of the system needs to be analyzed and considered for achieving high performance, and where the approach to optimize the system involves understanding the system as an integrated whole and not as the sum of independent parts.

2.2.5 **Performance Indicators in Healthcare**

In healtchare systems, performance indicators are used for multiple purposes. According to (Mant 2001), performance indicators may be used for; informing policy making or strategy at a a regional or national level, improving the quality of care of a health care facility, monitoring performance of healthcare funders, identifying poor performers to protect public safety, and/or providing consumer information to facilitate choice of care

providers. Furthermore, performance indicators can be used for ranking or comparing healthcare organizations, individuals, and health systems of coutries. In healthcare, there are two main types of performance indicators; outcome measures and process measures.

Outcomes are defined as the consequence of care (Campbell, Roland, and Buetow 2000). Outcomes Measures (OM) quantify and track patient's performance or changes on the health status of patients. Some examples of use of OM in healthcare include; OMs for rehabilitation processes based on standardized evaluation protocols and close-end questionnaires (Potter et al. 2011), OMs for measuring changes across a target population (Walsh et al. 2005) or, OMs for measuring patient satisfaction and behaviours in educational programmes (Belfield et al. 2001).

OMs are grouped, based on the purpose of the metric, into discriminative, predictive or evaluative measures (Potter et al. 2011). Discriminative OMs are metrics used to separate patients in groups based on a given characteristic or on the basis of predefined categories. Predictive OMs are metrics designed to forecast future status of the patient - useful for identifying risks, prognosis and discharge plans. Evaluative OMs are measures used to determine the effectiveness of an intervention by monitoring change over time (Potter et al. 2011).

(Potter et al. 2011) also group OMs into performance-based metrics or self-reported metrics. Performance-based OMs are used to assess performance of a pre-defined set of activities in a specific setting. Self-reported OMs are used to measure patient's perceptions on their condition and/or on activities performed in their home or in the community. The authors suggest a combination of both types of OMs to produce a more comprehensive

assessment of patient's health status. Finally, OMs can be generic (for use across all patient populations) or disease specific.

Outcome measures are relevant for measuring a broader perspective, as they reflect the inter-play of a wide variety of factors (indirect measure) and all aspects of the process of care (even the ones that cannot be measured). Outcome measures are useful, for example, for comparing healthcare organizations. As the perspective narrows (e.g. monitoring performance of single organizations, departments, or individual care providers), or when the occurrence of an expected outcome is rare to detect differences in quality of care, the use of process measurements would be more relevant and useful, as they are; 1) more specific to identify differences in quality of care, 2) they are easy to interpret and are a direct measure of the quality of care, and 3) are often less costly (Mant 2001). Choosing the type of indicators to measure performance will largely depend on the perspective of what is being monitored.

2.2.6 **Performance Measurement in Healthcare**

Performance measurement is defined as the continuous process of measuring and reporting metrics related to the operational execution of a strategy. Measurements are used to quantify progress towards achievement of a goal and to compare progress against benchmarks (when available). Metrics provide insights on how well a process or task is being performed (Kronz 2006).

"The fundamental role of performance measurement is to help hold its various agents to account, by enabling stakeholders to make informed decisions" (Smith, Mossialos, and Papanicolas 2008). For the accountability relationships in a performance

measurement system to be effective, the performance information system should be viewed within the context of a broader system design (and not in isolation) within which the measurement is embedded (Smith, Mossialos, and Papanicolas 2008). In the health care system, this broader context includes various stakeholders; Patients, clinicians, provider organizations, profession, government, citizens, and purchaser organizations. The authors proposed a map with the most important accountability relationships between stakeholders in the health system and indicated that, relationships between different stakeholders determine the nature, level of detail, and timeliness of the information required.

An example of tools used in healthcare organizations to report performance measures are hospital report cards. They provide a set of consistent performance measurements to; rank hospital services and practices (e.g. access to care, use of a drug or technology, consumer satisfaction), lead improvements in quality of care in hospitals, and give patients and physicians the data they need to make informed decisions (Esmail and Hazel 2009). The authors group hospital report cards into four main categories; 1) process report cards (describes inputs used by care actors in the course of treating a patient), 2) survey report cards (patient's evaluations of their quality of care and/or customer service), 3) outcomes report cards (average levels of health outcomes based on mortality or complications rates), 4) balanced scorecards (broadest view of hospital's operations and functions) (Esmail and Hazel 2009).

2.3. Tool Support

In this section, we provide an overview of different tools used for performance management of healthcare. We divide tools into four main categories. First, we review

Electronic Health Records as the main repositories of healthcare data for performance management. We provide definitions and limitations for its use. Second, we provide an overview of emerging technologies, how these are used to expand the boundaries of data collection compared to traditional systems (e.g. EHRs), and as alternative solutions to overcome some of the interoperability issues in healthcare. Third, we review clinical performance monitoring applications as tools to support data collection and reports to enable performance management. Lastly, we review the concept and relevance of business analytics tools for aggregating data, visualizing data, facilitating analysis and supporting decision-making processes.

2.3.1 Electronic Health Records

Various definitions exist in the literature for Electronic Health Records (EHR). An EHR is defined by Gartner as a system that "contains patient-centric, electronically maintained information about an individual's health status and care, focuses on tasks and events directly related to patient care, and is optimized for use by clinicians. The EHR provides support for all activities and processes involved in the delivery of clinical care" (Gartner 2013). (Gunter and Terry 2005) defines an EHR as "a longitudinal collection of electronic health information about individual patients and populations". (Ayrinen et al. 2007) defined an Electronic Health Record (EHR) as "a repository of patient data in digital form, stored and exchanged securely, and accessible by multiple authorized users. It contains retrospective, concurrent, and prospective information and its primary purpose is to support continuing, efficient and quality integrated health care".

One approach to performance monitoring in healthcare involves ad-hoc reporting. Data is compiled in loose spreadsheets towards loosely defined goals or reports that are generated against existing databases that do not necessarily contain the appropriate data to measure performance. One example of this approach is the use of data from EHRs complemented with data compiled in spreadsheets.

The Veteran's Health Administration implemented an Electronic Health Record for clinical data management. It has automated information systems to provide clinical and administrative capabilities across all facilities. Data in the systems is organized in a way that supports clinical decision-making by providing an overview of the patient status (Perlin, Kolodner, and Roswell 2004). They system also includes capabilities, beyond traditional EHRs features, to support performance improvement. These include: provider order entry that is used to alert clinicians on possible drug adverse effects when an order is placed; clinical alerts to notify clinicians on e.g. abnormal test results; remote data view so data can be accessed from different locations; and a clinical reminder system to improve preventive healthcare and ensure timely interventions (Perlin, Kolodner, and Roswell 2004)

In a separate study conducted by (Parsons et al. 2012), the authors review the use of EHRs derived measurements for public reporting of performance management. They raise concerns about reliability of using EHRs for this purpose, having found that not all providers documented data in the same way, and that in some cases standard EHR systems programing may not recognize some data, leading to issues such as undercounting patients eligible for preventive services, treatment or controlling target values. In the study, the

authors evaluated 82 practices. Each practice had a minimum of 200 EHR logs for a specific set of diagnoses. While some diagnoses were documented with an accuracy level of 80% or more (e.g. hypertension and diabetes), this was not the case for diagnosis such as ischemic cardiovascular disease diagnosis or dyslipidemia. They argue the reason for these findings could have been that, under-documented diagnoses were documented elsewhere in the charts. The issue with under documented diagnoses, highlights the importance that workflows and documentation habits have on EHR-derived quality measures (Parsons et al. 2012). The authors also found providers limit the number of assessments assigned to a patient, due to limitations in the number of diagnoses they could add in paper claims.

Since EHR are big repositories of health care data (collected at hospitals, physician clinics, labs, etc.) EHR systems are often seen as a natural data source option for extracting data for performance monitoring and improving the quality of care. However, some limitations exist. Different EHR systems from various software vendors can be implemented across different healthcare providers, which results in data collection inconsistencies due to different data formats used in the different EHRs (Chan, Fowles, and Weiner 2009). As care delivery is moving from care delivered in single locations and providers to care across multiple locations and providers (Kuziemsky 2016), security and privacy policies around data access at different locations constitute another challenge for using data stored in EHRs for performance management (Ellaway, Pusic, Galbraith, & Cameron, 2014). Further, issues related to data completeness, accuracy, and reliability due to incomplete or missing data, variations in documentation practices and data capture

methods, and data entered in open text fields also make EHR a less reliable source for performance monitoring and quality improvements (Chan, Fowles, and Weiner 2009).

2.3.2 New Technologies

New technologies have emerged in recent years that can be leveraged for the purpose of performance management in healthcare. These technologies can be grouped into two main categories: "mHealth" technologies and "eHealth" technologies.

"mHealth" is defined as the use of mobile technologies in the healthcare industry to support public and clinical care (Kahn, Yang, and Kahn 2010), while "eHealth" involves the use of any type of electronic devices (e.g. desktops) in the provision of health care (Dicianno et al. 2015). Research on the use of mHealth technologies on healthcare has increased in recent years due to the high prevalence of mobile devices in daily life of people (almost 84% of the USA population have their devices turned-on always), which represents an opportunity to serve a broader number of patients in a more cost-effective way.

While 'mHealth" applications are not intended to replace in-person interactions, they can be used to extend and enhance the relationships with care providers. mHealth technologies can be grouped into four main categories: 1) Life-style oriented apps for tracking progress of activities such as diets, exercise programs or weight lost (can be used by healthy individuals or patients with chronic conditions) ; 2) Patient-oriented apps aimed for patients with chronic conditions and used for self-identification of symptoms and adherence to treatment; 3) Clinical oriented apps, aimed to help clinicians with management of patients by providing reference or educational information, or decision making and measurement tools; 4) mHealth systems, use of mobile devices to enable

communication between patients in their natural environment and care providers (online or offline as data can be stored and send once wireless connectivity resumes), particularly useful for adherence to treatment (Dicianno et al. 2015). One example of "mHealth" apps for supporting community processes is the use of rehabilitation apps. This apps can be used for monitoring exercise routines, collecting measures, providing comprehensive feedback to the patient (interventions that are context based, and keep track of the symptoms adherence of the patient to the routines), educating the patient and, strengthening the relationship patient-clinician with encouragement messages (Dicianno et al. 2015).

mHealth apps can also be used to collect data and create bridges, for the data to flow from the external devices, e.g. sensors, to the care providers. This information can be used by clinicians for monitoring the patient, supporting decision-making and even sending encouragement messages to the patient (Dicianno et al. 2015). Also, data collected by mHealth apps can be used with machine learning systems to provide proactive responses that are context appropriate, e.g. therapy feedback.

Another type of technology than can be leveraged for the provision of care are the Mashup technologies. These technologies allow users to merge data coming from multiple data sources or web applications into one single integrated application (Sadeghi, Kuziemsky, and Benyoucef 2011). In a recent research, (Sadeghi, Benyoucef, and Kuziemsky 2012) leveraged the use of this type of technologies for supporting interoperability of data, processes and people. They developed a mashup framework that identifies six types of process interoperability requirements: Data; team member and task; policy and procedure; collaboration; social and knowledge exchange; and privacy and

security. The framework allows actors, in varying contexts, to collaborate and communicate via specific channels that can be customized to user's needs and preferences. Some of the key advantages reported by (Sadeghi, Kuziemsky, and Benyoucef 2011) in using mashup environments are: 1) versatility, as mashup applications can use different architectures for different delivery needs, 2) no limits on the type of technology used and, 3) customization, that allows use of different data sources or services. Among some of the disadvantages listed for the use of this type of technologies the authors listed: Coordination failures across departments, and possibility of losing the big picture of a problem (partial solutions created for particular problems) (Sadeghi, Kuziemsky, and Benyoucef 2011). Other mHealth technologies cited by the authors that can be leveraged for performance management of healthcare, and specifically for supporting healthcare interoperability, are: Wikis, Blogs, Social Networks, RSS feeds, among others.

2.3.3 **Clinical Performance Monitoring Applications**

A Clinical Performance Monitoring Application (CPMA) is a type of application used to collect data for metrics that instantiate clinical processes goals and to provide reports with indicators that allow measurement of progress towards goals (Chamney et al. 2014). In a CPMA, data is collected from multiple data sources and aggregated in such a way that facilitate the creation of reports that are specific for monitoring performance. SAID (Mata et al. 2014), RPP (Mata et al. 2015), and JIT (Ferenchick et al. 2013) are all examples of CPMAs used in healthcare.

2.3.4 **Performance Management and Business Analytics**

Business Analytics is "about leveraging value from data" (Acito and Khatri 2014). Vast amounts of data are generated every day across all industries, but the challenge is how to extract value from data.

Business analytics systems are designed to "monitor data generated in business operations so as to analyze performance based on key indicators and present the analysis results to a wide range of users in a format that can be grasped intuitively" (Azvine, Nauck, and Ho 2003). (Acito and Khatri 2014) suggests that the rise of business analytics as an important item in the agenda of executives in organizations is due to three main factors: availability of large amounts of data, the fact that performance management has evolved to include a variety of metrics rather than exclusively financial metrics, and the emergence of low-cost, self-serve, friendly apps for fact-based decision making at every level of the organization. These, coupled with the development of advanced techniques for data analysis have made organizations realize the potential of using data for making decisions and the value of using business analytics systems as an important component of any performance management system (Acito and Khatri 2014).

Business Analytics (BA) and Business Intelligence (BI) are often found in the literature as interchangeable terms (Chen 2010). In his work, the author explores the evolution of BA from BA1.0 or database management systems with structured content, to BA 2.0, which expand the capabilities of BA 1.0 to include text and web analytics for unstructured contents, to BA 3.0, which expand the characteristics of BA 1.0 and BA 2.0 to include mobile and sensor-based content.

At the core of BA is BA 1.0 that (Chen 2010) defines as a data-centric approach that relies on data collection, extraction, and analysis. Data is structured, collected from various sources, and stored in relational database management systems. BA uses data marts and Extract, Transform, and Load (ETL) processes for cleaning and manipulating data. For exploring data, BA uses database query language and online analytical processing, and finally, data is visualized and analyzed using tools such as dashboards and scorecards that allow interacting with the data in near real-time supporting this way real-time decision making (Chen 2010).

2.4. Related Works

This section reviews different approaches - systems and frameworks - used for performance management in healthcare. First, we review the implementation of a widely adopted performance management system, the balanced scorecard, but adapted for healthcare organizations. Second, we provide an overview of a clinical decision-making framework that guides clinicians on selecting outcome measures. Lastly, we review a framework for performance management of medical training. We considered it important to include an approach to performance management for medical training, as training impacts care outcomes; therefore, an important area for healthcare managers.

2.4.1 Balanced Scorecard for Public Sector (BSPS)

Implementation of the BSC in healthcare is slower and more diverse when compared to other industries. One of the main challenges for implementing the BSC in healthcare is the complexity of the health system. It encompasses multiple groups of stakeholders (patients, families, health plans, practitioners, communities, regulators, etc.)

and actors that not always operate in coordination. A successful implementation of the BSC requires communication, commitment and, support from all stakeholders and at all the different organizational levels, which is not always possible (Voelker, Rakich, and French 2001).

Research shows there has been some progress in the implementation of the BSC in healthcare organizations. What is common between these implementations is that the four dimensions of performance in the original BSC are modified to accommodate distinguished characteristics of organizations in the health sector or with a vision similar to public sector organizations.

For example, (Voelker et al., 2001) adapted the traditional four perspectives in the BSC into the following perspectives (from base to top); Learning and Grow, Internal, Financial (operating performance), and Stakeholders and Mission (top of the pyramid). The Learning and Grow perspective continue to be the foundation for future success. The next level up, 'Internal', focuses on the internal processes of the organization that, if performed effectively and efficiently, will drive the financial success. Since one main focus area for healthcare organizations is care of patients, achieving internal success means the organization also needs to achieve a healthy financial status to provide services to their customers (patients). This will lead to the achievement of their ultimate goal (top of the pyramid), which is to provide the highest standards of care and satisfy their customers (i.e. patients). This performance hierarchy will allow healthcare organizations to monitor performance to achieve their ultimate goal of providing high standards of care and satisfaction.

(Kaplan et al. 2004) developed a modified framework of the BSC for value creation –mission- in the public sector. They redefined the measure of success for public sector organizations based on their performance to achieve their mission. As in the private sector, this mission is achieved when the stakeholders' needs are met, through success of internal processes supported by the learning and growth perspective as shown in Figure 2.

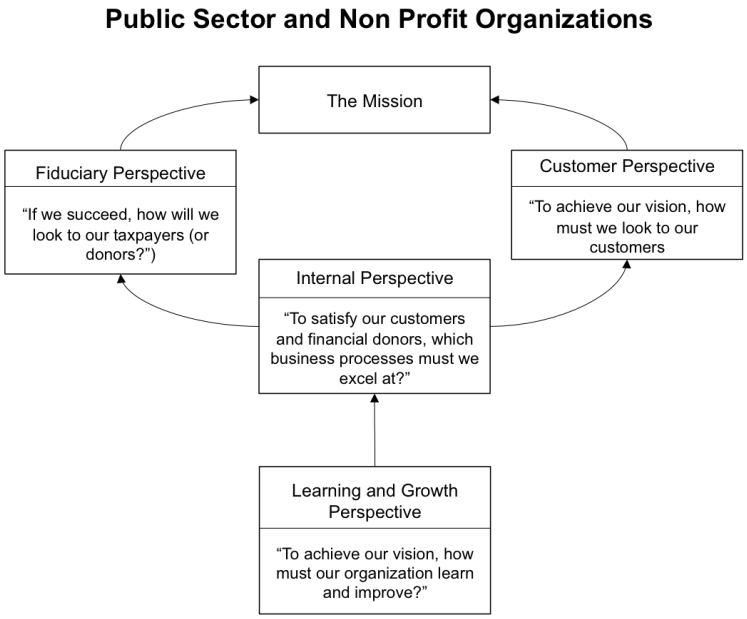


Figure 2: Strategy Maps: The Simple Model of Value Creation - Public Sector and Non-Profit Organizations. Adapted from (R. S. Kaplan et al. 2004)

Studies about the use of the BSC in the health industry indicate organizations have reported some benefits after implementing BSC, mainly in the areas of market competitive positioning, financial results, customer satisfaction, and excellence in operational execution (Inamdar, Kaplan, and Reynolds 2002). However, implementing the BSC in healthcare organizations is no simple task. In the study, the authors describe some of the main challenges and barriers they encountered in BSC implementations as well as benefit reported after implementation.

Among the main challenges and barriers (Inamdar, Kaplan, and Reynolds 2002) highlighted in their study was the time it took organizations to develop and implement their BSC. The implementation time typically ranged from one to five years. Other challenges described by the authors include:

1. Difficulty in obtaining approval for the implementation of the BSC,
2. Difficulty for the executive team to commit and dedicate time to the development of the BSC and skepticism about the value a system of balanced measurement generates given the complexity of healthcare systems,
3. Difficulty to reach consensus on a value proposition that satisfies different stakeholder groups - payers, patients, regulators, and physicians - and agreeing on a single set of measures to operationalize that single value proposition,
4. Time required to reach consensus on strategic and operational measures,
5. Difficulty in achieving commitment to implement the BSC
6. Difficulty for obtaining the right data for reports (in time and in the appropriate format),
7. Level of effort required to only include and maintain a reduced set of significant indicators.

Despite challenges encountered by (Inamdar, Kaplan, and Reynolds 2002) in BSC implementations, the study also highlights that organizations gained significant value after implementations. Among the main benefits, the authors cite:

1. Consensus on the strategy,
2. Increased credibility with the steering committee,

3. Real-time support for decision-making based on facts,
4. Focus on key processes
5. Coordination of strategic planning processes
6. Greater commitment to the organization's strategy at all levels
7. Better understanding of performance achieved vs. forecasted.

Based on (Inamdar, Kaplan, and Reynolds 2002) findings, the authors propose a series of guidelines to ensure successful implementations. Of particular interest to our work are guidelines related to BSC development and implementation process shown in Figure 3 and taking a systems approach when implementing a BSC.

Organizations that were more successful at implementing the BSC followed a two-step approach: 1. High-level development of the BSC and, 2. Implementation and cascade development of the BSCs at the lower levels of the organization as shown in Figure 3.

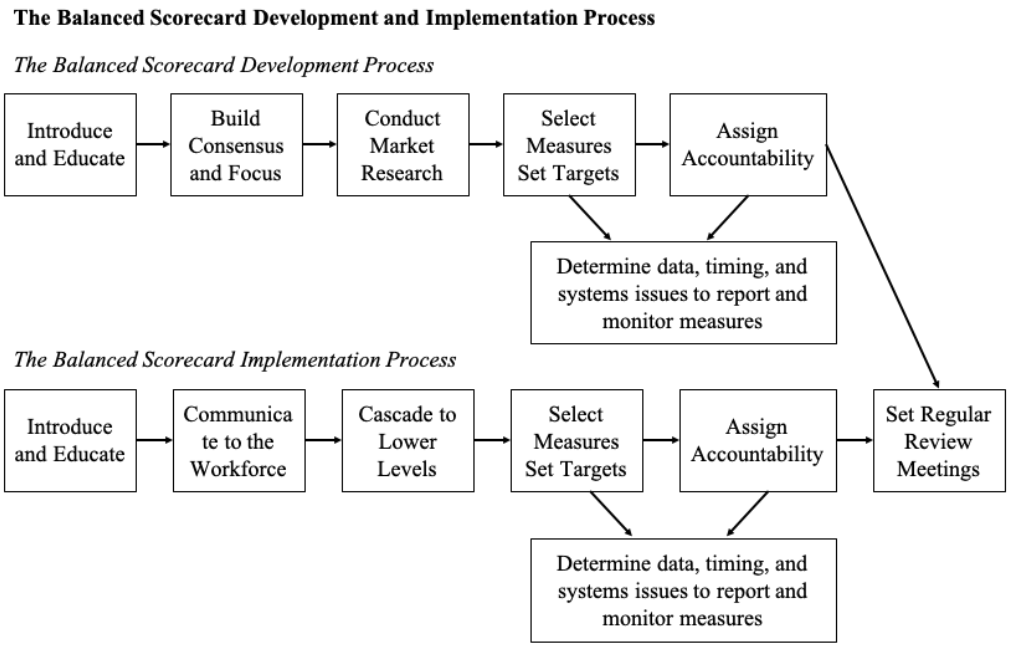


Figure 3: BSC Development and Implementation Process Source: (Inamdar, Kaplan, and Reynolds 2002)

The importance of following the development and implementation process resulted in increased cooperation among groups that participated in developing the BSC and increased the credibility of management on the use of the BSC (Inamdar, Kaplan, and Reynolds 2002). The systems approach ensured scorecards for individual healthcare service units were developed in cascade from and aligned to the organization level scorecard. In this particular, however, this process was reported as time-consuming and frustrating even though the fact it was useful to generate alignment between the different units towards a common mission.

2.4.2 **Clinical Decision-Making Framework (CDMF)**

The Clinical Decision-Making framework (CDMF) was developed to guide and help Physical Therapists (PTs) with the selection of Outcome Measures (OMs) for a clinical practice, i.e. neurological clinical practice (Potter et al. 2011; Sullivan et al. 2011).

In the framework, the authors refer to OMs as tools used for assessing patient status or for diagnostic or predictive purposes. Also, OMs are used for guiding selection of appropriate interventions.

One disadvantage reported in the literature when using OMs is that the value and accuracy of OMs will greatly depend on the ability of the clinician to select the right OMs (Potter et al. 2011). The CDMF (Figure 4) uses a deductive reasoning process to help PTs with the selection of OMs. The framework steps include; 1. Review of patient's referral information and selection of initial set of metrics, 2. Refinement of initial set of metrics based on interview with the patient and patient's history (patient's chart), 3. System review/screening for reviewing areas that require reassessment, and 4. Final selection of the OMs. At each step of the process the following factors are reviewed: what to measure, purpose of measurement, type of measurement, patient and clinic factors, psychometric factors and feasibility.

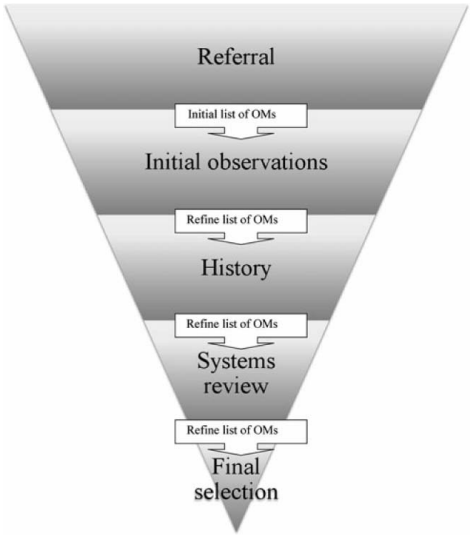
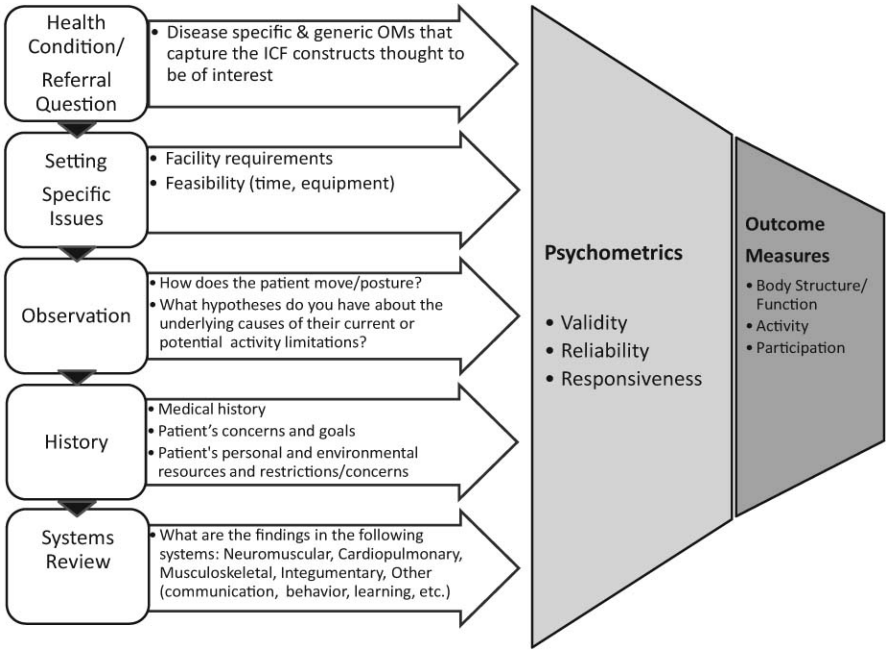


Figure 4: Clinical decision-making framework: the steps in selecting outcome measures. As the physical therapist proceeds through the examination process, she or he refines and narrows the list of possible OMs, leading to the final selection of OM(s) Source: (Potter et al. 2011)

With regard to 'What to measure', the framework leverages content from two other conceptual frameworks. The first framework – the World Health Organization's International Classification of Functioning, Disability, and Health (ICF) (World Health Organization 2019) – is used to identify categories of tests and measures (e.g. motor function) and within each category, constructs to measure (e.g. dexterity) and specifics aspects of the construct that could be measured (e.g. coordination screens). The second framework – Guide to Physical Therapist Practice (Guide) (American Physical Therapy Association 2016) - is a catalogue of specific tests and measures. The catalogue links specific tests and measures to categories of test and measure (e.g. motor function); however, the guide does not provide recommendations about when is better to use a measure over another (Potter et al. 2011), so it is hard for PTs to determine what measure to use. By using both frameworks as inputs to the CDMF, a PT can come up with an initial set of OMs to use for patient management and add more at every step of the CDFM.

In addition to 'What to measure', other factors are considered for the selection of the OMs. The purpose of the OMs and the type of OMs (see section 2.2.5) are factors that influence the selection of OMs. The patient's goals are also key to determine what OMs would be used and plan the interventions, as well as the status of the patient at each stage of the recovery process. With regard to the psychometric factors, (Potter et al. 2011) focus on two factors of OMs that detect change – the ability of the OMs to detect minimal change, and the minimal clinical importance difference. Finally, the authors discuss factors that impact the feasibility of using a specific metric. For example, the time required to complete OMs, space and equipment requirements, training required to administer OMs, patient's language and culture, among others.

The process of selecting OMs in the course of the therapy is dynamic and change through the different stages of the therapy. The initial set of selected OMs is re-evaluated, and new OMs may be added when all of other factors enumerated above are considered. Linking the selection of OMs to patient's goals is an important step. This will motivate the patient, PTs can provide specific feedback to the patient, and the patient can see the progress towards his/her goals. Figure 5 depicts a schematic representation of the process for selecting the tools (OMs) for patient management.



Abbreviations: ICF, International Classification of Functioning, Disability, and Health; OM, outcome measure.

Figure 5: Schematic representing the outcome measurement selection process. Source: (Sullivan et al. 2011)

For the 'Health Condition/ Referral question' step, the PT gathers information about the patient's status. The information comes from the medical record, in-patient settings, and nursing notes. The review leads to a preliminary selection of OMs. In the 'Setting/specific issues' step, the PTs factors in structural aspects for selection of OMs, such as time for administering the OM, equipment and space available, or use of specific

OMs required by the facility. The next step in the process, involves 'Observation' of the patient. The initial set of OMs is compared with the hypothesis made by the PT. The comparison may result in a refinement of the pre-selected set of OMs. Then, the next step involves reviewing the 'History'. The goals of the patient are used to further refine the list of OMs. Factors such as the context in which the patient wishes to function, available resources and limitations are also reviewed. The final step involves the review of body systems to evaluate the pre-selection of the OMs and come up with the final list.

Although the framework was developed for patient management in neurological clinical practice, the author suggest the framework could be used for any other type of health conditions.

2.4.3 **CanMEDS**

CanMEDS is a framework of competencies for training and continuing development of physicians. The overarching goal of the framework is to improve patient care by improving the building blocks of medical training. The framework comprehensively describes key competencies a physician must have to meet the health care needs of patients they serve. The framework is catalogued as an outcomes-based education framework, as competencies are described with the end in mind – to improve patient care (Frank and Danoff 2007; Royal College of Physicians and Surgeons of Canada 2020b). General descriptions of competencies included in the framework guide learners, supervisors, and institutions in teaching and assessment (ten Cate 2013)

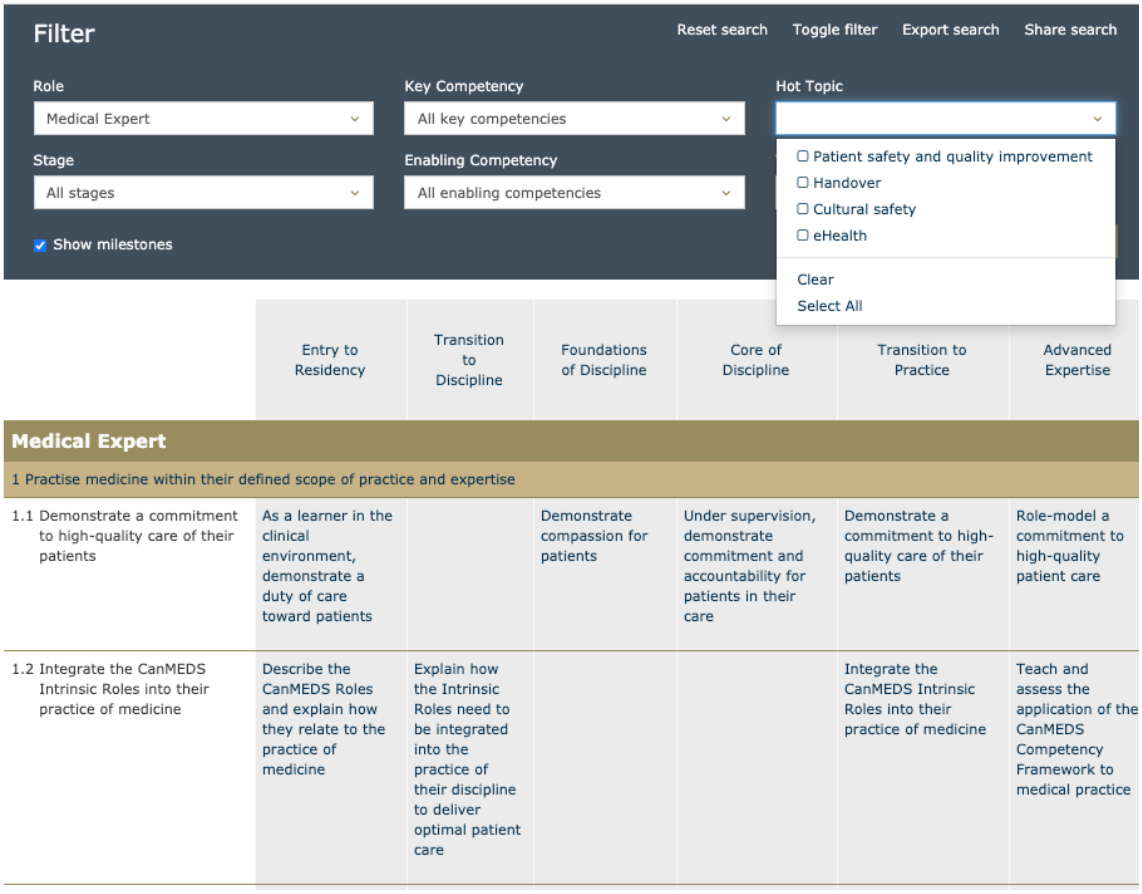
CanMEDS has been used worldwide, and beyond the health profession (Royal College of Physicians and surgeons of Canada n.d.). The framework was developed by the

Royal College of Physicians and Surgeons in the 1990s and has had two revisions and updates in 2005 and 2015. The framework provides the foundations for the Royal's College certification and accreditation (Frank and Danoff 2007; Royal College of Physicians and Surgeons of Canada 2020b).

Within the framework, key competencies physicians are expected to develop during training are organized around seven well-defined roles: Medical Expert, Communicator, Collaborator, Leader, Health Advocate, Scholar, and Professional. These roles will lead to optimal physician performance, care delivery, and healthcare outcomes (Royal College of Physicians and Surgeons of Canada et al. 2015).

For each role, there is a set of milestones (what is expected for the physician to achieve in terms of progress towards competencies) that are mapped to enabling competencies. An array of enabling competencies defines a key competency (or essential ability within a role) and key competencies are grouped through the different stages of the developmental continuum by role (stages) – i.e. entry to residency, transition to discipline, foundations of discipline, core of discipline, transition to practice, continuing professional development, transition out to professional practice. For example, within the role of Medical Expert, one of the key competencies is defined as "Practise medicine within their defined scope and expertise". Within the key competency, some of the enabling competencies are: "1.1 Demonstrate a commitment to high-quality care of their patients; 1.2 Integrate the CanMEDS Intrinsic Roles into their practice of medicine; 1.3 Apply knowledge of the clinical and biomedical sciences relevant to their discipline". An example of a milestone or ability expected for a trainee in the stage 'Entry to Residency' is

"Demonstrate a commitment to high-quality care of their patients". The framework provides an online tool to customize milestones by development stage and performance dimensions. The tool can be accessed at (Royal College of Physicians and Surgeons of Canada 2020a). A snapshot of the tool is shown in Figure 6.



	Entry to Residency	Transition to Discipline	Foundations of Discipline	Core of Discipline	Transition to Practice	Advanced Expertise
Medical Expert						
1 Practise medicine within their defined scope of practice and expertise						
1.1 Demonstrate a commitment to high-quality care of their patients	As a learner in the clinical environment, demonstrate a duty of care toward patients		Demonstrate compassion for patients	Under supervision, demonstrate commitment and accountability for patients in their care	Demonstrate a commitment to high-quality care of their patients	Role-model a commitment to high-quality patient care
1.2 Integrate the CanMEDS Intrinsic Roles into their practice of medicine	Describe the CanMEDS Roles and explain how they relate to the practice of medicine	Explain how the Intrinsic Roles need to be integrated into the practice of their discipline to deliver optimal patient care			Integrate the CanMEDS Intrinsic Roles into their practice of medicine	Teach and assess the application of the CanMEDS Competency Framework to medical practice

Figure 6: CanMEDS Tool for Customizing Milestones. Source: (Royal College of Physicians and Surgeons of Canada 2015)

In the update of CanMEDS framework in 2015, generic milestones and new competencies related to patient safety and quality improvement, handover, cultural safety, and e-Health were incorporated to the framework (Royal College of Physicians and

Surgeons of Canada 2020b). Milestones provide discrete information (measurable) about the skills of the discipline (Royal College of Physiciansand Surgeons of Canada, 2020c).

Program Directors of different medical disciplines are responsible for incorporating CanMEDS framework into their program curriculum. The process of how to translate CanMEDS milestones to a medical practice (or program curriculum) is not part of the framework. EPAs (Entrustable Professional Activities) are used to help mapping competencies in a competency-based framework to medical practice (ten Cate 2013). An array of competencies and milestones are related to an EPA. The bigger or more complex the EPA (task), the more competencies that are associated to it (Royal College of Physicians and Surgeons of Canada 2020c). Mapping milestones (abilities of the individual) to EPAs (tasks) is key for performance management based on levels of trust; however, EPAs and the process of mapping milestones to EPAs is outside of the scope of the CanMEDS framework. Without EPAs, (ten Cate 2013) argues a framework like CanMEDS would be too theoretical to be useful for training and assessment.

CanMEDS is a Competency Based Medical Education (CBME) framework. (Frank et al. 2010) define CBME as "an outcomes-based approach to the design, implementation, assessment, and evaluation of medical education programs, using an organizing framework of competencies". Competencies are defined as measurable, and observable abilities of a health professional (i.e. knowledge, skills, values, and attitudes) and constitute the building blocks that facilitate progressive development (Frank et al. 2010). A combination of multiple competencies (or abilities) are used to define a specific competence, and being competent is bound to specifics domain of ability, a context (e.g. ambulatory clinic), and

stage of medical education or practice it refers to (e.g. third-year medical student) (Frank et al. 2010).

Competency-based education starts with the end in mind, the outcome, and the curriculum is organized around outcomes expected of a resident. Outcomes guide the definition of the competencies or abilities needed by the learners, the milestones, instructional methods, and assessment tools that will facilitate the progress through the development path (Frank et al. 2010). The CBME approach allows for observation, feedback, coaching and assessment.

Entrustable Professional Activities (EPAs), are the tasks or responsibilities of a discipline that a supervisor decides to delegate, for the unsupervised execution by a trainee, once she/he has achieve a desire level of competence (ten Cate 2013). EPAs are competencies within a specific context (i.e. specific specialty). In planning a competency-based curriculum, (Frank et al. 2010) outlines six steps to follow: 1. Identify the abilities of the graduates, 2. Explicitly define the required competencies and their components, 3. Define milestones along a development path for the competencies, 4. Select educational activities, experiences, and instructional methods, 5. Select assessment tools to measure progress along the milestones, and 6. Design an outcomes evaluation of the program.

Competency-based medical education emphasizes continuous assessments of developmental milestones, and as such, can be categorized as a performance management system for clinical training. The design method is focused on the outcomes – the societal needs, but measurement is focused on inputs to achieve outcomes. While CBMEs can be exhaustive in the definition of any given competency, the level of granularity on the

definition of milestones can be a source of frustration for teachers and learners alike, as the process of defining a developmental path could easily become a cumbersome one.

2.5. Chapter Summary

In this chapter, we reviewed concepts as well as related works we deemed key for understanding this thesis. First, we reviewed concepts related to performance management. Next, we reviewed performance management in healthcare and the main aspects to consider when implementing performance management systems in healthcare, such as interoperability, contexts of use, and types of indicators. Then, we provide an overview of different tools that can be leveraged for healthcare management – well-established or new technologies. Finally, we reviewed related works where different approaches have been proposed for managing performance in healthcare.

The review of the literature revealed five important findings:

1. Improving performance management of healthcare is a complex problem due to the intrinsic complex nature of healthcare systems.
2. Data is needed for operationalizing effective performance management, and tool support is needed to make the right data available; otherwise, it is too complex.
3. New tools could be used to address challenges related to availability and interoperability of healthcare data for performance management.
4. In many cases, an ad-hoc approach is taking to generating Excel style reports from an EHR system. However, EHR systems may not contain all the data

needed for performance management, and the literature revealed issues with EHR data for performance management.

5. There are systems and frameworks available to provide systematic support for selecting metrics for performance management in healthcare. Still, no previous work provides a framework for integrating tool support of performance management for data collection and reports into healthcare processes following a systematic approach.

Chapter 3. Research Methodology

This chapter is organized into four sections; research questions, research methodology, research design, and research data. The research questions section describes our motivation and how our previous experience combined with a literature review led to the research questions. The research philosophies section describes our approach to research, in general, and the research questions, in particular, in terms of classical research methods to understand why and how we chose to follow a design science research methodology. Next, the research design provides a detailed description of how we structured our research through four iterations of our design science research method to answer our research questions. Lastly, the research data section provides complete details of how data was collected and analyzed for each iteration of our thesis research.

3.1. Research Questions

In previous work we developed a clinical performance monitoring app called Resident Practice Profile (RPP) (Mata et al. 2015). Although the tool was well designed and met the residents' adoption and usability criteria, it was abandoned after one year. Our initial motivation for this thesis was to understand and address that failure. When we investigated, it seemed that the failure was due to poor integration of the reports generated by RPP into supervisory processes (mesa level). The application was designed to support performance management for only one context of use - residents at the micro-level. We hypothesized that the main cause of failure was that the RPP tool was designed in isolation and was not integrated within the whole context of the performance management system.

Similarly, (Mata, Kuziemsky, and Peyton 2016) identified the lack of a systems view as a limitation when we assessed the adequacy of the methodological approach in (Mata and Peyton 2015) to develop a clinical monitoring application to support stroke rehabilitation. Stroke rehabilitation involves collecting data from different care providers, consolidating data from heterogeneous systems, integrating various workflows, and monitoring each patient's individual goals and indicators. It seemed that a framework was needed that looked at tool support for performance management across an entire clinical practice, to support understanding and modeling of a clinical practice as a whole complex system of actors, processes, tasks, and data flows and that incorporates elements of measurement (goals and indicators) for different user contexts – micro, meso, and macro levels (Kuziemsky et al. 2014).

Therefore, the research questions we aimed to answer with this thesis were:

1. Performance Management of a Clinical Practice
    a. Could a systematic approach be taken to integrating tool support of performance management into healthcare processes for a clinical practice?
    b. How can a design methodology for tool support be integrated into a system wide view of performance management for healthcare for a clinical practice?
2. Design of Tool Support
    a. How can we verify the participation of all required actors in the performance management of a clinical practice?
    b. How can we ensure all actors in a clinical practice have the right tool support for performance management?

With those questions in mind, we reviewed the literature to see to what extent those questions had been addressed. In particular, we took a look at specific frameworks or approaches in the literature and did a gap analysis (4.3) with respect to our four research questions in order to understand what existed, what was missing, and what evaluation criteria were identified in the literature to be relevant. This included the approach in current healthcare performance management (see section 4.2) to use a single EHR as a source of data from which ad hoc Excel-style reports are generated. It also included the approaches taken in related works (section 2.4) based on the classic Balanced Scorecard; based on outcomes measures in Clinical Decision-Making Framework (CDMF) similar to what we saw in our work on rehabilitation; and based on competency-based frameworks like CanMEDS that focus on training of health care professionals (similar to what we were exposed to in our original work on RPP).

3.2. Research Philosophy

Our approach to research is to develop and improve information system artifacts that can be used to address identified problems in practice for healthcare informatics. Design Science Research (DSR) is the methodology that best aligns with our approach to research. It is appropriate for information systems design (Hevner 2010; Peffers et al. 2007) and follows an iterative process to create and evaluate information technology artifacts to solve identified organizational problems (Hevner 2010). Typically, a series of research activities are undertaking to design a new artifact (Gregor and Hevner 2013). And, then evaluation is done to compare the objectives of the solution with the observed results from the use of the artifact to better understand what needs to be improved in the artifact, involving iterations of build and evaluate (Hevner 2010).

In this thesis, we followed (Peffers et al. 2007) DSR process model depicted in Figure 7.

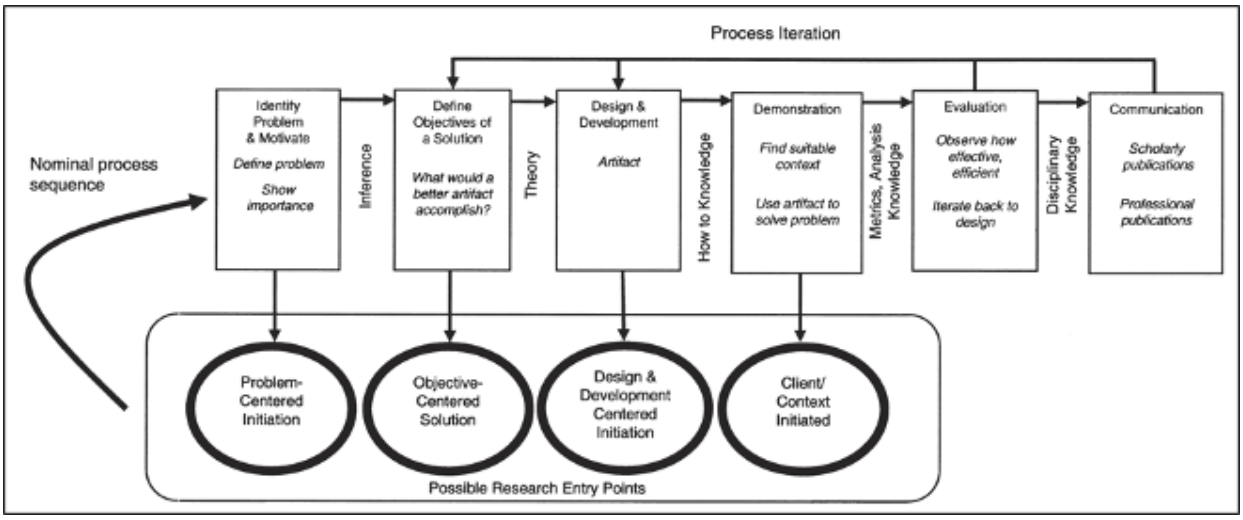


Figure 7: DSRM Process Model (Peffers et al. 2007)

Our research is typically a combination of first problem-centered and then objective-centered approaches. A problem-centered approach results from observing a problem or from suggested future work in a paper (Peffers et al. 2007). An objective-oriented solution can result from an industry need or research need (Peffers et al. 2007). In our previous work (Mata and Peyton 2015), the research started with an industry need. The Family Medicine group at The Ottawa Hospital needed to build a new tool for performance monitoring of the resident training program and we collaborated with them as part of a research team that developed the tool. In this work, the research was initiated from a problem-centered approach. We observed a problem with our previous methodology, as the tool which was initially very successful and well-received was abandoned. We wanted to understand why the methodology was not enough to guarantee adoption and understand

what type of artifacts might be relevant to addressing the problem (once the problem was well understood).

A problem-centered approach often involves inductive reasoning and creative exploration to infer or imagine what potential types of artifacts could be designed to address the problem once it is understood. Inductive reasoning entails moving from particular repeated observations to a general conclusion, while deductive reasoning moves from a general principle (or premise) to a conclusion (Walliman 2011). Once the artifact is invented to address the observed problem, subsequent DSR iterations are more objective-centered and focused on implementing and refining specific information system artifacts that are based on a general principle of conclusion. Typically, a deductive objective approach is the focus for evaluation where measurements or data are used to confirm that the artifact is functioning as design in terms of how it addresses the problem.

In this thesis, we followed an inductive reasoning process (Walliman 2011) to came to the general conclusion there was a need for a framework that looked at tool support for performance management across an entire clinical practice to support understanding and modeling of a clinical practice as a whole complex system of actors, processes, tasks, and data flows and that incorporates elements of measurement (goals and indicators) for different user contexts (Kuziemsky et al. 2014). In particular, that tool support is what bridged the gap between the data collected and reports reviewed in clinical practice by different actors as organized and mandated by the performance models (5.1). This was followed by deductive reasoning to implement and evaluate the framework. We had the

opportunity to interact with clinical practices in three different case studies to demonstrate and evaluate the framework to improve it.

The type of data used in a research can also be used to classify the research as qualitative or quantitative (Walliman 2011; Hancock and Algozzine 2017). We mainly use qualitative data. As we build artifacts to solve problems, we seek to understand, from participants in the research, how useful the artifacts are for solving their problems. We seek to gather rich information, observe how participants use the artifacts, the interactions among them, their comments, ideas shared while using the artifact to uncover new areas not previously selected for evaluation. We try to understand the problem from the participants' perspective. When appropriate, we complement data collected qualitatively with quantitative data. Quantitative data can be measured and analyzed using mathematical techniques, whereas qualitative research uses data that is expressed in words and reflects qualities, such as judgments, feelings, ideas, beliefs, etc. (Walliman 2011; Hancock and Algozzine 2017). Quantitative data is important, especially to measure how much improvement can be obtained. However, our research, especially in this thesis has typically been early research to establish the potential of different types of artifacts, and hence our research is mostly qualitative. To complete and follow through on the potential that is established for the artifacts we develop, more quantitative methods would have to be employed in future work.

For evaluation and demonstration phases, our approach is to take the artifacts to a real-world context to evaluate their usability and utility in solving the problem or need. In our previous work, we followed the action research method. Action research "involves

researchers working with practitioners to gain a shared understanding of a complex organizational problem situation, ameliorating the situation as experienced by various stakeholders in real-time" (Avison, Davison, and Malaurent 2018). Researchers collaborate with practitioners and actively participate in improving the situation (Avison, Davison, and Malaurent 2018). In our previous work, action research was the appropriate approach, as we actively engaged with the Family Medicine team at The Ottawa Hospital in the development and evaluation of a performance monitoring application, RPP (Mata et al. 2015).

In this thesis, we were not part of a team trying to solve a particular problem in practice, so action research was no longer the right guide for us. We were trying to develop a solution to a general problem. We interacted with three different clinical practices to demonstrate and evaluate our artifacts as a series of case studies. While the case study method also involves doing research in a real-world context, the researcher observes and comments on the situation but does not actively participate or give advice on how to do things or solve the problem (Avison, Davison, and Malaurent 2018). The phenomenon is "studied in its natural context, bounded by space and time" (Hancock and Algozzine 2017). In this thesis, we deemed appropriate the use of case studies for the demonstration and evaluation of the artifact, as we were not part of the team trying to build the solution nor we wanted to improved performance management of the clinical practice. Instead, we were interested in seeing how stakeholders used the framework to understand performance management of their clinical practices.

3.3. Research Design

3.3.1 Overview

This thesis's main motivation was to build an Information Systems artifact to address the problem we observed with previous work. We followed the DSR process model depicted in Figure 7 in section 3.2, and conducted a total of four iterations as shown in Figure 8. The first iteration (Iteration 0) was a literature review and reflection on previous experience that resulted in the idea of creating a Design Framework for Tool Support of Performance Management for Clinical Practice (set of information systems artifacts). The subsequent 3 iterations (Iteration 1, 2 and 3) were oriented around our interactions with three clinical practices. Each was used as a case study to demonstrate and evaluate our research artifacts.

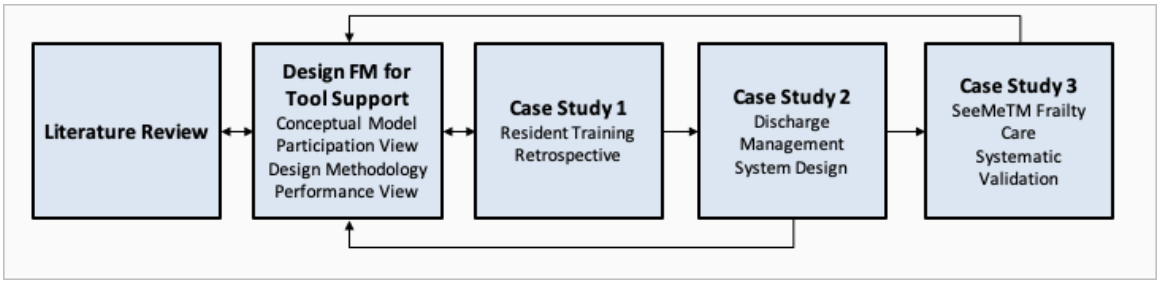


Figure 8: Research Overview

We conducted a literature review to establish the relevant background on performance management for the thesis (see section 2.1). We then searched for publications about performance management in healthcare (see section 2.2). Themes emerged related to issues with the quality of data, access of data, and exchanges of data, intra-organizational and inter-organizational. Considering the critical role of data for operationalizing performance management, we searched for tools available for data collection and data

reporting, with a focus on healthcare organizations and performance management (see section 2.3).

We also searched the literature for related works in terms of frameworks, methodologies, or systems for performance management of healthcare systems (see section 2.4). We selected three related works on the basis that the related works presented an approach for designing performance management systems applied to healthcare (sections 2.4.1, 2.4.2, and 2.4.3), and an approach for performance management that involved clinical training (2.4.3). We considered it important to include approaches of performance management to clinical training, as the problem we observed with our previous methodology (Mata and Peyton 2015) was related to clinical training. While many of the related works focused on outcome measures, training is a fundamental part of how healthcare managers can ensure care outcomes can be achieved.

We reflected on our previous work and confirmed themes that emerged from the literature review were also gaps in our previous methodology (Mata et al. 2015). The methodology presented by (Mata et al. 2015) was effective from the tool usability and adoption point of view for a specific context of use and to support only one clinical practice level. However, the methodology was not useful for integrating the tool within the whole context of performance management to support actors in supervisory and regulatory levels (see 2.2.4).

Based on the literature review findings and upon reflecting on our previous work, we induced or created the first version of the framework (the artifact). The framework was refined, demonstrated, and evaluated with three different case studies with three different

clinical practices. The case studies allowed us to take the artifact out to real-world clinical practices. One of the techniques used to select a case study is based on whether the case study is a typical representation of the variables and scenarios of what is being investigated (Gerring 2006).

Table 1 provides a complete map of the steps taken as we followed the DSR process model depicted in Figure 7. Each row of the table corresponds to one of our 4 iterations. Each column of the table corresponds to one of the steps (box) in the DSR process depicted in Figure 7. In each cell, we indicate the main result / focus / activity that took place for a particular step in the DSR process for a particular iteration. For the Problem Identification column, we list which of our four research questions was the focus. For the Defining the Objectives column, we identify our evaluation criteria (explained in detail in Section 4.4) for the iteration. For the Designing the Artifact column, we identify which artifacts or research contributions were the focus for each iteration. For Demonstrating the Artifact column, we identify the case study that was used, and in the final column for Communications we list our publications.

Problem-centered initiation as shown in Figure 7 was the initial entry point to the DRS methodology. We observed a problem with our previous methodology (Mata and Peyton 2015), and we wanted to build an artifact to solve the problem. We conducted a total of four iterations. In iteration 0 we followed an inductive approach to build the framework. In iterations 1 to 3, we experimented with the framework in three different case studies and deductively improve the framework.

Table 1: Research DRS Stages

DSR Phase	Problem Identification, Definition & Motivation	Defining the Objectives & Accomplishments of a Better Artifact	Designing and Developing the Artifact	Demonstrating the Artifact on a Case Study	Evaluating Effectiveness & Efficiency of Artifact	Communicating by Scholarly Publications
Iteration 0	Could a systematic approach be taken to integrating tool support of PM into healthcare processes for a clinical practice?	Literature review Identify gaps and issues General criteria for evaluation	Design Framework to address gaps	RPP (Master's Thesis)	Gap Analysis	9th International Joint Conference on Biomedical Engineering Systems and Technology; HEALTHINF 2016 uOttawa Engineering Poster Competition 2016 CREATE-BEST Poster Competition 2017
Iteration 1	How can a design methodology for tool support be integrated into a system wide view of performance management for healthcare for a clinical practice?	Literature Review Define PM Criteria Retrospective Analysis Tool/System design System Evaluation and validation	Participation Diagram and table Participation View	Resident Training - Retrospective	Stakeholders review compared to related works	12th International Conference on Health Informatics; HEALTHINF 2019 uOttawa Engineering Poster Competition 2018 CREATE-BEST Poster Competition 2018
Iteration 2	How can we verify the participation of all required actors in the performance management of a clinical practice?	Design Tool Support criteria	Performance View and table (measurement) Design Methodology	Discharge Management System Design	Stakeholders review compared to related works	uOttawa Engineering Poster Competition 2019
Iteration 3	How can we ensure all actors in a clinical practice have the right tool support for performance management?	Complete set of criteria	Tool Support table Framework Combined table Conceptual Model	SeeMeTM Frailty Care Systematic Validation	Stakeholders review compared to related works	PhD Thesis

3.3.2 DSR Iterations

Below for each row (iteration) shown in Table 1 we give details.

Iteration 0 – Literature Review

In this iteration, we wanted to see if a systematic approach could be taken to integrating tool support of performance management into healthcare processes for a clinical practice. The objective of iteration 0 was to complete a literature review and reflect on our previous experiences to identify gaps. We wanted to confirm that our observations about the problem with our previous methodology (Mata and Peyton 2015) matched the gaps that emerged from the literature review (4.3). Given the gaps, we wanted to select the evaluation criteria. We inductively invented the framework (5.1) to answer question 1b (3.1). We used the framework to confirm our hypothesis the main cause of failure of the RPP tool was that the tool was designed in isolation. We conducted a gap analysis for evaluation. The results of iteration 0 were communicated in HEALTHINF 2016 (Rome), uOttawa Engineering Poster Competition 2016, and CREATE-BEST Poster Competition 2017.

Iteration 1 –Retrospective

During this iteration, we wanted to see how a design methodology for tool support could be integrated into a system-wide view of performance management for healthcare for clinical practice. The objective of iteration 1 was to use our framework for a complete retrospective analysis of the RPP tool that was designed following the methodology in (Mata and Peyton 2015).The main researcher of this thesis completed the analysis. The focus was on analyzing tool and system design and complete system evaluation and validation. We also wanted to redefine the performance management evaluation criteria.

We improved the participation diagram (5.3.1) and built the participation table (5.3.2). We demonstrated the artifact in the case study Resident Training (6.1). We evaluated the artifact on a review and feedback session with stakeholders and by comparing it with related works. Results of iteration 1 were communicated at the HEALTHINF 2019 conference in Prague, the uOttawa Engineering Poster Competition 2018, and the Create-Best Poster Competition 2018, Ottawa.

Iteration 2 – System Design

During this iteration, we wanted to see how we could verify participation of all required actors in the performance management of a clinical practice. The objective was to help with the design of a new system to support management for discharge of hip fracture patients and define the evaluation criteria for design of tool support. We deductively improved the performance measurement view (5.4) and design methodology (5.5.1). We demonstrated the artifact in the case study Discharge Management (6.2). Participants of the case study used the framework (artifact) to map their performance management system to tool support. We evaluated the artifact on a review and feedback session with stakeholders (7.1.3) and by comparing it with related works. Results of iteration 2 were communicated at the uOttawa Engineering Poster Competition 2019.

Iteration 3 – Systematic Validation

During this iteration, we wanted to see how we can ensure all actors in a clinical practice have the right tool support for performance management. The objective of the iteration was to do a complete full validation of an existing performance management

systems for SeeMe™ and the focus was on analyzing relationships between individual tables and the framework combined table and the set of evaluation criteria to evaluate the artifact. We deductively improved the tool support table and framework combined table. We demonstrated the tables in the case study SeeMe™ Frailty Informed care with a systematic validation of the use of the diagram and tables. Participants of the case study used the framework (artifact) to validate their performance management system and tool support. We evaluated the artifact on a review and feedback session with stakeholders (7.1.4) and by comparing it with related works. Results of iteration 3 were communicated in this thesis.

3.4. Research Data

Data collected was mainly qualitative data. Data collection included: literature review papers and analysis, observations, notes taken during meetings, email communications, screen-share sessions, and audio recordings. There was some quantification in a 5-point Likert scale questionnaire used during the stakeholders' review sessions (chapter 7.1) for each case study.

3.4.1 **Iteration 0 – Literature Review**

Data collection included a combination of primary and secondary data. Motivated by the fact the tool we developed in our previous work (Mata and Peyton 2015) was phased-out, we gathered secondary data from articles published in journals (of management, healthcare, business intelligence, business performance, operations, hospital topics, production and economics, educational, biomedical informatics, and research and innovation), books, articles published in conference proceedings and magazines issued by

reputable institutions. We reviewed literature published in English from 1988 to 2020. We searched within the main categories of performance management, performance management frameworks and systems, performance management in healthcare, and tools and technologies for performance management. We used secondary data to define the problem in terms of the gaps we wanted to address. We selected the initial evaluation criteria from the literature review and recommendations from domain experts. We used the analysis of the secondary data and our observations of previous work to induce the first version of the framework.

3.4.2 **Iteration 1- Retrospective**

We collected primary data during one review and feedback session with stakeholders (7.1.2). We presented to stakeholder the tool's analysis in light of the framework. We observed their reactions to the framework and collected their feedback. We asked stakeholders specific questions about the framework (7.1.2) and recorded their likes and dislikes and their feelings towards using our framework. Data collected during the review and feedback session was audio recorded on the researcher's personal mobile device. The recording was stored in the researcher's personal mobile device. We complemented the audio recording with notes taken during the session by the thesis' main researcher.

For the analysis of data collected, the main researcher of this thesis carefully listened to the audio recording, took detailed notes, and looked for critical feedback/thoughts – what stakeholders thought worked, what did not. Feedback was also recorded using the five-point Likert- Scale questionnaire. We did not use a formal method

for decoding the audio recording. We summarized the results of the session in writing and sent the summary to the stakeholders. We asked them to confirm whether written summary was an accurate representation of their evaluation of the framework.

3.4.3 **Iteration 2 – System Design**

The data collection method was exclusive via primary data. We conducted a total of three video conference (screen-share) calls. We observed and analyzed how the stakeholder used our framework for their clinical practice. Our participation as observers was mainly unstructured background observation (Crabtree and Miller 1999). We did not actively engage or influence what participants should do for their clinical practice. We took notes in the background and clarified questions about the framework as facilitators. The stakeholders shared preliminary versions of the tables as they applied the framework to their clinical practice. Table versions were shared as file attachments via email. The downloaded versions of the tables were stored in the personal computer of this thesis's researcher.

We also collected primary data during the review and feedback session with stakeholders (7.1.3). During the session, we asked the stakeholder specific questions about the framework and recorded their likes and dislikes and their feelings towards using our framework. The format of the session was a screen-share call. The screen-share session was recorded and stored on the researcher’s personal computer. We also had stakeholders confirmed their views of the framework's utility using a 5-point Likert scale questionnaire.

Analysis of the data collected was done following the same steps described for data analysis of iteration 1.

3.4.4 **Iteration 3 – Systematic Validation**

The data collection method was exclusive via primary data. We conducted a total of four in-person sessions. We observed how the stakeholders applied our framework to validate their performance management system. Similar to iteration 2, our participation as observers was mainly unstructured background observation (Crabtree and Miller 1999). We took notes during the in-person sessions. Notes were stored in the thesis's main researcher notebook. Preliminary versions of the framework's diagram and tables resulting from each session with stakeholders were stored in a word document in the thesis's main researcher computer.

We also collected primary data during the review and feedback session with stakeholders (7.1.3). During the session, the stakeholders shared their feedback about the framework's utility and their experience using the framework. We gathered their feedback using notes. The stakeholder leading the research summarized their feedback in an email that was shared with us after the in-person session. Notes taken during the session were stored in the notebook of this thesis's main researcher. Email and the file shared in the email were kept in the thesis main researcher's personal computer. The 5-point Likert scale questionnaire was completed using the feedback provided by the case study lead stakeholder.

For the analysis of data collected, the main researcher carefully reviewed the notes of the review and feedback session and analyzed the email with feedback from stakeholders. Feedback was translated to the 5-point Likert- Scale questionnaire. We summarized the results of the review and feedback session in writing and sent the summary

and the questionnaire answers to the lead stakeholder. We asked him to confirm whether our written summary was an accurate representation of their feedback and evaluation of the framework.

3.5. Chapter Summary

We started this chapter by reviewing the research questions and research methods we selected for this thesis - Design Science research and case studies for evaluating the artifacts. We described how the research started with a problem centred/inductive approach t create the framework to then move to an objective centred/deductive approach that we followed to iteratively refine, demonstrate and evaluate the framework. We reviewed the type of data used during each iteration of the research. Next, we provided details on the research design - the complete map of the steps taken during each iteration of the research as we followed the DSR process model. We end the chapter by providing a review of the data collected during each iteration of the research and how it was analyzed.

Chapter 4. Problem Definition

In this chapter, we provide definitions of terms we use throughout the rest of the thesis. We present a gap analysis and identify main areas where related works fail short in terms of design for tool support of performance management for clinical practice. Finally, we define the evaluation criteria we use to evaluate our work against related works and evaluate the effectiveness of using our framework in the three case studies (described in detail in Section 6).

4.1. Definitions of Terms

Clinical Practice: A clinical practice is a set of actors that participate in processes and perform tasks to deliver healthcare services that are required to meet quality of care goals.

Tools: In this thesis, in the context of performance management, tools are any applications used to support data collection tasks and/or review report tasks for performance management of clinical practice.

Actor: An Actor is a role played by individuals participating in a Process at a Clinical Practice and that have specific tasks they are responsible for. An Actor is not exclusively attached to a single individual, as one individual can be assigned to different roles and one role can be assigned to different individuals.

Some common Actors mentioned in this thesis include; patients, care providers (e.g. physicians, nurses, geriatric team, etc.), managers, researchers, supervisors, program

coordinators, steering committees, and regulatory agencies. This is not an exhaustive list of Actors, but rather an example of common roles. Depending on the clinical practice, there could many other roles.

Goal: A Goal refers to the high level objectives for a Clinical Practice that are usually related to quality of care or the ability of the Clinical Practice to deliver quality of care. Goals are usually expressed as a significant, concrete, action-oriented, and (ideally) inspirational statement (Doerr 2018).

Indicator: An Indicator measures some aspect of a Goal for a particular Clinical Practice that can be communicated in a report.

Process: A Process is a collection of Tasks performed by a group of Actors to deliver or manage care in a Clinical Practice.

Tasks: A task is any activity in a Process that is performed by an Actor. In the context of this thesis we are strictly focused on tasks related to performance management of a clinical practice and do not consider tasks related to the delivery of care.

Task Type: In this thesis, task types refer to:

- Data Collection Task: A task in a process where an Actor collects data for an Indicator.
- Report Review: A task in a process where an Actor reviews an Indicator in a report.

Tool Support: Refers to the use of a tool to support Data Collection or for Report Review Tasks related to Indicators.

Performance Management System (PMS): A Performance Management System is a collection of Tools used in a Clinical Practice to support the Data Collection and Report Review tasks by Actors in order to measure Indicators.

Clinical Practice Level (CPL): A Clinical Practice Level is defined as the contextual level at which a set of Tasks are performed by Actors in a process as defined by (C. E. Kuziemsky et al. 2014). According to the authors, there are three contextual levels (micro, meso, and macro) at which tasks in a process can take place and that need to be considered for implementation of Tool Support;

Micro level: Is the level of Clinical Practice at which care is delivered. Examples of common Actors at this level include physicians, nurses, and patients and caregivers.

Meso level: Is the level of Clinical Practice at which care processes are managed. Examples of common Actors at this level include supervisors, researchers, and program directors.

Macro level: Is the level of Clinical Practice at which clinical practice is regulated and governed. Examples of common Actors at this level include steering committees, regulators, and research funders.

4.2. Current Healthcare Performance Management

The healthcare industry produces vast amounts of information every day; however, it is often difficult to obtain precise data for performance management of clinical processes. The data overload limits the capacity to manage effectively (Smith, Mossialos, and Papanicolas 2008; Voelker, Rakich, and French 2001). Administrators tend to measure what they control and what they can measure easily, instead of what matters for outcomes (Porter 2010). In many cases measurement is done for internal quality assurance (Mannion and Davies 2002), which limits the reliability of measurements for performance management.

Clinical performance measurements are in many cases limited to the use of administrative data (Esmail and Hazel 2009) or data that is readily available in IT systems (Roth et al. 2009). Many IT systems implementations (i.e. EHR) are often driven by billing requirements, which limits the type of data available for effective performance management (Roth et al. 2009; Foshay and Kuziemsky 2014).

Furthermore, data is often locked in siloes (Foshay and Kuziemsky 2014; Bhaskaran et al. 2013). Organizations using EHR systems limit access to data only to actors within their own organization, which could even mean data is only available within the business unit that owns the system. Privacy and security policies around data also limit the timely access to data. These challenges are even more prevalent in performance management implementations that involve collaborative processes across multiple organizations (Esmail and Hazel 2009).

Another challenge for implementing effective performance management systems in healthcare arises from process interoperability issues. In recent years, there has been an increased interest in using Information Technology (IT) to support performance management initiatives in healthcare, in response to requests for increased health care accountability, transparency, and better quality of care (System et al. 2005). While information technologies have an important role in facilitating performance management, ongoing interoperability issues continue to be a challenge with use of IT (Kuziemsky and Peyton 2016). The complexity of the healthcare system makes it almost impossible for a single IT vendor to have a solution that address all functionality requirements (Gaynor et al. 2014).

As a result, performance management in healthcare often involves ad-hoc data collection in the form of manual data entry using paper or electronic forms, combined with data pulled in from EHR systems. Data is then aggregated in loosely spreadsheets for reporting purposes on an 'As-needed' basis. This approach is often taken by organizations to meet the requirements of funding agencies, accreditation visits, or for research and investigation purposes. As a consequence, healthcare public reports in the United States are diverse, market-based, lack organization and structure, and vary in what they measure, how they measure performance, and for whom they measure (Marshall et al. 2003).

An additional concern is that performance management requests tends to preclude a systematic approach for evaluating performance of health care processes, which includes front-line care providers and patients (micro level), review of performance across all patients for care processes enacted by a team or various teams of providers (mesa level),

or across all instances of such care processes for an entire region or health care system (macro level).

In the context of our thesis and using the terms we defined in 4.1, we represent our view of current situation for performance management of healthcare in Figure 9.

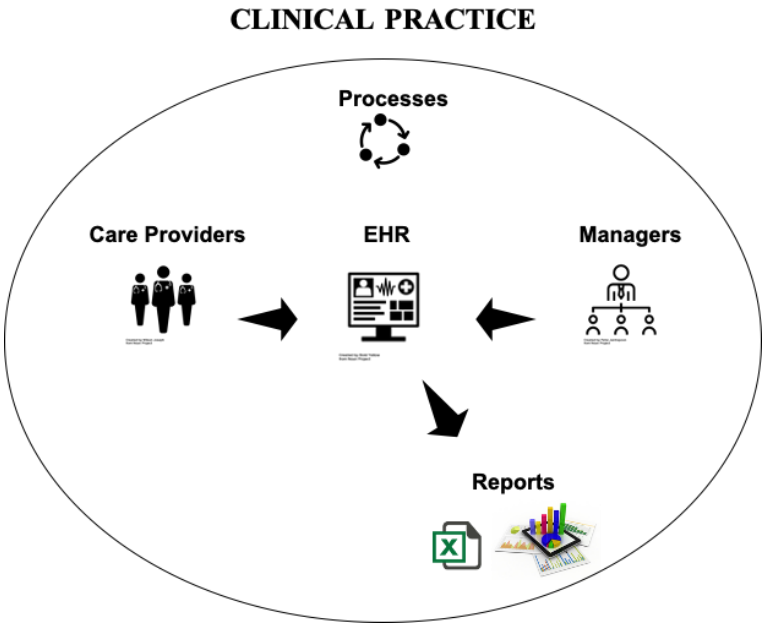


Figure 9: Ad-Hoc EHR

Clinical processes are often well-defined and outlined in the form of clinical guidelines. EHR systems are used in clinical practice, but EHR design and implementations are not focused on data collection and reports for performance management of clinical processes. Care providers interact with EHR systems to record data about patient encounters (what was done), for billing purposes or to later refer to notes about patients. Managers pull in data from EHR systems to generate reports that they compile in loose

spreadsheets for monitoring ad-hoc indicators. However, these reports are not typically designed to be systematically linked to either specific care processes or specific goals of care. As a result, there is a disconnect between what managers and care providers do, how it relates to performance management, and the design of tools to support performance management.

4.3. Gap Analysis

Based on our understanding of the current practice (section 4.2) and review of the literature, we identified gaps for tool support of performance management for clinical practice. We then review how each of the related works addresses these gaps and to what extent. Finally, we determine what gaps still remain unaddressed and these areas are the focus of our work. Below, we list the main four gaps identified in current practice.

First, there is lack of adequate tool support for performance management in current practice. There is a frequent perception that use of an "EHR fits-all" approach is the only tool support needed for performance management. However, EHR systems may not contain all the data needed for performance management (Foshay and Kuziemsky 2014), there are reported issues with EHR data reliability (Parsons et al. 2012), data quality, and lack of timely access to data for decision-making (Foshay and Kuziemsky 2014). A systematic approach needs to be taken that integrates performance management into both clinical and managerial processes with tool support to ensure the right data for performance management is collected in the right place and by the right actor and reports are provided at the right place and reviewed by the right actor.

Second, performance management systems should address issues related to data collection and sharing. A key factor for performance management is to have accurate, timely and relevant information. In complex systems, such as healthcare, this is often a challenge. Different providers and organizations collect vast amounts of data on a daily basis, using different data collection tools and methods. As a result, data comes in various formats, often incomplete, unstructured, and unstandardized (Esmail and Hazel 2009). Moreover, privacy and security restrictions on data, make it particularly difficult to use the data for performance reporting of clinical processes that involve multiple care providers.

Third, there is a lack of translation of the strategy into performance indicators, availability of benchmarks, and use of standard definitions (Kadri and Peyton 2017). (Reid et al. 2005) described the healthcare delivery system as a "cottage industry", where many of the system units (e.g. clinics, physicians, laboratories, hospital departments) operate independently – in "silos" -, focusing on their own performance. As a result, there is lack of performance standards and poor coordination between processes for performance management across different units.

Fourth, healthcare systems are complex and involve multiple interdependent and interacting parts (Kuziemsky 2016; Reid et al. 2005). It is difficult to visualize all actors and reports needed as part of a performance management system. Each actor has its own view on quality of care, how to assess performance, and who is to assess performance (Donabedian 1988; ng, G., Grossman, J. H., Compton, W. D., & Reid 2005), which makes it difficult for stakeholders to visualize and instrument a coherent strategy that includes all components needed for effective performance management. This lack of agreement often

leads to undesired, harmful behaviors, and divergent approaches such as gaming of the system, resistance to performance monitoring, and slow progress in performance improvement (Porter 2010; Lilford et al. 2004).

In Table 2, we summarize what each of the related works has done to address the gaps identified above and to what extent. We highlight in bold gaps that still need to be addressed.

Table 2: Performance Management for Clinical Practice - Gap Analysis

Identified Gaps	**BSPS**	**CDMF**	**CanMEDS**
Lack of adequate tool support for performance management in current practice at the clinical and managerial level	Only focuses on performance management at management level. Not directly connected with processes at the clinical level. **No mechanisms to integrate tool support.**	Structured and systematic approach for tool selection. **Only focuses on performance at clinical level.** **No mechanisms to integrate tool support at managerial level.**	Only focuses on tool support for trainees and supervisors at clinical level. **No mechanisms to integrate tool support at managerial level.**
Performance management systems should address issues related with data collection and sharing, relevance of data, and privacy and security issues	Focus on indicators to measure goals by balanced dimensions **No mechanisms to define data collection or data sharing - what actors collect what data and what actors need to review reports intra-organization or inter-organizational.** **No mechanisms on how to overcome data security and privacy issues.**	Leverage standardized tests for data collection and reports Intra-organizational No mechanisms to overcome data security and privacy issues **No mechanisms for reporting data across system levels.**	Standard file templates for data collection. **No mechanisms to understand what and when actors review what reports.** No mechanisms to overcome data security and privacy issues.
Lack of translation of the strategy into performance indicators, use of benchmarks, and standard definitions to overcome "silos" in healthcare	Focus on how to translate strategy into performance indicators. Intra-organizational. **No mechanisms to support data standardization inter-organizational** (Gurd and Gao 2008).	Standardized tests with scores, benchmarks and standard definitions.	Standardized indicators to measure goals for clinical training. Standard definitions for indicators. Only focuses on training.
Difficult to visualize and instrument a coherent strategy with all components for effective performance management	Provides a compact and coherent way to visualize dimensions of performance. Provides clear relationships between dimensions, goals, and indicators. Only focuses on intra-organizational performance (Esmail and Hazel 2009). Only focuses at strategic (macro) level (Gurd and Gao 2008).	**Only focused on patient (micro) level.** Exclusive focus on outcome measures	Focused on Training. Main focus on trainees (micro) and supervisory levels. **No visual support for overview of the whole strategy**

BSPS provides a systematic approach for defining goals and indicators by dimensions for a PMS that is relevant to organizations in the public sector. It provides a compact and coherent way to visualize the strategy for one single organization and at the strategic, high level; however, the approach does not provide a systematic way to identify where in the organization data needs to be collected for an indicator, or where in the organization indicators need to be reviewed using a report. Nor does it provide a systematic way for identifying what tools can be used for data collection or what tools can be used for reviewing indicators, or what actors are responsible for these tasks and in what process. In addition, the approach does not provide guidance on the issue related to data sharing between organizations, to overcome silos that result from using unstandardized data terms, unstandardized definitions for indicators, and different views on how performance is managed.

CDMF provides a systematic and structured approach for selecting tools for data collection for indicators for PMS but only at the clinical level. The approach ensures a standard sequence of steps is used to select a tool. Each tool defines what data needs to be collected for the indicator. Using the same tool by indicator ensures the same data is used for the same indicators, as well as the same scales, and rubrics. One limitation of CDMF is that it does not provide guidance on how to integrate tools to support performance management at the managerial level. Focus is at the clinical level and there is no guidance on what data needs to be collected by what actors, where, and when in the clinical practice, or what actors need to review what indicators, where, and when in the clinical practice for managing performance of processes at the managerial level. Consequently, CDMF does

not provide a systematic approach to integrate tools for data collection tasks and report review tasks at the regulatory level.

CanMEDS provides a systematic and structured approach for selecting indicators to measure various dimensions of training by stages of learning. Also, CanMEDS provides a systematic approach for selecting tools for data collection for indicators at the clinical level. While tools are available at the clinical level for data collection, it is not clear when an actor needs to review reports. Further, it is no clear how tool support integrates into the whole system to support managerial levels. While the framework provides a comprehensive and structured view of key metrics at the clinical level, the approach does not provide a way for visualizing the whole system - all actors by task at all clinical Practice levels that need tool support for Indicators.

In summary, we can see that all related works propose a systematic approach for defining goals and indicators in a PMS for clinical practice. However, none provides a systematic approach for integrating tool support into a PMS that takes into account the data needs of Actors for all Tasks at all Clinical Practice Levels. There is no systematic approach for identifying what Actors in what Process and Task need to use what Tools for data collection for an Indicator and what Actors in what Process and Task needs to use what Tools for Report Reviews of an Indicator at the clinical, managerial, and regulatory levels. While Tool support exists to some extent in CDMF and CanMEDS, none of these works review tool support from the perspective of data needs at three Clinical Practice Levels.

4.4. Evaluation Criteria

To address the problems described in sections 4.2 and 4.3, we developed a set of evaluation criteria (checklist) to evaluate our proposed framework. The checklist can also be used to evaluate any other approach used for the design of tool support for PM of clinical practices.

The evaluation criteria described in this section were selected based on:

1. Careful analysis of the literature review. In particular, careful analysis of literature in section 2.4, related works.
2. Recommendations from domain experts in the areas of healthcare and software development that were also members of the research team.

We grouped the evaluation criteria in two categories. The first category is related to the effort required by stakeholders to design a PMS that measures performance effectively. The second category provides a checklist of must-have design elements for effective tool support in a PMS.

4.4.1 Performance Management for Clinical Practice

In this section, we define the criteria to evaluate the design of a system that measures performance effectively. These criteria will help determine whether the system results in good performance management for clinical practice.

1. **Goal Dimensions:** This criterion refers to whether there is balance between dimensions, within the healthcare system level, that indicators are measuring (e.g.

patient safety, effectiveness of care, quality of care, patient-centeredness). The relevance of this criterion is established in the literature by (Canadian Institute for Health Information 2013). The importance of this criterion lies in that one of the main weaknesses reported in the literature about performance management frameworks is the narrow and unidimensional scope of systems. For example, systems that focus exclusively on the financial perspective of performance (Robert S Kaplan and Norton 1992; Voelker, Rakich, and French 2001).

2. **Type of Indicators:** This criterion refers to the type of indicators the system measures. The relevance of this criterion is established in the literature by(Robert S Kaplan and Norton 1996). Its importance lies in that a good performance management system must incorporate outcome indicators and drivers (process) indicators to; 1) Communicate how outcomes will be achieved and provide an early indication about the success of the strategy (driver indicators), and 2) Confirm the successful implementation of the performance management strategy (outcome indicators (outcome indicators) (Robert S Kaplan and Norton 1996).
3. **Clinical Practice Levels.** This criterion refers to whether definition of indicators takes into account a broader perspective of performance system design and is not narrowed to only some of the participating units. The importance of this criterion is established in the literature by (Reid et al. 2005). The relevance of the criterion lies in that, for optimizing the performance of clinical practice as a whole, the system design must recognize the dependencies and influences of every participating unit on all other units in the clinical practice; therefore, independent

units can achieve their own performance while contributing to the performance of the clinical practice as a whole.

4. **Data Lineage.** This criterion refers as to whether there is a structured approach to capture data lineage when using a tool for an indicator - Who, what, when, where, and how the tool is used for data collection and report notifications for indicators. The importance of this criterion is established in the literature by (Sebastian-Coleman 2013), and its relevance lies in that well-documented data lineage allows tracing indicators back to its origins to understand any changes in indicators through the data lifecycle.
5. **Indicators aligned with care practice goals.** This criterion is used to evaluate whether selection of indicators is aligned with care practice goals (why is the data collected for the indicator?). This criterion was validated by health experts in my research team and domain experts in the case studies. All emphasized the importance of having indicators aligned with care practice goals as a key aspect for effective performance management of clinical practice.
6. **Care Process Interoperability:** Refers to the structured approach for defining indicators that support interoperability of care processes. Where, who, and when for data collection for an indicator across different processes, and where, who, and when for review reports of the indicator across different processes. The importance of this criterion is established in the literature by (Smith, Mossialos, and Papanicolas 2008), and lies in that the design of performance measurement systems must recognize the various information needs of diverse groups of users the system is designed for.

4.4.2 Design of Tool Support

In this section, we define the criteria to evaluate whether an approach is good guidance on how to operationalize the performance management strategy – how well is the design of tool support for performance management supported? The criteria include graphical elements, participatory design elements, support for measuring and monitoring, and how goals are mapped into indicators and indicators mapped into tool support (data collection and reports).

1. **Participation of actors:** This criterion is defined as the level of involvement of actors and stakeholders in the design of tool support. The relevance of this criterion is established in the literature by (Geert Bouckaert 2007). The importance of this criterion lies in that the involvement of the concerned actors in the design of tool support will increase acceptance of the system (legitimation the system). A system needs to be legitimate to be effective. "The more the bottom and middle management is involved in the creation of the measures and the measurement system, the more they will be committed to it" (Geert Bouckaert 2007). Therefore, this criterion has a twofold purpose; 1) increase the buy-in and motivation of clinicians and stakeholders to use any tool to support performance management, and 2) increase the attention stakeholders pay to measurement.
2. **Compact view of relevant processes and actors.** This criterion refers to the compact graphical representation of all of the key processes and actors and relationships between them relevant to the design of tool support for performance management. The importance of this criterion was raised and confirmed by the experts, Dr. Gary Viner and Dr. Eric Wooltorton in our first case study on resident

training (section 6.1). During our interaction with them, they indicated that it is essential to have a clear high-level view of who (what actors) will be using any tool in the context of what process across different system levels of healthcare. The importance of thinking about tool support linked to processes of clinical practice is key to successfully implement a performance management system.

3. **Operationalization of the Performance Management Strategy:** This criterion is defined as the structured process of decomposing the high-level performance management strategy into indicators that operationalize it. The relevance of this criterion is established in the literature by (Neely et al. 2000; Smith, Mossialos, and Papanicolas 2008). The importance of this criterion lies in that, a well-structured high-level view of the performance management strategy without a clear structure on how to select indicators to operationalize it may result in redundant, ambiguous, or vague indicators. Terms included in the high-level view of performance management frameworks (e.g. quality, flexibility, resource utilization, customer satisfaction, customer results, etc.) are too open and can lead to a myriad of indicators, making it harder to prioritize performance areas to focus on (Neely et al. 2000).
4. **Incorporation of Indicators**: This criterion refers to the mechanisms for ensuring there is complete tool support for both data collection for indicators and for reviewing reports of indicators, at all the correct places, and for all relevant processes of clinical practice - a match between demand of indicators and supply of indicators. The importance of this criterion is established in the literature by (Geert Bouckaert 2007) and its relevance lies in that the incorporation of indicators

helps reduce asymmetries of information that cause ambiguity and uncertainty, as well as the frustration of actors over the mismatch between the demand and supply of indicators.

5. **Tool support.** This criterion refers to the well-defined, structured approach for identifying and understanding where, in the care process, there is a need for tool support and what tool support is needed for either data collection or report notifications so that low-level process interoperability is ensured. The importance of this criterion is established in the literature by (Kuziemsky and Peyton 2016). The importance of this criterion lies in that early identification, during the design process, of tools needed to support performance monitoring requirements will prevent 1) implementation of tool support that is not needed, 2) redesign of existing tools. Finally, it will help uncover whether there is a need to create new tools.

Chapter 5. Design Framework for Tool Support of Performance Management for Clinical Practice

5.1. Overview of Framework

In this chapter, we describe our design framework for tool support of performance management for clinical practice. The framework provides a systematic and structured approach, guided by a set of tables and diagrams, to reduce the complexity of clinical practice into a sequence of steps for defining and validating how performance management of a clinical practice is operationalized with tool support. The framework consists of:

- A Conceptual Model of the relevant entities and actors for performance management of clinical practice.
- A Performance Management Participation View of what tool-supported tasks performed by what actors in what processes are needed to enact performance management for the clinical practice.
- A Performance Measurement View of what clinical practice goals are measured by what indicators in which tool-supported tasks for the clinical practice.
- A Tool Support Design Methodology for the design, implementation and validation of tools for performance management of the clinical practice.

Figure 10 depicts the key relationships between the two views and the methodology. The link between the **Performance Management Participation View** and the **Performance Measurement View** captures that all **Processes** in the clinical practice

must have clear and measurable **Goals** associated with them. The relationship between the **Performance Management Participation View** and **Tool Support Methodology** captures that there needs to be tool support for **Data Collection** tasks performed by **Actors** in different **Processes** of clinical practice and tool support for **Report Review** tasks performed by **Actors** in different **Processes** of clinical practice**.** Finally, a third relationship between the **Tool Support Methodology** and **Performance Measurement View** captures that all **Data Collection** tasks for **Indicators** must be supported by clearly identified tools, and all **Report Review** tasks for **Indicators** must be supported by clearly identified tools. These three relationships ensure a clear map of which **Actors** in what **Processes** are doing what **Tasks** (**Data Collection** or **Report Review**) with what tool-support for operationalization and monitoring of what **Indicators** for measuring what **Goals** that managing performance at different levels of clinical practice.

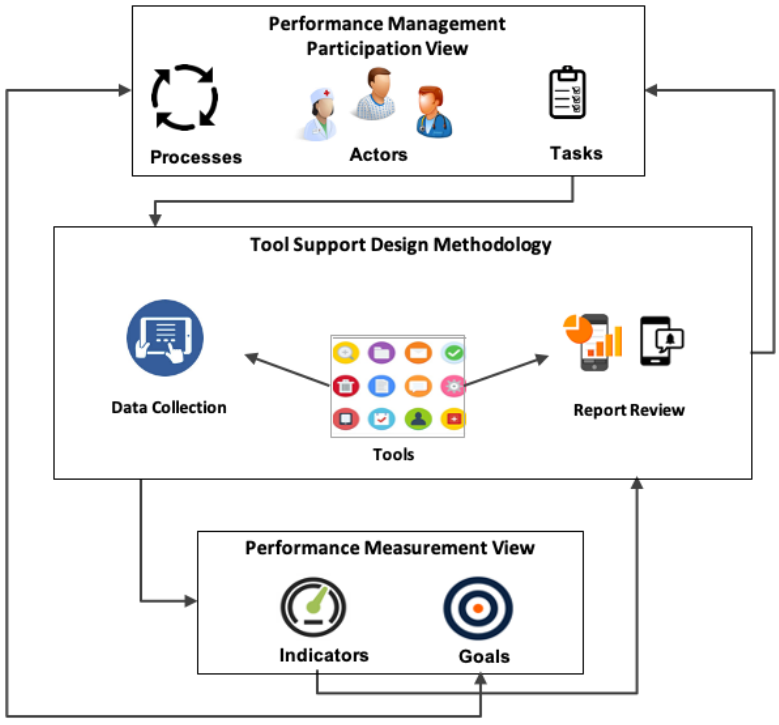


Figure 10: Design Framework for Tool Support of Performance Management for Clinical Practice

The Tools "box" in the middle of Figure 10, is a collection of all the Tools used in a Clinical Practice to support the Data Collection and Report Review Tasks by Actors in order to measure Indicators. In the rest of this thesis, we will refer to this collection of Tools as the Performance Management System (PMS) for the Clinical Practice. In the next sections, we describe the different aspects of the framework with a focus on the sequence of diagram and tables used to systematically guide and structure the design and validation of a PMS for a particular Clinical Practice.

5.2. Conceptual Model

The Conceptual Model is used to represent relevant entities, attributes, and relationships between entities of clinical practice. The Conceptual Model as shown in Figure 11, defines key relationships between entities in the Performance Management Participation View, key relationships between entities in the Performance Measurement View, and mapping of Tool to Task and Task Type in the Tool Support Design Methodology. These relationships are key to develop a performance management system (PMS) that supports the information needs of Actors in all Clinical Practice Levels. The objective is to identify what Actors perform Data Collection Tasks using what Tool and in what Task and Process to calculate what Indicator that measures what Goal of Clinical Practice, and what Actors perform Report Review Tasks using what Tool and in what Task Process to monitor what Indicator that measures what Goal of Clinical Practice.

Relationships between Entities in the Framework Conceptual Model are as follow;

- A Clinical Practice has one to many Clinical Practice Levels. Micro, Meso, and Macro are Types of Clinical Practice Levels.
- One Clinical Practice Level has one to many Actors.
- One Clinical Practice has one to many Goals.
- One Clinical Practice is comprised of one to many Processes.
- One to many Actors are part of one Clinical Practice.
- One Actor performs one to many Tasks. One to many Tasks are part of one Process.
- One Indicator is associated to one to many Tasks.
- One Goal is measured by one to many Indicators.
- One Task is associated to one Task Type. Data Collection is a Task Type. Report Review is a Task Type.
- One to many Task Type are associated to one Tool. One Tool is associated to one to many Task Types.

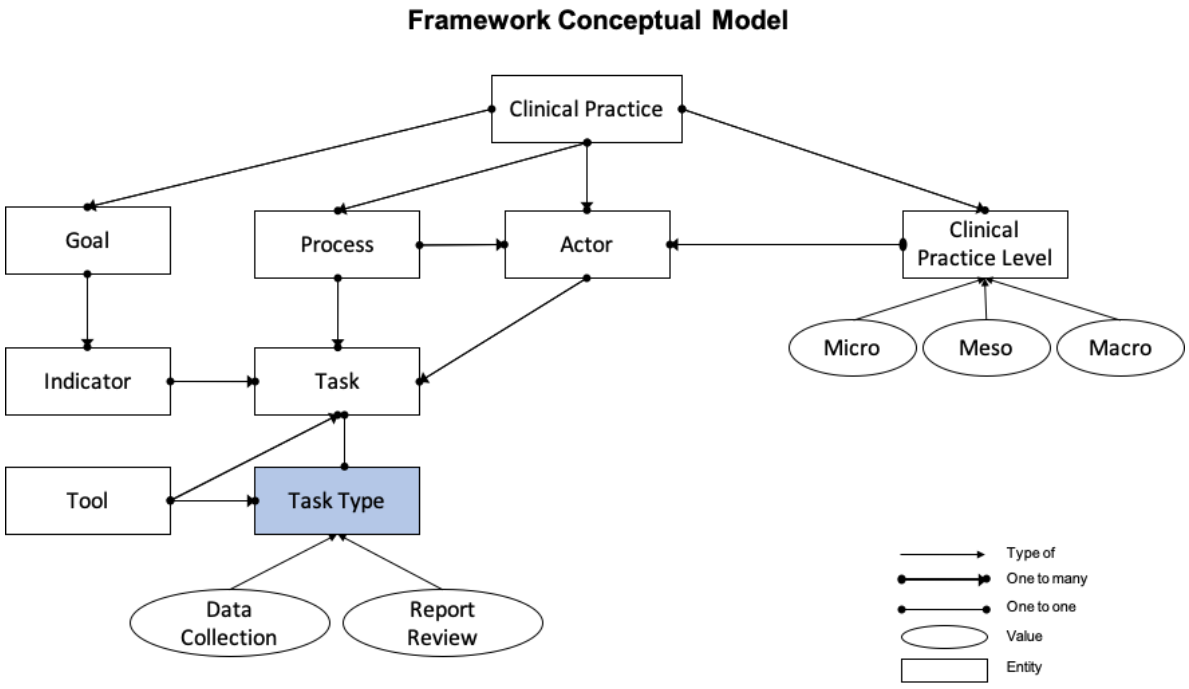


Figure 11: Framework Conceptual Model

Task Type is highlighted in blue, as this entity is at the intersection of the Performance Management Participation View, Performance Measurement View, and Tool Support Design Methodology.

5.3. Performance Management Participation View

The 'Performance Management Participation View' is used to identify Processes, Actors, Tasks and Task Types relevant to the design of the PMS for a Clinical Practice, across all three Clinical Practice levels. The objective is to identify what Actors perform Data Collection Tasks and in what Process and Task, and what Actors Review Reports for monitoring what Process of the Clinical Practice.

To facilitate the development of the 'Performance Management Participation View', there is one diagram and one table, which are described in detail below.

5.3.1 **Performance Management Participation Diagram**

The Performance Management Participation diagram (Figure 12) provides a template that can be instantiated to show a compact high-level view of the PMS in terms of the Actors, Processes and Clinical Practice Levels. There are three Clinical Practice Levels: Micro, Meso, and Macro (as described in section 4.1) which correspond to Actors who deliver care, Actors who manage care processes, and Actors that are responsible for regulating and governing the clinical practice. Actors at the Macro level typically own or coordinate Regulatory Processes. Actors at the Meso level participate in Regulatory Processes but typically own or coordinate Supervisory Processes while actors at the Micro level participate in Supervisory Processes but typically own, coordinate or participate in Clinical Processes. For performance management of a particular Clinical Practice, it is important to identify which Actors and which Processes at all three Clinical Practice Levels will be participating in the collection of data and reviewing of reports.

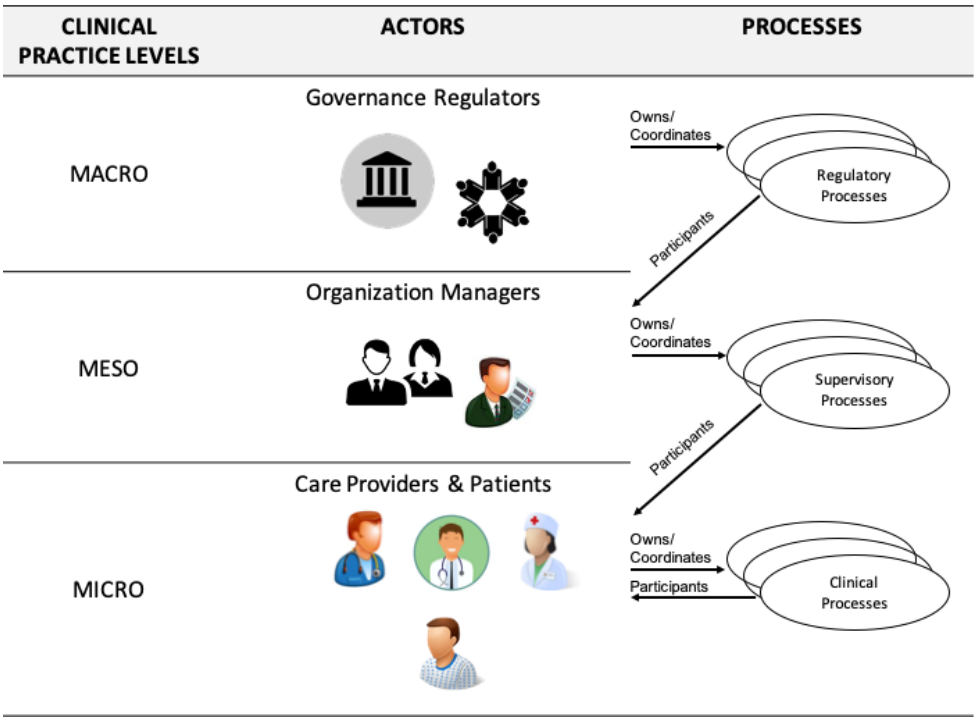


Figure 12: Performance Management Participation Diagram - Template

The sequence of steps followed to populate the diagram is to start by identifying what Processes across all three Clinical Practice Levels need to be monitored by the PMS. Then for each process, identify what Actors in those processes will be involved (directly or indirectly) in collecting data for the PMS and reviewing reports provided by the PMS. The approach of using a diagram to capture what is needed for a PMS ensures there is alignment among stakeholders on what Processes are relevant for performance management, what Actors must be supported by the PMS, and that there is coordination of processes at all three Clinical Practice Levels to support performance management.

5.3.2 **Performance Management Participation Table**

Once the Processes and Actors that need to be supported by the PMS are clearly identified, Data Collection and Report Review tasks are defined for each Process. For this, we provide a Performance Management Participation Table template. The table template includes all elements of the Performance Management Participation Diagram and is expanded to include Tasks and Tasks Types. In Table 3, we provide an example to illustrate how the template is used.

Table 3: Performance Participation Table Example

Clinical Practice Levels	Actor	Process	Tasks	Task Type
Micro	Nurse	Manage Bed Utilization	Log Bed Usage Form	Data Collection
Meso	Manager	Manage Bed Utilization	Monitor Bed Utilization	Review report
		Oversee Hospital Capacity	Report Bed Utilization	Data Collection
Macro	Hospital COO	Oversee Hospital Capacity	Monitor Hospital Capacity	Review Report

The table columns for Clinical Practice Levels, Actors, and Processes are populated from the Performance Participation Diagram. Tasks are identified and mapped to each Process. Tasks, where data is collected for performance measurement, are marked as data collection tasks. These are usually associated with Actors identified as participants of a process in the diagram, but not always. Tasks, where reports are reviewed to monitor performance, are marked as review report tasks. These are usually assigned to actors identified as owners/coordinators of the process in the diagram, but not always. The first iteration of populating this table captures the 'As-Is' situation of clinical practice.

In the example above, consider the processes for managing hospital bed capacity utilization and overseeing hospital capacity. At the micro level, a Nurse collects data for the process Manage Bed Utilization. Data is collected while performing the task Log Bed Usage Form. For the same process, the Manager, who owns/coordinate the process, reviews a report with data collected by the Nurse. At the meso level, the Manager participates in the process Oversee Hospital Capacity and collects data for the process while performing the task Report Bed Utilization. The Hospital COO, who owns/coordinates the process Oversee Hospital Capacity at the macro level, reviews a report for monitoring the process with data collected by the Manager. The table provides a clear map of who in the clinical practice collects data to support performance management, and who, in the clinical practice, reviews a report for monitoring performance.

5.4. Performance Measurement View

The Performance Measurement View complements the Performance Management Participation View. The two views are connected via the Data Collection and Report Review tasks identified in the Performance Management Participation View. In the Performance Measurement View, these tasks are linked to the goals for performance management of the Clinical Practice in terms of the indicators used to measure the goals (based on the data collected and the reports reviewed).

5.4.1 **Performance Measurement Table**

After identifying the Actors and Tasks involved in the Performance Management Participation View, the Tasks need to be mapped to the goals of the Clinical Practice via indicators that are used to measure performance in terms of the goals. This is done using

the Performance Measurement' Table template shown in Table 3. The values in the table columns for clinical practice levels, actor, process, task and task type come from the Performance Management Participation table. Each indicator is mapped to the goal it measures, and each indicator is mapped to at least one data collection task and to at least one review report task. Tasks associated to the same indicator are not necessarily performed by actors at the same Clinical Practice Level. For example, one actor at the micro level can collect data for an indicator that is reviewed by an actor at the meso level.

Tasks, where data is collected for an indicator, are marked as data collection tasks and often assigned to actors that have been identified as participants in a process in the Performance Participation diagram (Figure 12), but not always. Tasks, where reports are reviewed to monitor a process, are marked as Review Report tasks and are often assigned to actors identified as owners/coordinators of a process in the Performance Participation diagram (Figure 12), but not always. The first iteration of this process captures the 'As-Is' situation of clinical practice for actors, processes, goals and indicators across all clinical practice levels. In Table 4, we provide an example to illustrate how the template is used.

Table 4: Performance Measurement Table Example

Performance Measurement Model						
Clinical Practice Levels	**Actor**	**Process**	**Goal**	**Indicator**	**Tasks**	**Task Type**
Micro	Nurse	Manage Bed Utilization	Ensure Efficient Capacity Utilization	# Patients	Log Bed Usage Form	Data Collection
Meso	Manager	Manage Bed Utilization	Ensure Efficient Capacity Utilization	# Patients	Monitor Bed Utilization	Review report
		Oversee Hospital Capacity		Bed Utilization Rate (#Patients/#Beds)	Report Bed Utilization	Data Collection
Macro	Hospital COO	Oversee Hospital Capacity	Ensure Efficient Capacity Utilization	Bed Utilization Rate (#Patients/#Beds)	Monitor Hospital Capacity	Review Report

In this example, the clinical practice has a goal to Ensure Efficient Capacity Utilization. Data for indicators flows from one clinical practice level to another. At the micro level, a nurse logs bed usage form (data collection task) that support indicator #Patients. The Manager, at the meso level, reviews the report #Patients and collects data for indicator #Beds. At the macro level, the hospital COO reviews Bed Utilization Rate (#Patients/#Beds) to ensure efficient capacity utilization.

Completing this table builds consensus among stakeholders in terms of the terminology used (names of indicators, goals, performance management tasks), the actors and processes involved at different clinical practice levels for performance management, and the validation of who collects data for what indicators where. The “As Is” situation that is captured through this initial pass, can be improved upon by iterating through the tables looking for areas of improvement. The key to tool support of effective performance management is to trace data flows for indicators (data collection and review report tasks)

across all clinical practice levels to create a compact visualization of what actors and tasks are relevant to the performance management of the goals for a clinical practice.

5.4.2 Tool Support Table

Once the Performance Measurement table is completed, the next step is to identify what tools are used to support what tasks. We use Table 5 to analyze tool support for data collection and report review tasks for the clinical practice. In the table, each Tool is mapped to the Tasks it supports across Clinical Practice Level. The goal of completing the tool support table is to identify tasks where tool support is missing, tasks where tools are redundant or tasks where tools can be replaced by other tools that integrate better with processes at different clinical levels. In this example, an EHR is used for data collection tasks at the micro and meso levels. Review Reports tasks are supported by the EHR and a dashboard. The column Comments allow participants to add notes about existing tools, e.g. specifications of use, or a list of potential new tools.

Table 5: Performance Measurement Tool Support Table Example

Tool	Clinical Practice Levels	Indicator	Tasks	Task Type	Comments
EHR	Micro	# Patients	Log Bed Usage	Data Collection	
EHR	Meso	# Patients	Monitor Bed Utilization	Review report	
EHR	Meso	Bed Utilization Rate (#Patients/#Beds)	Report Bed Utilization	Data Collection	
Dashboard	Macro	Bed Utilization Rate	Monitor Hospital Capacity	Review Report	

5.5. Tool Support Design Methodology

In our previous research work (Master's Thesis), we developed a methodology for the design of a Care Process Monitoring application (Mata et al. 2015). The methodology focused on the design of a single standalone tool without taking into account the full context of performance management across an entire clinical practice at different clinical practice levels. While an effective methodology for designing a single Care Process Monitoring Application to meet requirements, it did not take into account the complexity of healthcare and the need for a systems view (see section 6.1 for a full analysis of the relevant case study).

The framework we are presenting in this thesis, now provides a context that can be used to ensure that any tools developed fit completely into the performance management strategy of an organization. In this section, we introduced the Framework Combined Table along with updates to our previous methodology in order to provide a Tool Support Design Methodology that is integrated with a system view of performance management for clinical practice.

5.5.1 **Framework Combined Table**

We defined a Framework Combined Table to set the context for tools that are being designed or evaluated to support performance management of a clinical practice. The Framework Combined Table merges the Performance Management Participation View and the Performance Measurement View into a single summary table. The table rows are sorted and grouped by tool so that one can easily see all the tasks that a particular tool is supporting.

Table 6: Framework Combined Table Example

Framework Combined Table								
Tool	**Clinical Practice Levels**	**Actor**	**Process**	**Goal**	**Indicator**	**Tasks**	**Task Type**	**Comments**
EHR	Micro	Nurse	Manage Bed Utilization	Ensure Efficient Capacity Utilization	# Patients	Log Bed Usage Form	Data Collection	
EHR	Meso	Manager	Manage Bed Utilization	Ensure Efficient Capacity Utilization	# Patients	Monitor Bed Utilization	Review report	
EHR			Oversee Hospital Capacity		Bed Utilization Rate (#Patients/ #Beds)	Report Bed Utilization	Data Collection	
Dashboard	Macro	Hospital COO	Oversee Hospital Capacity	Ensure Efficient Capacity Utilization	Bed Utilization Rate (#Patients/ #Beds)	Monitor Hospital Capacity	Review Report	

Table 6 depicts an example. The table is grouped by Tool. Table rows are now sorted by Tool, then by Clinical Practice Level and finally by Actor. The focus is now in identifying what Tool is used to support what Actors at what Clinical Practice Level and for what Tasks and Task Type - Data Collection for Indicators and Review Report of Indicators.

The individual steps to build each of the other tables of the framework are useful to define the whole picture of the Performance Management System. Once this is clearly defined, we can now focus on what Tool is used to support what Actors and Tasks for what Indicator, and for what Process.

5.5.2 **Updated Methodology**

The original methodology (elements are shown in black in Figure 13) combines technical and managerial aspects of application development following a user-centered approach. It involves the engagement of stakeholders and users throughout in a three-phase iterative process of modeling, implementation, and evaluation to ensure user acceptance and adoption of applications when deployed. The focus of the original methodology was on development of a Clinical Performance Monitoring Application, where raw data about clinical problems are logged by healthcare providers and then transformed into meaningful reports that support decision-making (Mata and Peyton 2015). We developed a Resident Practice Profile (RPP) application. In section 6.1, as a case study, we review RPP in the full context of performance management for Resident Training.

In Figure 13, we highlight the updates to the original methodology. We added two new components, **Select Tool** and **Map Tasks**, and additional elements to phases **Model** and **Implement** to ensure the methodology fits within the context of the Framework Combined table (Section 5.5.1).

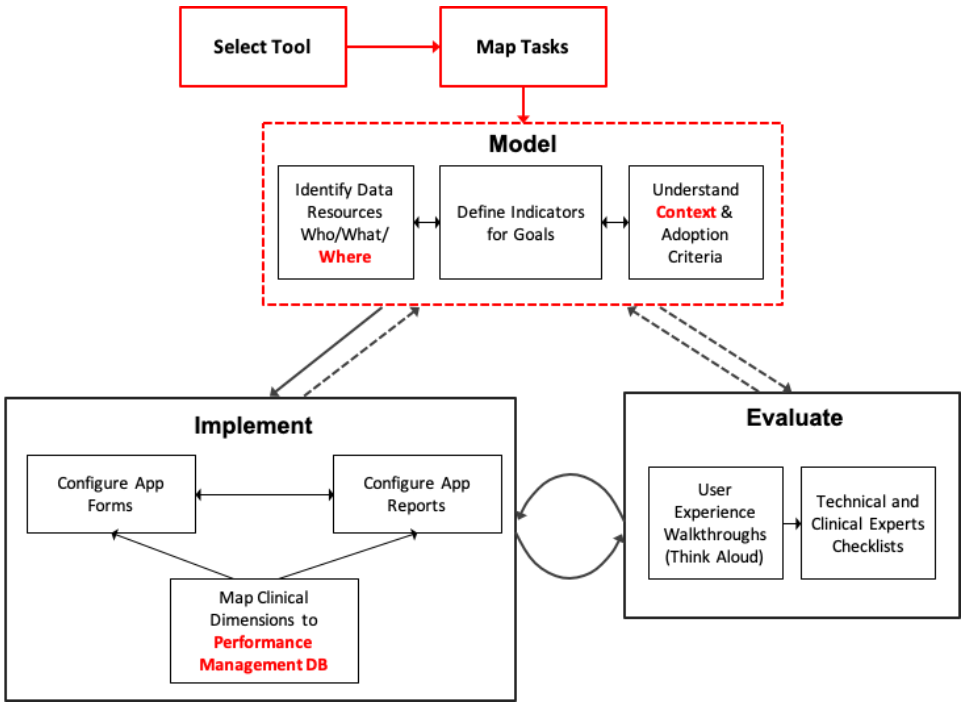


Figure 13: Updated Tool Support Design Methodology

1. **Select Tool**

The component **Select Tool** in the updated methodology guarantees a systematic approach for reviewing tools already available in the clinical practice or identifying the need to develop new tools. For each tool in the Framework Combined Table, we use the methodology to ensure the tool is optimized to support the task, or we look at candidate tools that could be a better fit to support the task or for tasks with no tools.

2. **Map Tasks**

If there are no tools mapped to a task in the Framework Combined Table, we evaluate candidate tools. Comments in the Framework Combined Table are used to identify and evaluate whether there is room for improvements for existing tools or to select candidate tools.

3. **Model**

In the first component of the Model, "Identify Data Resources Who/What/Where" in Figure 13, a new element **Where** is added to confirm where in the clinical practice (process, clinical practice) the tool will be used, in addition to who (actor) will use it and for what purpose (task, indicator). Then, in the second component of the Model "Define Indicators for Goals" we confirm the detailed definition of indicators (in terms of data that will be collected and reports that will be reviewed) for measurement of goals. The final component of the Model, "Understand Context and Adoption Criteria" takes into consideration the full system **Context** for the design of the tool as articulated in the Performance Management Participation View and Performance Measurement View and summarized in the Framework Combined Table while focusing on the adoption criteria specific to the Actors and Tasks it will be supporting.

The systematic approach for selecting one tool at a time, and mapping it to all the tasks it supports, provides a better structure for understanding where, in the clinical practice, the tool is used or needed, for what task by what actor at what clinical practice level. The context in which the tool is used is factored in to define the adoption criteria.

4. **Implement**

This component is largely unaffected except that the focus is NOT the development and implementation of stand-alone apps, but rather the implementation of tools to support tasks (Data Collection and Report Review) within the whole context of a complete performance management system for clinical practice.

5. **Evaluate**

This component is largely unaffected. The use of User Experience walkthroughs continues to be the main method for evaluating user acceptance and adoption. Insights gained from User Experience walkthroughs continue to be the main input for technical and clinical experts' checklists. Similar to the Implement phase, the scope and focus of the evaluation phase is now tool support within the whole context of a complete performance management system for clinical practice, rather than the development of stand-alone applications.

5.6. Chapter Summary

In this chapter, we presented our design framework for tool support of performance management for clinical practice. We provided an overview of the framework, detailed descriptions for each of its components, and examples on how to use each of the framework diagrams and tables to define a tool-supported performance management system for clinical practice. Finally, we explained the main updates to a previous methodology for the development of clinical performance monitoring applications. We explained how the updates are critical to ensure tool support fits within the whole context of a complete performance management system for clinical practice.

In the next section, we use our framework to design, analyze, or evaluate tool support of performance management for three different clinical practices.

Chapter 6. Case Studies

In this section, we present three case studies where we used our framework to analyze, design, or validate tool-supported performance management for three different types of Clinical Practice. In the first case study, Resident Training, we used our framework to do a retrospective analysis and validation for Family Medicine Resident Training based on our previous work developing a Care Process Monitoring Application (Mata and Peyton 2015). In the second case study, Discharge Management, we used our framework to support a clinician/researcher in the design of tool support for performance management of an online process for discharge management for hip fracture patients, Path to Home, (Backman et al. 2020) that was supported by a customizable online system, NexJ, provided by a third party software vendor. In the third case study, SeeMe^{TM} Frailty Informed Care, we provided our framework to a long term care facility who used it with minimal guidance to validate and improve their tool support of performance management for care of frail patients.

In all three case studies, the framework diagrams and tables shown have been reformatted and data cleaned from the originals, in order to show in a consistent manner how the finalized version of our design framework models and documents the three case studies.

6.1. Resident Training

In this section, we summarize a case study to analyze and validate the context for tool support of performance management for previous work that we had done in developing a tool, Resident Practice Profile (RPP), that was used to provide tool support for

performance management of resident training (Mata, Kuziemsky, and Peyton 2019). The purpose of the case study was to analyze and validate the following questions.

- Is the framework useful to communicate Where the RPP tool was used (and not used) by Who to measure and review what Indicators in order to support performance management of resident training?
- Is the framework useful to explain why the RPP tool was ultimately perceived to be not providing adequate tool support for performance management of resident training (it was abandoned two years after its introduction for lack of use) despite being enthusiastically reviewed by individual users as being easy-to-use and useful during user acceptance testing?

6.1.1 **Overview**

RPP was designed as a stand-alone tool for tracking data about patient encounters seen by medical residents in family health (Austin Chamney et al. 2014). The main goal for implementation of the tool was to ensure residents gained sufficient breadth of experience across a broad range of family health diagnoses, patient populations, and various medical procedures. To accomplish this, the tool offered reports that allow residents, supervisors, and program directors to see what types of patients, diagnoses, and procedures residents were encountering during their residency. The tool also supported self-evaluation by residents, allowing them to flag areas of practice where they felt they needed more training so that they and their supervisors could schedule appropriate patient encounters to address gaps in their resident training.

The RPP tool was successfully developed and well-received during user acceptance testing; however, two years after its introduction, residents, supervisors, and program coordinators stopped using the tool. The tool was developed using a methodology for development of clinical performance monitoring applications described in detail in (Mata et al. 2015).

In this case study, our goal was to understand the reasons why medical residents, supervisors, and coordinators of the family medicine resident training program did not continue using RPP. We used our framework to analyze and validate the full context in which RPP provided tool support for performance management of resident training. We identified and mapped actors and processes at different clinical practice levels of resident training in a Performance Management Participation View (6.1.2) and elaborated the Performance Measurement View (6.1.3). We reviewed the case study with the directors of the resident training clinical practice for family medicine at The Ottawa Hospital to validate how we conducted the case study and our conclusions concerning the applicability of our framework. We conducted one in-person review and feedback session for evaluation and validation of our framework applied to Resident Training.

6.1.2 Performance Management Participation View

In this section, we first identify the main processes and actors, grouped by clinical practice level, relevant for the effective design of tool support for performance management of family medicine residents training. We use the Performance Management Participation diagram shown in Figure 14 to visually depict clinical practice levels, actors, and processes for Resident Training.

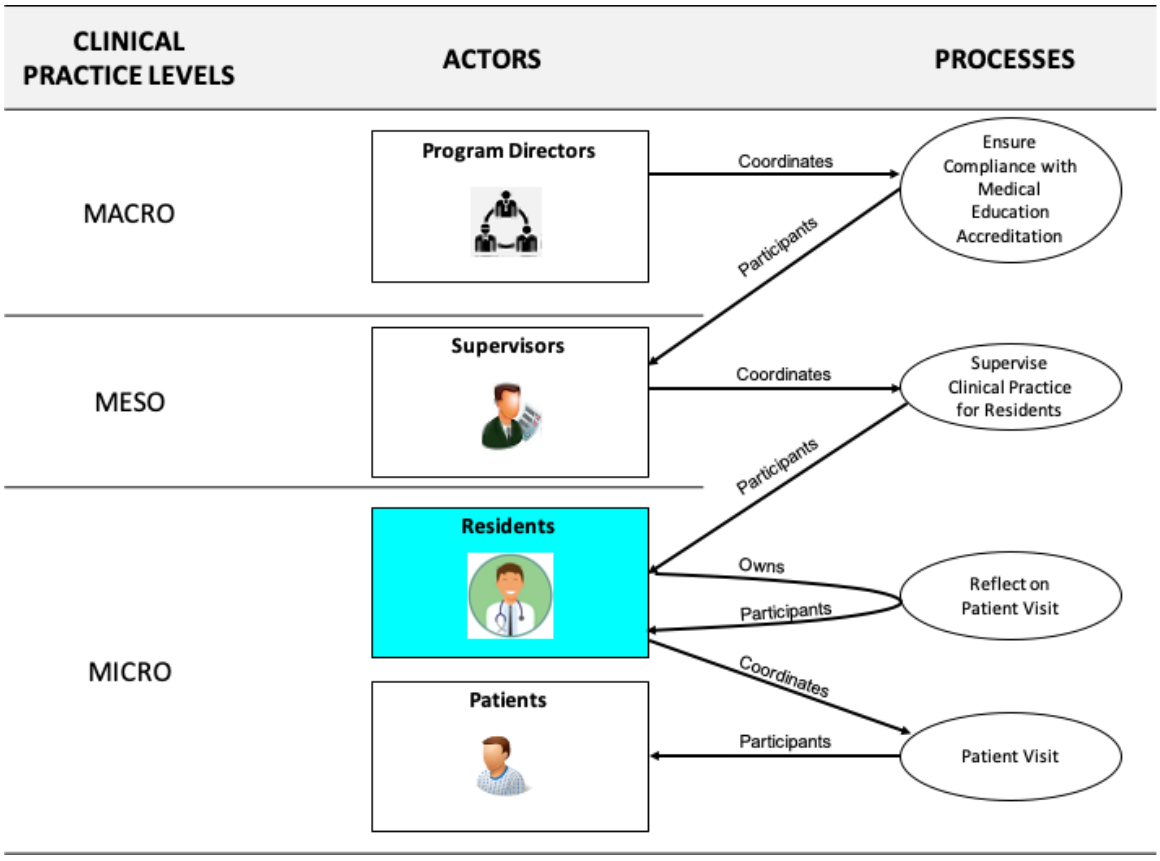


Figure 14: Resident Training Performance Management Participation Diagram

To generate the diagram, we start by mapping actors to clinical practice levels. We identify all processes relevant for performance management of the training program and list actors that are involved in each process. We use the Performance Management Participation diagram to understand relationships between actors and processes – who coordinates a process and what actors participate in the process. Once all actors and processes by clinical practice level are mapped in the diagram, the next step is to identify tasks and task types for each process and actor across the different clinical practice levels. We use the Performance Management Participation table to complete this step for RPP Table 7.

Table 7: Resident Training Performance Management Participation Table

Performance Management Participation				
Clinical Practice Levels	**Actor**	**Process**	**Task**	**Task Type**
Micro	Residents	Patient Visit	Log every patient visit in RPP	Data Collection
	Residents	Patient Visit	Submit Field Note to supervisor for selected visit	Data Collection
	Residents	Reflect on Patient Visit	Self-Reflect with RPP reports	Review Report
Meso	Supervisors	Supervise Clinical Practice for Residents	Review RPP reports and provide feedback	Review Report
	Supervisors		Assess resident breadth of experience in RPP	Data Collection
	Supervisors		Review Field Note and provide feedback	Review Report
	Supervisors		Assess resident level of competency in Field Notes	Data Collection
Macro	Program Directors	Ensure Compliance with Medical Education Accreditation	Review resident breadth of experience across training program	Review Report
	Program Directors		Review resident level of competency across training program	Review Report

With the Performance Management Participation Diagram, we get a high-level picture of who is involved in residents training. In the Performance Management Participation table, in addition to mapping actors to processes, we identify and map tasks and task types (data collection or review report tasks) to each actor and process. We can see in Table 7, data collection tasks occur at the micro and meso levels while review report tasks occur at all levels of clinical practice. At the micro level, residents collect data about patient visits and their own assessments after self-reflecting about the patient visit. This data is reviewed in reports by; residents at the micro level for self-reflection, and supervisors at the meso level to complete assessments about the breadth of experience of residents (data collection task) and provide feedback to residents (review report). Finally, program directors review reports with data collected by supervisors at the meso level, to ensure compliance with medical education accreditation.

As shown in Table 7, at the macro level, Program Directors coordinate the process to **Ensure Compliance with Medical Education Accreditation**. Directors must ensure the resident training program adheres to guidelines specified by The College of Family Physicians of Canada and The Royal College of Physicians and Surgeons, the healthcare authorities responsible for regulating training and creating standards for clinical training programs (College of Family Physicians of Canada. 2020; The Royal College of Physicians and Surgeons of Canada 2011). Supervisors, at the meso level, participate in this process by generating reports with information about breadth of experience and level of competency of residents. They collect data for these reports during the process **Supervise Clinical Practice for Residents**. They review with the resident the patient visits logs and field notes. Residents participate in the process **Supervise Clinical Practice for Residents** by completing and submitting reports to supervisors about patient visits logs and selecting field notes for review with the supervisor. This data is collected during the process **Patient Visits**, at the micro level. Finally, in the process **Reflect on Patient Visit**, residents review patient visit logs, and self-reflect on their own performance. Residents later review these reports for planning self-learning activities and closing gaps self-identified during patient visits.

6.1.3 Performance Measurement View

In this section, we first identify goals and indicators for training of family medicine residents and map these to the tasks that were identified in the Performance Management Participation View created in section 6.1.2. For each indicator, there is at least one Data Collection task and one Review Report task, as shown in Table 8. For example, data collection for indicator i1, Distribution of Visits, is done at the micro level, by the resident,

in the process, Patient Visits, and the indicator is reviewed by supervisors, at the meso level, in the process Supervise Clinical Practice for Residents, and by program directors, at the macro level, in the process Ensure Compliance with Medical Education.

Once the mapping of indicators, tasks, and task types across all clinical practice levels is complete, we identify tasks and task types for which RPP was not used but should have been used. Task and task types for which RPP was not used are shown in bold red italic. For example, at the micro level, data is collected in RPP for indicator i1, Distribution of Visits. This indicator should have been reviewed at the meso and macro levels; however, during the design of RPP, the tool was not mapped to support review reports tasks at these levels as a requirement, and therefore adoption and use of the tool for this task type were not validated during user acceptance testing of RPP.

While the RPP tool includes reports that could have been used by supervisors to assess residents' breadth of experience and provide feedback to residents, and by program directors to review residents breadth of experience across training program, given these tasks were not considered during the design and implementation of RPP, the design team did not validate whether the reports were optimized to support actors at the meso and macro levels.

The RPP development team, while aware there was another tool implemented for performance management of residents training, Field Notes (Viner, Wooltorton, and Archibald 2014), did not evaluate how to integrate the two tools into a whole performance management system. (Mata and Peyton 2015) methodology did not provide a way to

visualize how tool support could be integrated, and as a result, there was data collection redundancy.

Table 8: Resident Training Performance Measurement Table

Performance Measurement Table						
Clinical Practice Level	**Actor**	**Process**	**Goal**	**Indicator**	**Task**	**Task Type**
Micro	Residents	Patient Visit	Ensure residents are trained across clinical domains and population types	i1. Distribution of Visits i2. Distribution of Procedures i3. % Visits flagged for follow-up	Log every patient visit in RPP	Data Collection
	Residents	Patient Visit	Ensure residents are trained across clinical domains and population types	i4. % Field Notes completed	Submit Field Note to supervisor for selected visit	Data Collection
	Residents	Reflect on Patient Visit	Ensure residents are trained across clinical domains and population types	i3. % Visits flagged for follow-up	Self-Reflect with RPP reports	Review Report
Meso	**Supervisors**	**Supervise Clinical Practice for Residents**	**Ensure residents are trained across clinical domains and population types**	**i1. Distribution of Visits i2. Distribution of Procedures**	***Review RPP reports and provide feedback***	***Review Report***
	Supervisors	**Supervise Clinical Practice for Residents**	**Ensure residents are trained across clinical domains and population types**	**i1. Distribution of Visits i2. Distribution of Procedures**	***Assess resident breadth of experience in RPP***	***Data Collection***
	Supervisors	Supervise Clinical Practice for Residents	Ensure residents are trained across clinical domains and population types	i4. % Field Notes completed	Review Field Note and provide feedback	Review Report
	Supervisors	Supervise Clinical Practice for Residents	Ensure residents are trained across clinical domains and population types	i5. % Field Notes approved	Assess resident level of competency in Field Notes	Data Collection
Macro	**Program Directors**	**Ensure Compliance with Medical Education Accreditation**	**Ensure residents are trained across clinical domains and population types**	**i1. Distribution of Visits i2. Distribution of Procedures**	***Review resident breadth of experience across training program***	***Review Report***
	Program Directors	Ensure Compliance with Medical Education Accreditation	Ensure residents are trained across clinical domains and population types	i5. % Field Notes approved	Review resident level of competency across training program	Review Report

We use Table 9 to visualize indicators, tasks, and task types grouped by tool and clinical practice level. This step allows us to confirm tasks and indicators that should have been supported by RPP but the design team did not take into consideration during user acceptance testing of the tool.

Table 9: Resident Training Tool Support Table

Tool Support Table				
Tool	**Clinical Practice Level**	**Indicator**	**Task**	**Task Type**
RPP	Micro	i1. Distribution of Visits i2. Distribution of Procedures i3. % visits flagged for follow-up	Log every patient visit in RPP	Data Collection
	Micro	i3. % visits flagged for follow-up	Self-Reflect with RPP reports	Review Report
	Meso	***i1. Distribution of Visits*** ***i2. Distribution of Procedures***	***Review RPP reports and provide feedback***	***Review Report***
	Meso	***i1. Distribution of Visits*** ***i2. Distribution of Procedures***	***Assess resident breadth of experience in RPP***	***Data Collection***
	Macro	***i1. Distribution of Visits*** ***i2. Distribution of Procedures***	***Review resident breadth of experience across training program***	***Review Report***
Field Notes	Micro	i4. % Field Notes completed	Submit Field Note to supervisor for selected visit	Data Collection
	Meso	i4. % Field Notes completed	Review Field Note and provide feedback	Review Report
	Meso	i5. % Field Notes approved	Assess resident level of competency in Field Notes	Data Collection
	Macro	i5. % Field Notes approved	Review resident level of competency across training program	Review Report

In Table 9, we highlight again in red, bold, and italic task and task types for which RPP should have been used but it was not used. In black bold, we highlight indicators that while available in RPP, were not optimized to support actors at the meso and macro levels. For example, at the meso level the indicators i1 and i2 could have been used to provide feedback to residents. While these indicators were available in RPP, reports were not optimized to support supervisors in this task. As a consequence, supervisors did not use

RPP. Similarly, we can see in Table 9 that while indicators were available in RPP for reviewing the resident breadth of experience across the training program, reports were not optimized for this task, and consequently the tool was not used by program directors for this purpose.

6.1.4 **Tool Support Design Methodology**

We did not use the Tools Support Methodology in this case study. However, should we have used it, it would have resulted in a clearer Model with clearer design and development requirements for RPP. In particular, it would have been clearer where in the Clinical Practice and for what Context of use, an actor needed to review a RPP report (Indicator) to manage a Process. As it is evidenced by the analysis of Table 8, requirements to develop reports that support actors that monitor processes at the meso level and macro levels were missed. Consequently, reports were not created in the Performance Management Database. Similarly, requirements to develop data collection forms in the tool to assess the breadth of experience of residents, task done by actors at the meso level (Context), were missed.

6.1.5 **Results**

- Is the framework useful to communicate Where the RPP tool was used (and not used) by who to measure and review what Indicators in order to support performance management of resident training?

The performance management participation diagram was key to ensure that the right actors at all clinical practice levels were considered for the design of tools to support

the performance management system of a resident training program. The diagram was also useful to ensure actors' information needs at different clinical practice levels (micro, meso and macro) had the support of the right tools.

Table 8 was useful to identify actors and tasks by process and clinical practice level for which we need tool support for data collection and review report tasks for an indicator and highlight which of these tasks were not considered in the design of tool support for residents training.

The case study validated that clinical practice levels was a useful way to understand performance. It ensures and help identify processes where data collection and review reports needed to happen.

- Is the framework useful to explain why the RPP tool was ultimately perceived to be not providing adequate tool support for performance management of resident training (it was abandoned one year after its introduction for lack of use) despite being enthusiastically reviewed by individual users as being easy-to-use and useful during user acceptance testing?

Table 9 was useful to map RPP to tasks and task types for indicators by clinical practice level and confirm that while data for indicators was available in RPP to support indicators at the meso and macro levels, the tool was not optimized to support data collection or review report tasks at these levels.

Our framework was useful to communicate in a systemic way the importance of matching tool support with actors, tasks and processes at different clinical practice levels to ensure data collected at one level for one indicator, is reviewed in a task at a higher level. The relationship between data collection for an indicator at one level and review of the indicator at a higher level helps to drive adoption. In this case study, we demonstrated that the design of RPP to support tasks at the micro level was not enough to drive adoption across other levels of the clinical practice as RPP was not optimized for supporting tasks at the meso and macro levels.

While we validate with this case study our framework was useful for us to communicate issues with RPP in a systematic way, we also received feedback during our review of the case study with the directors of the clinical practice for resident training (see section 7.1.2 for complete details of this review) that the use of too much text in tables, instead of visuals made it difficult for the stakeholders to see and follow issues with ease. Also, while stakeholders found the use of the three clinical practice levels relevant to evaluate performance of residents training, they were not convinced these were only the three levels that need to be included. They suggested including a Meta level where there were processes to review the performance management system and governance for the clinical practice was also necessary to have a complete picture of performance.

6.2. Discharge Management

In this section, we summarize a case study in which we used our framework to help a clinician/researcher in the design of tool support for performance management in an online discharge management process for hip fracture patients (Backman et al. 2020) that

was supported by a customizable online system, NexJ, implemented by a third party software vendor. The focus of the case study is strictly on how useful our framework is to guide the design of tool support for performance management of discharge management.

In this case study we wanted to validate the following:

- Is the framework useful to guide a clinician in a systematic way in the design of new tool support for performance management of a clinical practice?
- Is the framework easy to use by clinician/researcher?

6.2.1 **Overview**

Discharge Management case study was conducted in collaboration with Dr. Chantal Backman, a clinician researcher. Dr. C. Backman is an Affiliate Investigator at the Bruyère Research Institute, The Ottawa Hospital Research Institute, and the Nursing Best Practice Research Centre at the University of Ottawa.

The focus of the case study was on the design of a new online process, Path to Home, to enable better communications between the members of the "Circle of Care" for a patient (including the patient) for discharge management of hip fracture patients. An important aspect of the application was tool support for data collection and report review tasks needed for performance management of both the clinical care and the research trial.

Our framework was suggested as an approach to help with the design of tool support for Path to Home, as our framework models what data is collected for an indicator in which tasks for what process as well as where reports for the indicator are reviewed (which task in what process).

Dr. Backman shared with us a high level understanding of the requirements for Path to Home including identifying the main actors and processes which we used to generate a rough first draft for the performance management participation diagram and table. The draft was not intended to be an accurate representation of discharge management but rather a starting point to show the clinician how to use the framework.

The draft Performance Management participation View (diagram and table) was reviewed in a one-hour long video conference call (with shared screen) with the clinician researcher. We reviewed the first version of the diagram and table and explained how these contained information that would be a starting point for the Performance Measurement View (performance measurement table). We adjusted names for actors and processes and confirmed actors that should participate in each process by clinical practice level during the call at the request of the clinician researcher. Once confirmed what actors and processes by clinical practice level should be supported by the tool, we cleaned up the participation table and reviewed how to use tasks and task types to represent what actor and in what process collects data or reviews a report for an indicator.

A second video conference call was also done to populate the Performance Measurement table. After the call, the clinician researcher on her own created the framework combined table and then went through two iterations of revising and improving the Framework Combined table based on interaction with the third party vendor. The second iteration of the Framework Combined table (see Appendix I) was also reviewed by Dr. Craig Kuziemsky and Dr. Liam Peyton with expertise in software development of

healthcare information systems related to specifying software requirements to third-party software vendors. The Framework Combined table is reviewed in detail in section 6.2.4.

A third and final video conference call was done to conduct the review and feedback session with the stakeholder.

It is important to note that this case study was based on an early iteration of our framework. Some aspects of both the Performance Management Participation View and Performance Measurement view were refined for the case study SeeMe^{TM} Frailty Informed Care (5.3). In this chapter, though, we use the latest version of our framework to document these views.

6.2.2 **Performance Management Participation View**

In this section, we first identify the main processes and actors, grouped by clinical practice level, relevant for the design of tool support for Path to Home. We use the Performance Management Participation diagram shown in Figure 15 to visually depict clinical practice levels, actors, and processes for Discharge Management research trial.

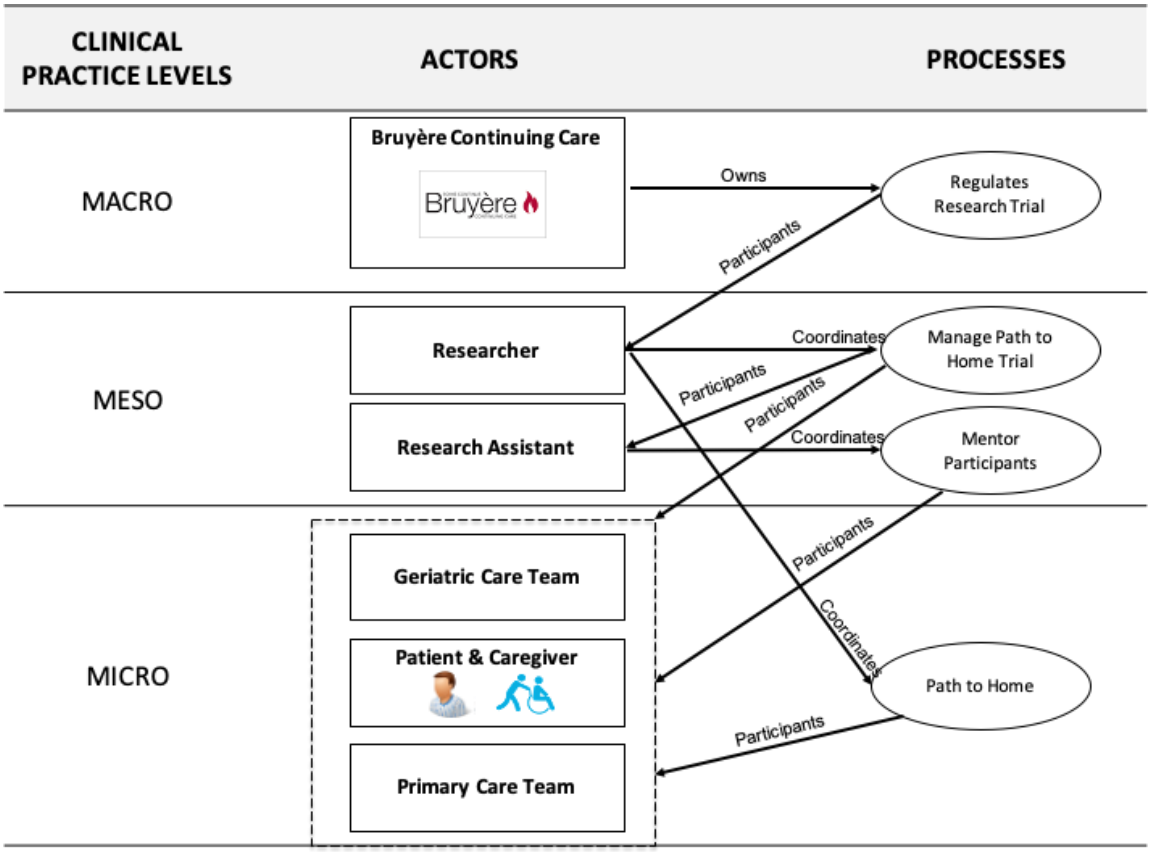


Figure 15: Discharge Management - Performance Management Participation Diagram

The mapping of actors to processes by levels of clinical practice defines what needs to be supported by the tool. At the micro level, the geriatric care team, the patient and caregivers, and the primary care team participate in the **Path to Home** process. In this process, actors collect data that is relevant to allow monitoring usage of the data exchange tool and success in the use of the tool to achieve better follow-ups of patients after they are discharged from the hospital to the community. The research assistant at the meso level assists actors at the micro level on how to use the tool and ensures proper use of the tool. This is done as part of the **Mentor Participants** process that is coordinated by the research assistant. Then, the researcher also at the meso level reviews data on tool usage and reports

results to the Bruyère Continuing Care committee. This is done in the process **Manage Path to Home Trial**. The committee at the macro level reviews this information in the regulatory **Research Trial process**.

Once there was agreement on what needs to be implemented in the tool, we identified task and tasks types for Discharge Management that needed to be supported by the tool and populated this information in the Performance Management Participation table shown in Table 10.

Table 10: Discharge Management - Performance Management Participation Table

Performance Management Participation				
Clinical Practice Levels	**Actor**	**Process**	**Task**	**Task Type**
Micro	Patient or caregiver	Path to Home	Admissions	Data Collection
	Geriatric Care Team	Path to Home	Rounds	Data Collection
	Patient or Caregiver	Path to Home	Rounds	Data Collection
	Patient or Caregiver	Path to Home	Discharge	Data Collection
	Geriatric Care Team	Path to Home	Discharge	Data Collection
	Primary Care Team	Path to Home	Follow-Up	Data Collection
	Patient or Caregiver	Path to Home	Follow-Up	Data Collection
Meso	Research Assistant	Mentor Participants	Registration	Data Collection
	Researcher	Manage Path to Home Trial	Review Usage	Review Report/Data Collection
Macro	Bruyère Continuing Care	Regulates Research Trial	Review Success of Path to Home	Review Report
	Bruyère Continuing Care	Regulates Research Trial	Review Success of Path to Home	Review Report

In Table 10, we can see most of the data collection tasks occur at the micro-level. This is because one of the main objectives for the researcher is to monitor and understand the usage of the tool to support data exchanges by patients and caregivers, the primary care team, and the geriatric care team during the admission process, clinical rounds, discharge

of the patient, and the follow-up of the patient by the primary care team when the patient is discharged home. Data collected at the micro-level is reviewed by the researcher to create reports for the Bruyère Continuing care committee that reviews the success of the Path to Home research trial.

6.2.3 Performance Measurement View

The goal of this case study was to guide the researcher with the definition of requirements for a new tool that facilitates the exchange of data related to the discharge of patients to home. The researcher wanted to monitor the usage of the tool and its impact on the discharge process.

Since there is only one tool the discharge management researcher would use, the focus was on defining what data should be collected in the tool to generate reports to monitor usage and impact on the discharge management process. Therefore, the researcher did not go through the Performance Measurement View's intermediate tables, where indicators are mapped and filtered by tools to confirm all the indicators are supported by at least one tool. The discharge management researcher instead completed the Framework Combined table directly. We review the Framework Combined table in detail in section 6.2.4.

6.2.4 Tool Support Design Methodology

The focus of this case study is to define requirements to design data collection and reports in the tool that allows the investigator to monitor and report usage and impact of Path to Home for Discharge Management. In Table 11, we can see how the only tool that

is mapped to data collection tasks to generate indicators is NexJ. NexJ is the customizable system that the third party vendor customized to provide data collection Forms and generate Reports. We will refer to the tool support for Path to Home from here on as NexJ.

Starting from actors, processes, tasks, and task types in the Performance Management Participation table, the clinical researcher (meso level) completed the information for Goal and Indicator columns in the Framework Combined table. During this process, it was confirmed why they wanted to monitor the indicators, which was summarized in two main objectives: monitor usage for data exchanges in discharge management (Monitor Path to Home usage) and monitor whether data-exchanges lead to the successful discharge of patients (Ensure successful discharge). These objectives are tied to tasks of the Path to Home process: admissions, clinical rounds, discharge of the patient, and follow-up at home. With data collected in NexJ, the tool generates reports with indicators of usage (i2) and indicators that measure the impact on discharge management (i1, i3, i4, i5). The researcher reviews the reports in NexJ, complements data from reports (not all reports in NexJ can be configured the way the investigator needs them due to limitation on the customization of the platform), and prepares reports in Excel to share with Bruyère. The table is used to confirm data is collected in NexJ for all indicators the investigator needs to review to accomplish the two goals of the research.

Table 11: Discharge Management Framework Combined Table

Framework Combined Table							
Tool	**CPL**	**Actor**	**Process**	**Goal**	**Indicator**	**Task**	**Task Type**
NexJ	Micro	Patient or caregiver	Path to Home	Monitor Path to Home usage	i1. Socio-Demographic /My-Needs Distribution i2. Path to Home Usage distribution	Admissions	Data Collection
	Micro	Geriatric Care Team	Path to Home	Ensure successful discharge	i2. Path to Home usage distribution i3. % Patients with complete Home Care Plan i4. Goals of Care Progress Distribution	Rounds	Data Collection
	Micro	Patient or Caregiver	Path to Home	Monitor Path to Home usage	i2. Path to Home Usage distribution i5. Resources Usage Distribution	Rounds	Data Collection
	Micro	Patient or Caregiver	Path to Home	Monitor Path to Home usage/Ensure successful discharge	i2. Path to Home Usage distribution i4. Goals of Care Progress Distribution i5. Resources Usage Distribution	Discharge	Data Collection
	Micro	Geriatric Care Team	Path to Home	Monitor Path to Home usage/Ensure successful discharge	i2. Path to Home usage distribution i3. % Patients with complete Home Care Plan	Discharge	Data Collection
	Micro	Primary Care Team	Path to Home	Monitor Path to Home usage	i2. Path to Home Usage distribution	Follow-Up	Data Collection
	Micro	Patient or Caregiver			i2. Path to Home Usage distribution i5. Resources Usage Distribution	Follow-Up	Data Collection
	Meso	Research Assistant	Mentor Participants	Monitor Path to Home usage	i2. Path to Home Usage distribution	Registration	Data Collection
	Meso	Researcher	Manage Path to Home Trial	Monitor Path to Home usage/Ensure successful discharge	i1. Socio-Demographic /My-Needs Distribution i2. Path to Home Usage distribution i3. % Patients with complete Home Care Plan i4. Goals of care progress Distribution i5. Resources Usage Distribution	Review Usage	Review Report/Data Collection
Excel	Meso	Researcher	Manage Path to Home Trial	Ensure successful discharge	i6. % of Readmissions	Discharge	Data Collection
	Macro	Bruyère Continuing Care	Regulates Research Trial	Ensure successful discharge	i6. % of Readmissions	Review Success of Path to Home	Review Report
	Macro	Bruyère Continuing Care	Regulates Research Trial	Monitor Path to Home usage	i1. Socio-Demographic /My-Needs Distribution i2. Path to Home Usage distribution i3. % Patients with complete Home Care Plan i4. Goals of care progress Distribution i5. Resources Usage Distribution	Review Success of Path to Home	Review Report

6.2.5 **Results**

- Is the framework useful to guide a clinician in a systematic way in the design of new tool support for performance management of a clinical practice?

The framework was useful in assisting the clinician researcher specify the requirements for tool support. The Performance Management Participation diagram (Figure 15) allowed the clinician to confirm which actors and processes needed to be supported by the tool. Levels of clinical practice were not the focus of this case study, however, the researcher confirmed the value of viewing all actors by clinical practice level to confirm not only who should be involved within the scope of the research project, but also who should be involved when the project is fully rolled-out. For example, NexJ was not implemented in the research phase for the actor at the macro level, but it is still important to consider the actor when designing the tool to anticipate any information needs and plan accordingly. The Performance Management Participation table (Table 10) was useful to determine what tasks needed to be monitored for the usage of the tool and therefore ensure data was collected for these tasks.

Finally, the researcher mentioned that the Framework Combined table (Table 11) was useful to think about the main purpose behind data collection in the tool (why/for what objectives and how to measure them) and to define the reports (indicators) that they needed. The table allowed them to articulate the 'why' (indicators) for using the tool in each process and what was relevant for measuring the goals of the research trial.

- Is the framework easy to use by clinician/researcher?

After the two initial meetings with the clinician researcher to explain how to use the framework, she was able to work on her own, complete the tables, and use the information in the tables to validate requirements for NexJ. The clinician validated the information in the Framework Combined table with Dr. C. Kuziemsky and Dr. Peyton and finalized the final version of the table. The table was useful for her to communicate the requirements to NexJ and was used as a checklist to validate all requirements had been implemented.

While the clinician could use the tables with no major interventions from us, we noted that she modified the headers of the Framework Combined table to better understand what information needed to be filled in. Also, we observed that in this particular case study, as the use of clinical practice levels was not the focus (the clinician was interested in processes at the micro-level), the clinician did not feel a need to complete this information in the tables as it was obvious to her once it was collected at the micro level what meso level and macro level reports would contain the information and who would review them. We filled in this rows, based on our observations to complete the documentation. Although clinical practice levels were not relevant for the purpose of the research trial, the clinician mentioned the importance of seeing the performance management system as a whole and in particular, she found useful visualizing actors and processes by clinical practice level in the Performance Management Participation diagram (Figure 15).

6.3. SeeMe™ Frailty Informed Care

In this case study team members of the Center of Excellence (CoE) in Frailty Informed Care at The Perley and Rideau's Veteran Center used our framework with

minimal guidance to validate and improve their tool support of performance management for care of frail patients (including training of healthcare workers) for a new program called SeeMe^{TM}. One key aspect area in the program is the use of check lists for understanding and monitoring a person's level of frailty and align care to the person's goals of care (The Perley and Rideau Veterans' Health Centre 2019b). Our hypothesis was that our framework could be useful for the team at Perley Rideau to evaluate, improve, and validate their current performance management system. In this case study, we want to validate the following:

- Is our framework useful to evaluate, redesign, and validate existing tool support for performance management of SeeMe^{TM}?
- Is our framework is easy to use by a team of clinicians and administrators?

6.3.1 **Overview**

SeeMe^{TM} is a comprehensive program developed by, and implemented at, The Perley and Rideau Veterans' Health Centre in Ottawa. The program goal is to help aging population and their families deal with frailty, finding a care approach that best works for each individual and that validates residents' individual goals, values, and preferences (The Perley and Ridein au Veterans' Health Centre, 2019).

In this case study, we presented our framework to team members of the Centre of Excellence (CoE), for evaluating, validating, and redefining the performance management system for SeeMe^{TM}. We held a total of four meetings with the team, one-hour long each. In addition to these meetings, the CoE team conducted four additional meetings (without our participation) where they iterated through versions of the Performance Management

Participation table, Performance Measurement tables, and Tool Support tables to generate a final version for the performance management system of SeeMe^{TM}.

In the case study, the CoE research coordinator, the manager of CoE and Applied Research, the manager of quality improvement, the coordinator for the CoE and interprofessional clinics and, the collaborative practice nurse were all active participants that used our framework. They were the main actors responsible for SeeMe^{TM} Frailty Informed Care at the time of the case study. The CoE research coordinator and the manager of CoE and Applied Research were part of the SeeMe^{TM} Steering Committee.

We served as facilitators during the first three meetings and showed the CoE team how to populate and navigate the framework tables. The CoE research coordinator took the role of facilitator in the following four meetings that they held without our participation.

Below, we describe the background of participants in the study and their responsibilities in the program during the case study.

- Centre of Excellence (CoE) research coordinator. Responsible for coordinating and overseeing research activities for the SeeMe^{TM} program. This actor has a social sciences background.
- Manager of the Centre of Excellence (CoE) and Applied Research. Responsible for overseeing the implementation of the SeeMe^{TM} program at the center. This actor has a background in health and physical education.

- Coordinator for the CoE and interprofessional clinics. Responsible for overseeing the use of clinical tools for monitoring performance of the SeeMe^{TM} program. This actor has a healthcare background. Her role is focused on management of the program.
  -Collaborative practice nurse. Responsible for mentoring staff members that interact with residents and families of the SeeMe^{TM} program.

During the first meeting, we presented our framework to the team. We shared preliminary results about the other two case studies (6.1 and 6.2) to illustrate the applicability of the framework to performance management initiatives in other clinical practices.

Following the first meeting, the CoE team provided us with Excel templates they had already implemented for data collection and review report tasks. We analyzed data collected in each Excel template and, with information gathered during the first meeting, we developed a first pass version of the Performance Management Participation diagram and Performance Management Participation table for SeeMe^{TM}. Both, the diagram and table reflected our initial understanding of actors, processes, and tasks at different clinical practice levels for performance management of SeeMe^{TM}.

During the second meeting, we presented our first iteration of the Performance Management Participation diagram for SeeMe^{TM}. The review encouraged a rich discussion about what processes needed to be monitored and who were the main actors that should be involved in a performance management system for SeeMe^{TM} at each clinical practice level. As facilitators, we helped guide discussions to be structured and framed around our framework with the end goal of filling in the elements of the Performance Management

Participation diagram and table. The key outcome of the meeting was a general consensus on what processes and actors were key for the performance management of SeeMe™ and the final version of the Performance Management Participation diagram. After the meeting, and with information gathered for the diagram, we started to fill in the Performance Management Participation table.

During the third meeting, we presented a preliminary Performance Management Participation table to the team, explained how we went from information in the diagram to the table, and reviewed a few rows in the Performance Management Participation table to confirm they had understood how to populate the table. The process to get to the final diagram and table is described in detail in 6.3.2. We also explained how to use the information in the Performance Management Participation table to complete the Performance Measurement view (described in detail in 6.3.3).

After the three initial meetings with the CoE team, they continued working on iterations of the Performance Management tables until they reached a final version of the Framework Combined table (explained in detail in section 6.3.4).

Our fourth and last meeting with the CoE team was to present their final version of the Framework Combined table and share their feedback with us about their experience using the framework. Details about insight gathered during this meeting are described in detail in section 7.1.4.

6.3.2 **Performance Management Participation View**

The main inputs to generate the Performance Management Participation diagram and table were PDF documents used by the CoE team to collect data about the degree of the frailty of residents, their care goals and preferences, as well as an Excel file the CoE team uses for monitoring the level of training of Perley Rideau staff in using these PDF documents.

The two PDF documents used to collect data about the goals of care and preferences of a resident are 1) Care Conference Agenda (The Perley and Rideau Veteran's Health Centre 2019) and the 2) Goal of Care & Future Health and Personal Care Preferences (The Perley and Rideau Veteran's Health Center n.d.) . For monitoring and reporting usage of the two documents, the Coordinator for the CoE and interprofessional clinics uses an audit tool implemented in Excel, where she reviews data about the proper use of the documents, training provided to staff, and level of independence of the staff in using the tools properly. She also collects additional data such as comments or a need for follow ups. The collaborative Practice Nurse trains the staff on how to use the documents properly and collects data about usage.

With data fields included in the three documents mentioned above, plus additional details about SeeMe^{TM} shared by the team during the first meeting, we developed a strawman version of the Performance Management participation diagram for SeeMe^{TM} that we presented to the CoE team during the second meeting. After a careful review of each actor and process by the clinical practice level, we came up with a final version of the diagram that is shown in Figure 16.

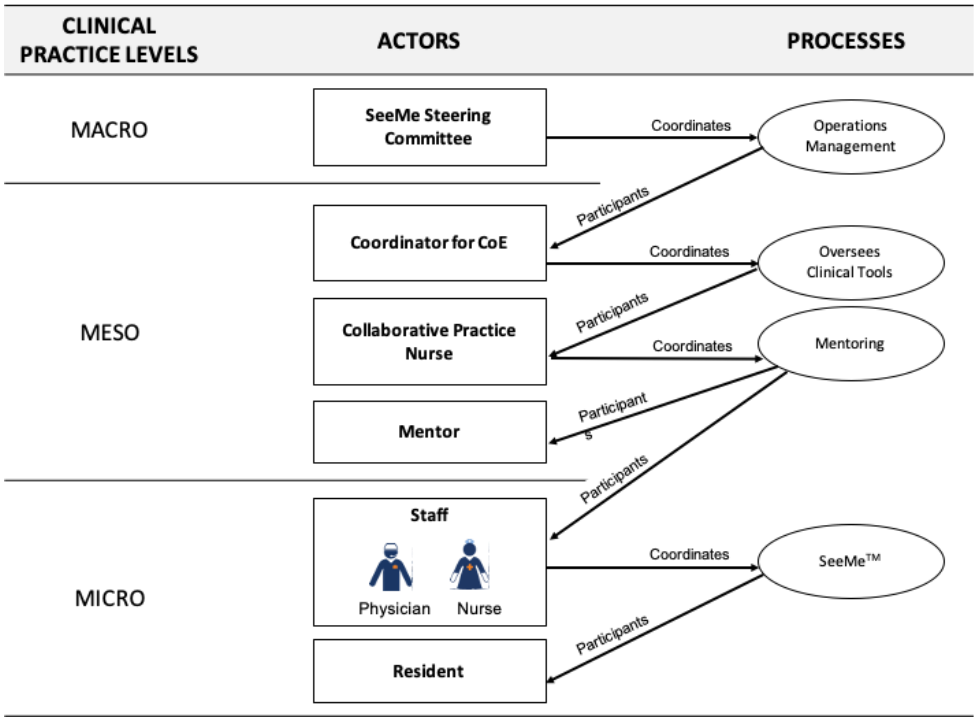


Figure 16: SeeMe™ Performance Management Participation Diagram

At the macro level, the SeeMe™ Steering Committee oversees the implementation of the documents Care Conference and Goal of Care & Future Health and Personal Care Preferences for the management of residents in the program. They monitor the correlation between training on the proper use of tools, data collected in the documents, and adherence to residents' care preferences across the program. At the meso level, the coordinator for CoE audits proper use of the documents, identifies gaps in proper use, and flags when a follow-up is needed. The coordinator informs the collaborative practice nurse is a follow-up is needed. The collaborative practice nurse is responsible for mentoring staff on how to properly use the Care Conference and Goal of Care & Future Health and Personal Care Preferences documents and works with them to close gaps reported by the coordinator for CoE. Staff at the micro-level uses the documents Care Conference and Goal of Care &

Future Health and Personal Care Preferences to collect data when a resident is admitted to the SeeMe^{TM} program and during Care Conferences.

The next step was to populate the Performance Management Participation table. Actors and processes at different Clinical Practice Levels (CPL) identified in Figure 16 are transferred to table and we add tasks and tasks types. We created the first version of the Performance Management Participation table and presented it to the CoE them during the second meeting. The final version of the table was completed by the CoE team and results are shown in Table 12.

Table 12: SeeMe^{TM} Frailty Informed Care Performance Management Participation Table

Performance Management Participation				
Clinical Practice Level	**Actor**	**Process**	**Task**	**Task Type**
Micro	Nurse	SeeMe^{TM}	Complete Goals of Care Forms	Data Collection
	Physician	SeeMe^{TM}	Complete Comprehensive Frailty Informed Assessment Form	Data Collection
	Nurse	SeeMe^{TM}	Complete Comprehensive Frailty Informed Assessment Form	Data Collection
	Resident	SeeMe^{TM}	Review Goals of Care and Frailty Informed Assessment Form	Data Collection
	Staff	Mentoring	Review the Evaluation Form for Trainees	Review Report
Meso	Mentor	Mentoring	Complete the Evaluation Form for Trainees	Data Collection
	Collaborative Practice Nurse	Mentoring	Follow up Goals of Care Audit Notes	Data Collection/ Review Report
	Collaborative Practice Nurse	Mentoring	Follow up w/Trainees needing additional training	Data Collection/ Review Report
	Coordinator for CoE	Oversees Clinical Tools	Audit Evaluation Forms	Review Report
	Coordinator for CoE	Oversees Clinical Tools	Collect data for SeeMe^{TM} Steering Committee	Data Collection
Macro	SeeMe^{TM} Steering Committee	Operations Management	Review Audit Results	Review Report
	SeeMe^{TM} Steering Committee	Operations Management	Review Training Implementation Progress	Review Report

The table shows tasks by process and actor where data is collected for managing the performance of SeeMe^{TM} processes and tasks where a report is reviewed. For example, we can see at the micro-level stakeholders collect data in the SeMee^{TM} process by completing Goals of Care forms and the Comprehensive Frailty Informed Assessment form. At the meso level, a mentor reviews these forms and completes an evaluation with information about the correct use of forms. The collaborative nurse follows up with the trainees who have been flagged in the evaluation as needing follow up on how to use forms. The coordinator for CoE reviews the evaluations and compiles results in a report for the SeeMe^{TM} Steering committee. The SeeMe^{TM} Steering committee reviews the results of audits and progress in the implementation of the training program.

6.3.3 **Performance Measurement View**

The next step for the CoE team was to complete the Performance Measurement table. The table uses all columns from the Performance Management Participation table (Table 12) and it is expanded to include Goals and Indicators for each process of SeeMe^{TM}.

We showed the CoE team how to map some actors, processes, and tasks from the Performance Management Participation table to the Performance Measurement table. We facilitated the process of completing goals and indicators for some processes and tasks to validate the CoE was using the table correctly. The goal in this step was to ensure the team had identified goals of the clinical practice, for each goal at least one indicator, and for each indicator at least one task in which data is collected for the indicator and one task in which the indicator is reviewed in a report. Table 13 shows a complete picture of the final version of the performance measurement model for SeeMe^{TM}.

In the Table 13, we can see highlighted in bold and red that for indicator i2. % CFA completed, the nurse and physician complete the Frailty Informed Assessment forms, and these forms are used to generate i2. The resident participates in this process by providing information about their condition, preferences, and goals of care. The SeeMe^{TM} Steering Committee, at the macro level, reviews the indicator in a report and monitors the impact between the adoption of the Comprehensive Frailty Informed Assessment forms and the percentage of unwanted transfers to the ER.

In another example, we see highlighted in blue and bold what actors, process and task collects data for indicator i3, and what actor, and in what process and task reviews a report with the indicator. At the meso level, we can see the Mentor collects data for the indicator i3, % Training Completed in the task Complete Evaluation Form for Trainees. The Mentor reviews Goals of Care and Comprehensive Frailty Informed Assessment forms and mark forms that have been completed (i3). The Collaborative Nurse reviews evaluations done by the mentor, flags forms for which a follow-up with staff has already been made and no other action is necessary (the nurse used forms properly), staff (nurses) that still need supervision in the use of forms and therefore require additional follow-ups, staff that require no additional follow-ups, and finally staff for which additional training is required. The breakdown of indicator i3., allows drill-down of all training dimensions (% Independent after training, % Supervision, % More training). The Coordinator for CoE also reviews the report with indicator i3., audit the training results, and collects data for the indicator i4, % Independent after Training. The indicator i3 is also reviewed in a report, at the macro-level, by the Steering Committee to monitor progress in staff training.

Table 13: SeeMe™ Performance Measurement Table

Performance Measurement Table						
Clinical Practice Level	**Actor**	**Process**	**Goal**	**Indicator**	**Task**	**Task Type**
Micro	Nurse	SeeMe™	Adoption	i1. % GoC completed	Complete Goals of Care Forms	Data Collection
	Physician	**SeeMe™**	**Adoption**	**i2. % CFA completed**	**Complete Comprehensive Frailty Informed Assessment Form**	**Data Collection**
	Nurse	**SeeMe™**	**Adoption**	**i2. % CFA completed**	**Complete Comprehensive Frailty Informed Assessment Form**	**Data Collection**
	Resident	**SeeMe™**	**Adoption**	i1. % GoC completed **i2. % CFA completed**	**Review Goals of Care and Frailty Informed Assessment Form**	**Data Collection**
	Staff	Mentoring	Adoption	i3. % training completed	Review the Evaluation Form for Trainees	Review Report
Meso	**Mentor**	**Mentoring**	**Adoption**	**i3. % training completed**	**Complete the Evaluation Form for Trainees**	**Data Collection**
	Collaborative Practice Nurse	**Mentoring**	**Staff competency**	**i3. % training completed**	**Follow up Goals of Care Audit Notes**	**Data Collection/ Review Report**
	Collaborative Practice Nurse	**Mentoring**	**Staff competency**	**i3. % training completed** i5. # of training hours	**Follow up w/Trainees needing additional training**	**Data Collection/ Review Report**
	Coordinator for CoE	**Oversees Clinical Tools**	**Staff competency**	**i3. % training completed**	**Audit Evaluation Forms**	**Review Report**
	Coordinator for CoE	Oversees Clinical Tools	Reduced unwanted ER transfers	i6. % Unwanted ER transfers i7. Frailty Assessment Distribution i8. % DNR (CPR)	Collect data for SeeMe™ Steering Committee	Data Collection
Macro	**SeeMe™ Steering Committee**	**Operations Management**	**Monitoring progress and impact of Goals: Adoption, Reduce unwanted ER transfers**	i1. % GoC completed **i2. % CFA completed** i6. % Unwanted ER transfers i7. Frailty Assessment Distribution i8. % DNR (CPR)	**Review Audit Results**	**Review Report**
	SeeMe™ Steering Committee	**Operations Management**	**Track progress of Goals: Staff Competency**	**i3. % Training completed** i4. % Independent after training i5. # of training hours	**Review Training Implementation Progress**	**Review Report**

Once the Performance Measurement table was completed, the CoE team started to complete the information for the Tool Support table, however, given the process was cumbersome and required to go back and forth between tables, they decided to fill in all the information in one combined table, the Framework Combined table that is shown in 6.3.4.

6.3.4 Tool Support Design Methodology

The final step for SeeMe^{TM}, was to complete the Framework Combined table (Table 15). The SeeMe^{TM} Steering Committee was strictly focused in collection of indicators for the two reports they review on a monthly basis – the audit results reports and the training implementation progress. During the whole process to complete the Performance Management Participation table and Performance Measurement table, the CoE team reversed engineered goals monitored by the steering committee in reports and indicators included in the reports.

With the Framework Combined table, they confirmed which tools were going to be used by what actors, process and task by clinical practice level for data collection for an indicator and for review reports of an indicator. As new indicators were added, the CoE also confirmed what tool was going to be used for new indicators.

In Table 14, we list some of the original indicators the SeeMe^{TM} Steering Committee was initially monitoring, and the list of final indicators that resulted after the CoE team used our framework to validate and refine their performance management system. We also include the level of granularity for each indicator in the Framework combined table (based on Appendix II).

Table 14: SeeMe™ List of Indicators - Original vs. New in Framework Combined Table

Indicators - Original	New Indicators in Framework Combined Table	Granularity of New Indicators
# CCs scheduled	i1. % GoC completed	
# GOC tools completed to date	i1. % GoC completed	
GOC tool % Completion Rate	i1. % GoC completed	
# Staff requiring F/U support for GOC tool	i3. % training completed	% Follow up needed % Follow up NOT needed
% Staff requiring F/U for GOC tool	i3. % training completed	% of corrections completed within a month of audit % Follow up needed % Follow up NOT needed
# Residents that prefer not to transfer to Emerg	i6. % Unwanted ER transfers	
% Residents that prefer not to transfer to Emerg	i6. % Unwanted ER transfers	
# CFA completed based on training schedule	i3. % training completed	% Independent after training (green) % Supervision (yellow) % More training (red)
# CFA completed to date (CC completed)	i3. % training completed	% care conferences with CFA tool completed by assigned due date (approx. 2 weeks)
# Physicians requiring F/U support for CFA	i7. Frailty Assessment Distribution	% Physician Initially Completed - Follow up needed % Physician Initially Completed - Follow up NOT needed
% CFAs requiring F/U support	i7. Frailty Assessment Distribution	% Nurse Initially Completed - Follow up needed % Nurse Initially Completed - Follow up NOT needed
	i2. % CFA completed	% care conferences with CFA tool completed by assigned due date
	i5. # of training hours	Average # hours per roll-out phase that it took for all RNs, RPNs, to become green; Minimum and Maximum # hours for becoming 'green' per roll-out phase
	i8. % DNR (CPR)	

In Table 15, we can see the final list of indicators the CoE team defined for performance management of SeeMe^{TM}. Indicators are grouped by tool support. For example, for the indicator i3, % Training completed, at the meso level, the Mentor collects data using the Staff Training tool during the task Complete the Evaluation Form for Trainees. This information is reviewed by the Collaborative Practice Nurse to follow up with staff needing more training or follow-ups and she updates the Performance Management (Audit) Spreadsheet tool (% Training completed) and the Master Frailty Schedule Spreadsheet tool (% Training completed)). This information is reviewed by the Coordinator for CoE in the task Audit Evaluation Forms using the Performance Management (Audit) Spreadsheet tool and by the Steering Committee in the task Review Training Implementation Progress using the tool Staff Training Spreadsheet tool.

After completing the Framework Combined table, the next step is to follow the Tool Support Methodology to confirm each tool that has been selected is mapped to the appropriate task, used in the correct process, and meets the information needs of the actors after careful review of all clinical practice levels.

The CoE team did not complete this step. After finalizing the Framework Combined table, they realized they needed better tool support. The way they were collecting data for indicators in spreadsheets was prone to error. They used color codes and rubrics for indicators and filled in these manually. Also, they used open text in forms and they felt this is an area that could be improved. They realized they needed better tools to support the performance management system they designed in Table 15. The design of the new tools was outside the scope of this case study.

Table 15: SeeMeTM Framework Combined Table

Framework Combined Table							
Tool	**CPL**	**Actor**	**Process**	**Goal**	**Indicator**	**Task**	**Task Type**
Performance Management (Audit) Spreadsheet	Micro	Nurse	SeeMe™	Adoption	i1. % GoC completed	Complete Goals of Care Form	Data Collection
	Micro	Physician	SeeMe™	Adoption	i2. % CFA completed	Complete Comprehensive Frailty Informed Assessment Form	Data Collection
	Micro	Nurse	SeeMe™	Adoption	i2. % CFA completed	Complete Comprehensive Frailty Informed Assessment	Data Collection
	Micro	Resident	SeeMe™	Adoption	i1. % GoC completed i2. % CFA completed	Review Goals of Care and Frailty Informed Assessment Form	Data Collection
	Meso	Collaborative Practice Nurse	Mentoring	Staff competency	i3. % training completed	Follow up Goals of Care Audit Notes	Data Collection/ Review Report
	Meso	Coordinator for CoE	Oversees Clinical Processes	Reduce unwanted ER transfers	i6. % Unwanted ER transfers i7. Frailty Assessment Distribution i8. % DNR (CPR)	Collect data for SeeMe™ Steering Committee	Data Collection
	Meso	Coordinator for CoE	Oversees Clinical Processes	Staff competency	i3. % training completed	Audit Evaluation Forms	Review Report
	Macro	SeeMe™ Steering Committee	Operations Management	Monitoring progress and impact of Goals: Adoption, Reduce unwanted ER transfers	i1. % GoC completed i2. % CFA completed i6. % Unwanted ER transfers i7. Frailty Assessment Distribution i8. % DNR (CPR)	Review Audit Results	Review Report
Staff Training Spreadsheet (Master Frailty Schedule Spreadsheet)	Micro	Staff	Mentoring	Adoption	i3. % Training completed	Review the Evaluation Form for Trainees	Review Report
	Meso	Mentor	Mentoring	Adoption	i3. % Training completed	Complete the Evaluation Form for Trainees	Data Collection
	Meso	Collaborative Practice Nurse	Mentoring	Staff competency	i3. % Training completed i5. # of training hours	Follow up w/Trainees needing additional training	Data Collection/ Review Report
	Macro	SeeMe™ Steering Committee	Operations Management	Track progress of Goals: Staff Competency	i3. % Training completed i4. % Independent after training i5. # of training hours	Review Training Implementation Progress	Review Report

6.3.5 **Results**

- Is our framework useful to evaluate, redesign, and validate existing tool support for performance management of SeeMe™?

The diagram allowed the CoE team to visualize at a high level, who needs to be considered in the performance management system and how actors at different levels of clinical practice interoperate. The use of the diagram also allowed the CoE team to reach a consensus on terminology for processes and actors.

The use of the Performance Measurement table allowed the team to reassess indicators the Steering Committee was using. Since members of the Steering Committee participated in the redesign of the performance management system, there was buy-in from the committee for new indicators added to the measurement system. Also, the table allowed them to visualize and remove indicators they did not need, add new indicators, and validate what actor and at what clinical practice level had to collect the data for each indicator.

Finally, the Framework Combined table allowed the CoE team to see that for indicators they had selected and validated for their performance management system, the tools they were using could be replaced by new tools with more standardization for data collection to monitor indicators more effectively. The table also allowed them to visualize in what other ways they could collect data for indicators and automate certain indicators, e.g. automate color rubrics to flag when a staff member is fully independent (green), need supervision (yellow), or need more training (red) for the use of forms.

- Is our framework easy to use by a team of clinicians and administrators?

Once we completed the SeeMe^{TM} case study, we confirmed that the CoE team was able to follow our framework and complete the Performance Measurement table and the Framework Combined table. However, the process of completing the tables was not necessarily straightforward for them as they reported it was not easy to go back and forth between tables to guarantee consistency between data included in both tables. In part, this struggle is evidenced in the final version of the Framework Combined table. They used numbers beside some indicators to confirm where data for an indicator was collected and what report was used to review the indicator. Despite this, the team never got stuck, nor did they ask for any additional help.

The case study confirmed our approach is comprehensive. Tables for SeeMe^{TM} show that for each indicator that measures a goal at least there is one actor responsible for collecting data and at least one actor responsible for reviewing the indicator. All tasks are supported by one tool or it was clearly identified a need to replace or design a new tool for the task.

The framework was useful for designing/improving the performance management system for SeeMe$^{TM.}$ The team was able to complete all tables of the framework, build consensus on the terminology used in the system, agreed on goals and indicators, evaluate the adequacy of current tools or identify the need to use new tools, and assign accountability to different actors across clinical practice levels for tasks that support data collection and review reports to operationalize the performance management system.

A complete evaluation of the case study is done in 7.1.4.

6.4. Chapter Summary

In this chapter, we presented the three case studies we use to validate our framework. The three case studies are related to community clinical practices. Each of the three case studies presents the use of the framework from a different perspective. In the first case, the framework is used to make a retrospective analysis to understand why a carefully designed tool for performance monitoring of clinical practice was eventually found not to be useful. In the second case study, a clinician researcher used our framework to define the requirements for tool support. In the third case study, a multidisciplinary team of clinicians and administrators used our framework to validate and improve their current performance management system for SeeMe^{TM}, including evaluation and redesign of the participation model, measurement model and finally to conclude that there is room to replace the tools they currently use to monitor their indicators.

Chapter 7. Evaluation

In this chapter, we evaluate our framework. First, we report results from review and feedback sessions with stakeholders, during which they shared their insights and experiences in using our framework and reviewed our documentation of the case studies. Second, we use the criteria defined in section 4.4 to compare our case studies and highlight which criteria were the focus of each case study and which we were able to fully validate. Third, we compare our framework against each of the related works using the evaluation criteria in 4.4. Finally, we review assumptions, limitations, and threats to validate our proposed framework.

7.1. Stakeholders Review and Feedback

7.1.1 Overview

In this section we summarize the steps we followed to obtain feedback and validation from stakeholders on the three case studies described in chapter 6.

To validate the framework, we conducted stakeholders' review and feedback sessions. The stakeholders, who were involved in each of the three case studies in chapter 6, were invited to the sessions on the basis that they were competent to assess how well the framework supports performance management in their clinical practice and to provide evidence in support of their assessment.

The format of the sessions were either in-person or screen-share conference calls. For each session, we prepared a slide deck with a recap of the steps followed in the case study; the results obtained; and we highlighted five features of our framework to get their feedback.

The main goals for each of the validation sessions was to:

1) Confirm the steps followed during the case study.
2) Validate that we understood and depicted the case study correctly.
3) Gather feedback from the stakeholders about their experience when applying the framework to the clinical practice or usefulness of the framework for the design of tool support for performance management of a clinical practice.
4) Obtain objective evidence as to how useful the diagram and tables of views in our framework were for the design of tool support for performance management of the clinical practice.
5) Understand any pain-points the stakeholders identified for and when applying the framework.
6) Gather the stakeholders' recommendations on anything that could have made easier the use of the framework and missing areas in the framework.

We highlighted five features for discussion and asked the stakeholders to respond to the following five statements with a response on a five-point Likert scale:

1. The Performance Management Participation diagram was useful for designing the tool support for Performance Management of your clinical practice.

2. The sequence of tables –1) Performance Management Participation Model, 2) Performance Measurement Model, 3) Implementation/Evaluation of tool support – was useful for designing the tool support needed for Performance Management of your clinical practice.
3. The three tables were useful to structure the communication amongst team members responsible for the design of tool support for performance management of the clinical practice.
4. The Performance Management Participation diagram and the three tables were useful to verify the tool support for performance management of the clinical practice was implemented correctly.
5. The single combined table that incorporates the columns from all three tables was more useful for clearly seeing the current state and updating the design as corrections were made than the three-table step-by-step approach. However, the three-table approach was useful for the initial design of the tool support for performance management of the clinical practice.

For each statement, after a short discussion that allowed the stakeholders to freely review all aspects of the feature, provide feedback, and make suggestions, the stakeholders indicated their level of agreement using the following five-point Likert scale:

1 - Strongly Disagree

2 - Disagree

3 - Neutral

4 - Agree

5 - Strongly Agree

The stakeholders were encouraged to discuss and explain their thinking related to each feature in free-form feedback before formalizing the Likert response. The purpose of the feature discussion was twofold 1) to ensure all of the components of the framework were reviewed and evaluated by the stakeholders and 2) to quantify stakeholders' level of agreement to each question.

Each session ended with the open question "Was there anything missing in the framework that would have helped with the design of tool support for performance management of the clinical practice?" The purpose of this question was to encourage a free form discussion and allow stakeholders to expand their views on any other relevant areas for validation and applicability of the framework that had not been previously considered.

In the next sections we review the specifics for each of the case studies following the structure described above.

7.1.2 **Resident Training**

For the resident training case study, we had one stakeholders' review and feedback session. We invited Dr. Gary Viner and Dr. Eric Wooltorton, from the Family Medicine group at The Ottawa Hospital, as the main stakeholders for the session. Dr. Gary Viner is a family physician. He was the Director of Evaluation for the Department of Family Medicine at the University of Ottawa during the time that the RPP tool was developed. Dr. Eric Wooltorton is a family physician and, during the time the RPP tool was developed, he was the Director of for the Family Medicine curriculum at the University of Ottawa. The

format of the session was a meeting in person, 75-mins long. We used a slide deck as the supporting material for the session.

The meeting started with a presentation of the framework for designing tool support for performance management of clinical practice. We explained how we applied the framework to understand the complete context in which the RPP tool was developed and deployed; how we understood the clinical practice (residents training program) through the lens of our framework and; we reviewed with the stakeholders our findings - what we found could have been the main factors that explain why RPP user acceptance testing was successful, but the tool ended up not being fully adopted and rolled out. Following this, we discussed with the stakeholders the five features outlined in 7.1.1 and measured their level of agreement using the Likert scale. We ended the session with a free form discussion where the stakeholders shared additional feedback about the use and applicability of the framework.

It is important to note for this case study, that the stakeholders did not use the framework or performance views but rather we asked them to validate the way we had portrayed and analyzed the design and implementation of the RPP tool, in light of the framework; that the use of the framework was helpful to pinpoint issues with the RPP design and implementation; and finally, that the framework provided a logical way to analyze the complete context for tool support of performance management for resident training.

During the discussion of features, the stakeholders agreed that the Performance Participation Management diagram was useful. However, they indicated that perhaps a

Meta level should be added to the diagram where the process of designing / reviewing performance management for the clinical practice took part.

They strongly agreed 'The sequence of tables in 1) Performance Management Participation View, 2) Performance Measurement View, 3) Tool Support Design Methodology – was useful for the design of tool support for Performance Management of your clinical practice'. In particular, the stakeholders indicated that the tables allowed them to see how the design and implementation of RPP was flawed, because many of the steps outlined in the framework and tables were skipped or not considered. When designing RPP, the team did not explicitly define the context or map the tasks in terms of the processes. The focus was mainly on the user experience as opposed to the system view of where the tools contributed to the overall performance management of what was happening in the clinical practice.

For the Performance Measurement View, the stakeholders agreed it is very helpful and that if they have used the view from the beginning, it would have helped structure the design and implementation of the tool much better.

For the Tool Support Design Methodology, in addition to what the model currently includes, the stakeholder suggested that it could also include the frequency at what one wants to look at reports and therefore frequency for sending report notifications. The stakeholder indicated this is particularly important as a) you want to have enough data and b) you do not want the report reviews to be too burdensome.

The stakeholders strongly agreed ‘the three tables were useful to structure the communication amongst team members responsible for the design of tool support for performance management of the clinical practice’. Although the review of tables happened ex-post, the review of tables encouraged a negotiation amongst the stakeholders on what terminology was more appropriate for specific processes. The stakeholders strongly agreed the three tables approach is very useful for designing, negotiating and reaching a consensus on exact terminology to be used for different organizational levels and, to ensure the tool generates reports that can provide evidence for conducting an evaluation at a higher level.

For example, the stakeholders discussed what the appropriate terms were for processes at the micro-level - 'Treat Patient' vs. 'Reflect on Patient Encounter'; ‘Self-Assessment’ vs. ‘Self-Evaluation’ -, at the meso level – ‘Assess Breadth of Experience’ vs. ‘Assess Breadth of Competency’ and, terminology that was appropriate for processes at a level above the macro level – ‘Evaluate the Program’ for comparing a program against other programs using formative data that summarize what is happening in the programs.

During the discussion, the stakeholders also strongly agreed ‘the Performance Management Participation diagram and the three tables were useful to verify the tool support for performance management of the clinical practice was implemented correctly’. Although the framework was not used for the design of RPP but rather for the after-the-fact evaluation of the tool, the stakeholders indicated that the diagram and the information in the three tables portrayed a very close picture of what was relevant for the RPP practice. The tables were very close to what the process and the practice should have been; and, that

the diagram and tables were useful to highlight areas that explain why it did not make sense to adopt the tool.

The stakeholders indicated that tables were useful to identify whether the RPP tool supported in a complete way performance management of the clinical practice. For example, the use of RPP reports by supervisors to assess the breadth of experience of the resident, in bold in Table 8 and Table 9. As there was not a task for the implementation where the supervisor had to review the RPP report, their role and responsibility related to the use of the tool was not clear. We hypothesized that because of this, eventually the residents did not find an incentive to continue using the tool, to which the stakeholder agreed and indicated that, if there is no process to support the product, the product is no used.

Finally, the stakeholders agreed 'the single combined table that incorporates the columns from all three tables was more useful for clearly seeing the current state and updating the design as corrections were made than the three tables step-by-step approach. However, the three tables approach was useful for the initial design of the tool support for performance management of the clinical practice.' The stakeholders leaned towards using a compact single table for the analysis after the fact; however, they noted that if you are using the framework for designing tools for performance management before the fact, the three tables approach is definitively more useful. The stakeholders placed particular emphasis on the importance of having a performance measurement table as a single table when building up the picture, as goals - the why - are central regardless of the tools that will be used.

During the features discussion, the stakeholders shared additional in-depth feedback that we summarize below.

The stakeholders indicated they could see how the framework and all three tables are essential and vital in terms of what one thinks about processes and that the framework represent three aspects of a complex whole. They indicated the framework is very useful for pairing processes with a tool or product.

Finally, the stakeholders made some recommendations on how to depict data in the table, as too much text could lead to visual overload. Given the framework uses two well-defined tasks - data collection and review reports -, tables could be easier to use if these tasks were represented in a more visual way, e.g. using visuals or having second header level for each task type with checkmarks for a task that is applicable to a process. The same recommendation was also made for representing the various tools that could be used for the clinical practice.

7.1.3 **Discharge Management**

For the case study Discharge Management, we had one stakeholder review and feedback session. We invited Professor C. Backman, PhD, clinical researcher, as the stakeholder for the review session. Her role in the development of the data strategy for Path to Home was at the meso level, overseeing the research study. The format of the session was a screen-share call, 45-mins long that took place one year after the study was completed. We used a slide deck as the supporting material for the session.

The meeting started with a recap of the steps we followed to apply the framework to performance management of the clinical practice (explained in detail in section 6.2). We validated with the stakeholder that our understanding of steps depicted in 6.2.1 was correct. The stakeholder confirmed iterations between them and us allowed them to understand what was feasible in terms of the use of the framework for design of tool support, and, after this iterative process, they were able to adopt the framework.

During the discussion of features the stakeholder agreed 'the Performance Participation Management diagram (Figure 15) was useful for designing the tool support for Performance Management of your clinical practice'. The stakeholder indicated the diagram is a good visual depiction that clearly articulates who should be engaged for performance management of the clinical practice and allow them to see at a high level all actors and stakeholders that must be considered for designing tool support. The diagram also helps visualize actors and stakeholders that for a particular phase of the project do not need to be engaged but must, however, be considered for a full roll out of the performance management program (see greyed out actors in Figure 15). In particular, the actor and process at the macro level and the Acute Care Team and Primary Care Team at the micro level, greyed out in Figure 15, were not required for the research study; however, these actors and processes are relevant for the implementation of the app in the organization and need to be considered for the full roll out.

Another area that was discussed was whether a third-party organization, i.e. software vendor, not involved in the delivery of the care process, should be included in the diagram. It was agreed that this type of actor does not need to be added in the diagram and

the best way to represent them would be to add a symbol to the Tool Support table to indicate the specific role of the external actor for the task, e.g. software vendor responsible for the building of the tools (they could also be indicated as part of the Meta level suggested by the stakeholders in 7.1.1, but this was not discussed with the Discharge Management stakeholder).

Finally, the stakeholder indicated the diagram, as a visual, is very useful, in particular when projects get more complex and integrated with different organizations. The diagram gives a high-level overview of the structure "knowing who is doing what at each organizational level is very helpful".

The stakeholder also agreed 'the sequence of tables in –1) Performance Management Participation View, 2) Performance Measurement View, 3) Tool Support Design Methodology – was useful for designing the tool support needed for Performance Management of your clinical practice'. The stakeholder indicated that the use of tables was very helpful for analyzing and mapping tool support requirements. Tables helped them to clearly articulate care transitions as a process flow with goals and indicators and, tables were also useful to map what tools or documents needed to be implemented for each process in the app.

The stakeholder strongly agreed the three tables were useful to structure the communication amongst team members responsible for the design of tool support for performance management of the clinical practice. The stakeholder indicated the tables served as a good communication vehicle among team members as each member could see their part in relation to the others. Tables also helped them ensure all app requirements

were clearly outlined. It also helped them structure and facilitate the communication with the software vendor, which resulted in smooth communication, reduced friction during the process, and ensured nothing was missing in the implementation. Finally, the stakeholder indicated the final table was very useful as a checklist to confirm all requirements were considered for the app design and implementation.

During the discussion, the stakeholder also strongly agreed that 'the Performance Management Participation diagram and the three tables were useful to verify the tool support for performance management of the clinical practice had been implemented correctly'. The stakeholder indicated that the diagram and tables provided their team with a logical way to map and outline requirements of the tool and served as a checklist to confirm all requirements were implemented correctly in the platform they had chosen.

Finally, the stakeholder agreed that 'the single combined table that incorporates the columns from all three tables was more useful for clearly seeing the current state and updating the design as corrections were made than the three tables step-by-step approach. However, the three tables approach was useful for the initial design of the tool support for performance management of the clinical practice'. The stakeholder initial response was that she preferred to use a combined table but when pressed, she agreed that using a step-by-step approach was useful, at the beginning, to build up the initial picture. The stakeholder sees more value in having just one single table at the end of the process, to see all the information at once. However, to come up with the final table, the stakeholder agreed it was better to start with the table for the performance management participation view (actors, processes, tasks and task types) and then add additional columns from other tables

to include the goals and indicators and, finally, tools. The stakeholder sees the three tables approach as an intermediate process to get to the combined table that forced them to think about goals and indicators they had not previously considered until they had to complete the information in the table. Also, having had to follow the process of filling the combined table forced them to think about how they wanted to get the information out of the app (reports they wanted to see).

The features discussion led to more in-depth feedback about the framework and conceptual models. For the Performance Management Participation view (Table 10), the stakeholder highlighted some key results. Discharge Management was a research study and as such, actors (care providers) identified in the Performance Management Participation table did not necessarily played an active role in the research study. A research assistant facilitated some of the tasks during the research study and acted on behalf of some actors. There was the question as to whether this actor needed to be represented in the table. The stakeholder agreed it is useful to have the research assistant (facilitator) role represented in the tables for the purpose of the research study but also include the appropriate actors in the table for the future implementation of the tool.

With regard to the relevance of the columns included in tables of the framework, the stakeholder indicated that some of the columns were more relevant for the clinical team and help them clearly visualize the processes, tasks, and flow of tasks, whereas mapping of tools to tasks was more relevant for the software vendor to see what tools or documents needed to be implemented in the app. The stakeholder commented that there were limitations in the functionality provided by the software vendor platform and that not all

reports could be implemented, therefore the researcher had to develop alternative tasks as workarounds for this. The table helped highlight where there was a need for alternative tasks to address gaps in the functionality of the tool and plan for these tasks.

7.1.4 SeeMe™ Frailty Informed Care

For the case study SeeMe™, we had one stakeholder review and feedback session. Participants to this session were; the Centre of Excellence (CoE) research coordinator, the manager of the CoE and Applied Research the manager of quality improvement, the coordinator of the CoE and interprofessional clinics and, the collaborative practice nurse, responsible for the training of staff at the point of care and for reporting trainees' progress. The format of the session was a meeting in person, 60-minutes long. After the session, the health care researcher sent a follow up email summarizing the discussions and the shared experience of all five participants on using the framework. Based on the feedback provided, we confirmed with the health care researcher the five features outlined in 7.1.1 using the Likert scale.

During the discussion of features, the stakeholders strongly agreed 'the Performance Participation Management diagram was useful for designing the tool support for Performance Management of your clinical practice'. The stakeholders indicated that the diagram (Figure 16) helped them clarify every actor's role in the SeeMe™ process and their responsibilities. The diagram also helped them understand and reinforce the importance of each role for the whole program.

The stakeholders agreed with the statement 'the sequence of tables –1) Performance Management Participation View, 2) Performance Measurement View, 3) Tool Support

Design Methodology – was useful for designing the tool support needed for Performance Management of your clinical practice'. The stakeholders indicated there was room for improvement, though. It was hard to work with separate tables and that it was difficult to correlate the information between tables. Also, the stakeholders indicated that navigating between tables was not easy during the meetings and that the process was time-consuming. Finally, the stakeholders indicated that the approach of using a sequence of tables requires all process team members to be present at meetings for filling out the tables properly and that the process was not intuitive for them, at least at the beginning.

The stakeholders strongly agreed 'the three tables were useful to structure the communication amongst team members responsible for the design of tool support for performance management of the clinical practice'. The stakeholders indicated the use of the framework and tables generated extremely valuable discussions about roles, processes, indicators, etc. It helped to identify what indicators were relevant and get consensus on the value of the indicators versus the effort of getting them. Also, during the meetings they had for filling out the tables, participants brought forward questions that they had not thought about before, which helped clarify steps on what was needed to achieve a certain outcome. Finally, the stakeholders indicated the use of tables (although not easy as expressed above) was good for team building, consensus building and, it was fun for the team – they met once per week, for a total of seven times.

The stakeholders strongly agreed 'the Performance Management Participation diagram and the three tables were useful to verify the tool support for performance management of the clinical practice was implemented correctly'. The stakeholders

indicated the diagram and tables helped them identify additional process aspects and measures (indicators) for which they needed to collect data. It also helped them identify measures that were in use but were not relevant, and for which they did not need to continue collecting data. Also, the process of filling out the tables triggered ideas on how to improve the evaluation; as a result, some indicators in the framework were incorporated in the evaluation process. Finally, the stakeholders indicated the use of the tables allowed them to troubleshoot difficult areas; i.e. they were able to identify indicators they wanted to use, but did not have a reliable source of data for them; and, the diagram and tables served to look at the implementation process in a systematic way.

Finally, the stakeholders agreed 'the single combined table that incorporates the columns from all three tables was more useful for clearly seeing the current state and updating the design as corrections were made than the three tables step-by-step approach. However, the three tables approach was useful for the initial design of the tool support for performance management of the clinical practice. The stakeholders indicated team members preferred a compact single table that combines the elements of the three tables, as they found having to go back and forth between tables for building up the picture was not an easy and intuitive process. However, when pressed they agreed there is value in working with the three separate tables at the beginning to build up the picture and focus on and gain consensus on the specific components they need to fill out for each table.

7.1.5 **Summary**

In this section, we summarized commonalities, insights, and exceptions drawn from the review and feedback sessions with stakeholders for the Resident Training, Discharge

Management, and SeeMe^{TM} case studies. Table 16 summarizes responses for each case study to statements outlined in 7.1.1 using the Likert scale as well as the average response.

Table 16: Healthcare Stakeholders Review and Feedback - Likert Scale Response

	Resident Training	Discharge Management	SeeMe^{TM}	Average
1.The Performance Management Participation diagram was useful for designing the tool support for Performance Management of your clinical practice	Agree	Agree	Strongly Agree	4.3
2.The sequence of tables in the –1) Performance Management Participation View, 2) Performance Measurement View, 3) Tool Support Design Methodology – was useful for designing the tool support needed for Performance Management of your clinical practice	Strongly Agree	Strongly Agree	Agree	4.7
3.The three tables were useful to structure the communication amongst team members responsible for the design of tool support for performance management of the clinical practice.	Strongly Agree	Strongly Agree	Strongly Agree	5
4.The Performance Management Participation diagram and the three tables were useful to verify the tool support for performance management of the clinical practice was implemented correctly.	Strongly Agree	Strongly Agree	Strongly Agree	5
5.The single combined table that incorporates the columns from all three tables was more useful for clearly seeing the current state and updating the design as corrections were made than the three tables step-by-step approach. However, thee three tables approach was useful for the initial design of the tool support for performance management of the clinical practice.	Strongly Agree	Strongly Agree	Agree	4.7

Stakeholders across all three case studies found the Performance Management Participation diagram useful as a visual tool to depict a complex whole. However, the relevance in using the diagram for each of the cases studies varied. The average Likert scale response was 4.3. In Discharge Management, there was a tendency to focus mainly on processes at the micro level, possibly, because they were researchers studying the impact of tool support on patient transitions whereas SeeMe^{TM} was particularly focused on

how to justify the performance management initiative to a hospital steering committee, hence the relevance for SeeMe^{TM} to understand and reinforce the importance of each actor's roles and processes within the whole program and across all organizational levels. Stakeholders in Resident Training, on the other hand, evaluated the usefulness of the diagram ex post, and found all levels depicted in the diagram useful though suggested to add a new level.

The use of the sequence of three tables for the design of the tool support had an average Likert response of 4.7. Although it was common feedback the sequence of tables was hard to use and follow, stakeholders agreed that though painful, the approach is necessary to build-up the picture, gain consensus on terminology, processes, actors, and tools and; to break down a whole complex system into more manageable parts keeping the focus on what the purpose at each step of the process was. Particular emphasis was placed on the performance measurement model - goals and indicators; either because it forced team members to think about goals and indicators they had not thought about before (Discharge Management, SeeMe^{TM}) and indicators that were redundant in the current practice (SeeMe^{TM}) or because the stakeholders thought this was a central aspect to performance management (all three case studies).

It was common feedback the tables were very useful to structure the communication among team members responsible for design of the tool support. The average response in the Likert scale was 5. Similarly, it was common feedback the framework – diagram and tables- was very useful for identifying pain points in implementation and as a checklist to

verify the tool implementation was correct. Stakeholders liked the systematic approach to implementation.

Finally, common feedback among all stakeholders was that a compact table that combines all information elements from the three tables is the preferred approach, as the information is easier to read and process; But when pressed, all stakeholders similarly agreed that the step by step tables approach is necessary, as it is useful for build-up the picture and once you have all the data elements clearly defined, you can maintain a single compact table.

7.2. Evaluation across Case Studies

In this section, we use criteria defined in 4.4 and evaluate its relevance for each of the three case studies in Chapter 6.

7.2.1 **Performance Management for Clinical Practice**

In Table 17, we show for each row whether criteria defined in 4.4.1 was a main area of focus in the case study and our framework was fully validated against these criteria, or if a criterion was not relevant for the case study.

We use the following rubric to evaluate the criteria for each case study:

- Green/Bold – Indicates the criteria is key in the case study and it was fully validated.
- Blank/Plain text – Indicates the criterion was not the focus in the case study.

Table 17: Evaluation of Performance Management criteria across Case Studies

Criteria	Resident Training	Discharge Management	SeeMe™ Frailty Informed Care
1. Goal Dimensions	- One goal - Not a focus	- Not a focus	- Not a focus
2. Type of Indicators	- Outcome indicators - Not a focus of the case study - Not validated	- Not a focus	- Not a focus
3. Clinical Practice Levels	**- Critical for understanding that indicators must be optimized taking into account all levels of clinical practice**	- Not a focus - Clinical trial Research for discharge data exchanges	**- Critical to ensure indicators are relevant to right actors**
4. Data Lineage	- Focus was not in evaluating data lineage	**- Critical for defining where data comes from for indicators** **- Key for defining tool requirements**	**- Key for highlighting where data is collected to report to the Steering Committee**
5. Indicators aligned with care practice goals	- One goal - Not a focus	**- Relevant for ensuring NexJ is customized to support clinical trial research goals**	**- Key for understanding indicators that were not relevant** **- Critical to uncover aspects of processes that should be measured**
6. Care Process Interoperability	**- Critical to explain partial success of the tool** **- Indicators needed to support all actors**	- Not a focus -Tool design for clinical trial	**- Critical to confirm the right data is collected for indicators** **- Highlight missing or redundant indicators**

Goal dimensions and type of indicators while important aspects of a performance management system were not the focus for validation in any of the three case studies. The framework does not prevent those aspects to be considered, but it does not directly support them either.

Clinical practice levels is a key aspect of our framework and this criterion was fully validated in Resident Training and SeeMeTM case studies. In the Resident Training case study, mapping indicators to all clinical practice levels was fundamental for understanding the design of tool support should not focus exclusively on optimizing indicators for actors at one single level. Optimizing indicators for actors at the micro level (residents) was not

enough to ensure indicators were relevant for and used by actors at other clinical practice levels. In the case of SeeMe^{TM}, mapping indicators to actors across all clinical practice levels was essential to ensure performance at each level of clinical practice could be monitored, and data rolled up from the micro level to the macro level. Also, it was critical to understand if the right actors were collecting data for the right indicators, and that actors that needed to review reports had access to the right indicators. In particular, we validated with SeeMe^{TM} case study the importance of defining at what level of clinical practice and in what process data needs to be collected to provide the right indicators to actors at other levels of clinical practice.

Data Lineage was relevant for Discharge Management and SeeMe^{TM} case studies. With the Discharge Management case study, we validated that our framework was useful for helping the clinician document and communicate data collection requirements and reporting requirements to a software vendor. The clinician was able to clearly define what actors needed to collect what data to populate what reports, and map when (in what tasks) and where (what process) in the discharge management process actors collect data. A clear definition of data lineage allowed the clinician to have a checklist against to which validate if; reports in the tool were generating the right data for monitoring goals of the clinical trial, the right actors have access to the right forms in the tool for collecting only relevant data for reports, and the right actors that supervise the research trial have access to the relevant reports.

In the case of SeeMe^{TM}, we validated that it was essential for program participants to understand what data must be collected to support metrics required by the Steering

Committee. Identifying in a systematic way if there was a reliable data source for indicators - who collects what data, in what process, and in what task - was key for the team to review data they used for each indicator reported to the steering committee, ensure there was no missing data or redundant data, and validate the source used was reliable.

Indicators aligned with care practice goals was a focus area for the cases studies Discharge Management and SeeMe^{TM}, and we validated the relevance of our framework with regard to this criterion during these two case studies. In the case study Discharge Management, the clinician mentioned that while they were clear on what they wanted to achieve with each process (goals), they realized the importance of having indicators aligned with care goals when they started to fill out the tables of our framework. Initially, the clinician had not thought about indicators linked to goals, but the framework guided her to think in that way and helped her to articulate discharge management as a collection of process with goals and indicators to measure each goal.

In the case of SeeMee^{TM}, our framework allowed the team identify new aspects of a process, goals, and new indicators for these goals. The systematic approach of our framework also allowed them to identify indicators that were in use and for which data was collected, but that were not relevant to achieving goals of the clinical practice.

Care process interoperability was a key aspect of the case studies Resident Training and SeeMe^{TM}. For the Resident Training case study, our framework allowed us to communicate the importance of taking into account information needs of all actors at all levels of clinical practice when defining data collection and report review tasks. When presenting our findings to the stakeholders, they agreed that the lack of indicators that were

optimized for actors at the supervisory level helps to explain why the RPP tool was not used at that level in Resident Training. Residents who did not see value in using the tool for self-reflection stopped using RPP since supervisors were not reviewing the data residents collected, and therefore the use of the tool lacked practical value for getting feedback from supervisors. With regard to SeeMe™, one of the main goals of the study was to validate indicators monitored in the performance management system for SeeMe™ and confirm data collected for these indicators was relevant and met the information needs of actors at different levels of the whole clinical practice. Although the use of the diagram and tables in our framework was useful to validate the different information needs of all actors and confirm that data was flowing across appropriate processes and clinical practice levels, the SeeMe™ participants also reported difficulty in confirming the consistency of data between tables, which made ensuring care process interoperability for SeeMe™ cumbersome although possible to achieve for them.

7.2.2 **Design of Tool Support**

In this section, we use the criteria defined in 4.4.2 and evaluate whether the criteria was relevant and validated in each of the case studies in Chapter 6.

In Table 18, we show for each row whether the criterion was a main area of focus in the case study and our framework was fully validated against these criteria, or if a criterion was not relevant in the case study.

Table 18: Evaluation of Design of Tool Support criteria across Case Studies

Criteria	Resident Training	Discharge Management	SeeMe™ Frailty Informed Care
1.Participation of actors	- Not relevant	- Not relevant	**Critical for gaining consensus**
2. Compact view of relevant processes and actors	**- Focus of the case study** **- Critical to understand who should have tool support**	**Critical to confirm who needs tool support and in what process**	**Critical to understand and confirm roles for performance management**
3. Operationalization of the Performance Management Strategy	- Not relevant - After the fact	**Critical to confirm what needs to be measured to report on what goal to define data collection in the tool**	**Critical to streamlining the use of indicators**
4. Incorporation of Indicators	**Critical for understanding lack of optimized reports for supervisory level**	**Critical to ensuring the right data is collected in the tool to support reports for the right actors**	**Critical to identifying missing or redundant indicators**
5. Tool support	**Critical for understanding where there should be tool support**	- Only one tool - Focus was to ensure tool was designed to collect the data that needed to be collected	**Critical for identifying lack of proper tool support**

Participation of actors was a criterion only relevant for the case study SeeMe™. It was not relevant for the Resident Training case study, since it was us who used our framework to perform a retrospective evaluation of RPP implementation and presented the results to stakeholders. Participants in the original design of the RPP tool did not use the framework. In Discharge Management, given the case study was a clinical research trial to design and validate development of a single tool, the only participant in the design was the main researcher (clinician) and the participation of actors was not a main focus of the case study. As for SeeMe™, all participants in the case study were involved in the evaluation of the performance management system for SeeMe™. We validated participation of actors was extremely useful to gain consensus among actors about what roles should be included in the performance management system, processes, goals and indicators, and that our framework served to frame negotiations between the different actors.

Compact view of relevant actors was a key aspect and focus of all three case studies. In Resident Training, it was critical for understanding who should have had tool support. The fact that not all actors and processes were considered for the design of the tool, was useful to explain why the use of the RPP was phased out in Resident Training. In Discharge Management, the compact view was relevant to ensure there was a clear understanding of actors' roles and accountability and who and when they do tasks in the clinical trial research. It was also relevant to understand the participation of the members of the clinical research team in relation to the other actors. Similarly, in SeeMe™ this criterion was a main aspect of the case study as participants expressed it was key for them to understand and clarify every actor's role and responsibility within the whole program to determine what needed to be measured, when and whose was the responsibility.

Operationalization of the performance management strategy was a critical criterion for evaluation in case studies Discharge Management and SeeMee™. It was not relevant for Resident Training as we use the framework after the fact, and we did not define any indicators. We validated our framework was useful for the researcher in Discharge Management to articulate the research trial in terms of goals and indicators that mapped to requirements for the tool (data forms and reports requirements).

This criterion was also a main area of focus in SeeMe™. Our framework proved to be useful when we tested it against this criterion in SeeMe™. Participants found our framework was particularly useful as it allowed them to analyze each aspect of performance separately, actors and processes in a participatory model and goals and indicators in a measurement model to then make sure they could identify where tool support

should be implemented to operationalize the system. Evaluating each component separately allowed them to reflect on current practice, gain consensus on what was important, and measure the effort required to implement an indicator versus the actual value of the indicator to monitor a goal. However, a relevant comment in the SeeMe^{TM} case study was that navigating tables was not easy and having to go back and forth between tables to complete the performance management strategy proved not to be a trivial process.

Incorporation of Indicators was a main area of focus in all three case studies and we were able to validate our framework against this criterion in all cases. For the Resident Training case study, our framework was helpful in demonstrating that partial success of RPP can be attributed to limited but optimized support of the tool for data collection and review of reports at a single level of clinical practice. The use of the participation diagram and the tables in our framework allowed us to easily visualize and communicate how the information needs of all the actors were not taken into account as interrelated parts of a whole system and the need for indicators at the supervisory level or higher level was not supported with the implementation of RPP.

In the case of Discharge Management, the clinician expressed the importance of visualizing information requirements to be implemented in the performance management tool as a sequence of logical steps in terms of what information is needed for indicators, who should collect this information using what forms in the tool, and what reports need to be implemented in the tool to monitor indicators and who should have access to them. We validated our framework provides a structured and logical approach that allowed the

clinician to map and communicate these requirements as a checklist to the software developer.

Similarly, we were able to validate the importance of this criterion in the SeeMe™ case study and how our framework was useful to ensure all information needs of actors (indicators) were included in the design of the system (data collection and reports) to then define and evaluate tools to support these. The systematic approach of our framework allowed participants to question indicators that were in use but that they determined were not relevant to measure a goal, or to question areas that needed monitoring that they had not previously thought of as well as steps they should follow to guarantee the implementation of the tool support for these.

Tool Support was a relevant criterion in the case studies of Resident Training and SeeMe™. However, it was not relevant for Discharge Management as the focus of this case study was on one single tool and on ensuring that the tool was designed to collect the right data to generate reports with indicators.

In the case of Resident Training, our framework was useful to demonstrate a lack of tool optimization to support indicators at the supervisory level of the program and suggest this as a strong hypothesis that explains why the RPP was phased out as a tool support from the program. The fact that there was no connection between the use of the tool at the micro level and that data collected at this level was not reviewed at the meso level, meant that actors at the meso level did not reinforce the use of the tool, and therefore, the tool was abandoned as part of tools support for managing the performance of the whole program.

In the case of SeeMe^{TM}, this evaluation criterion was relevant and we validated the use of our framework allowed participants to realize the tool support they had implemented to collect data and generate indicators can be further optimized, and new tools need to be developed to collect data for indicators they want to monitor but for which they did not have a reliable data source.

7.3. Comparison with Related Works

In this section, we look at the three case studies in Chapter 6. We evaluate how our framework is a better approach than related works or Ad-Hoc EHR approach for tool-supported performance management for clinical practice. We also summarize the shortcomings of our framework when compared to the related works.

7.3.1 Performance Management for Clinical Practice

In this section, we use the criteria defined in 4.4.1 to compare our framework against the related works described in section 2.4 as well as the “Ad-Hoc EHR" approach to performance management described in section 4.2.

In Table 19, we show by row if the related work; a. Provides a structured approach to meet the criterion for effective performance management, b. Addresses the criterion in an ad-hoc way but does not represent a barrier for meeting it, or 3. Does not provide a structured approach to meet the criterion and it is not possible to ensure the criterion is addressed. We use the following rubric color to evaluate the criteria:

- Green – Indicates a clear structure for ensuring the criteria is met.

- Yellow – Indicates no clear structure but rather and ad-hoc approach that does not constitute a barrier to address the criteria.
- Red – Indicates no structure for meeting the criteria.

Table 19: Performance Management - Evaluation of Framework against Related Works

Criteria	Ad-Hoc EHR	BSPS	CDMF	CanMEDS	Framework
1. Goal Dimensions	- Goals not always present	- Well defined dimensions (minimum four) - Goals setting by dimension	- Based on patient goals - Various dimensions are not required	- Balanced performance dimensions - Focused on training	- Based on clinical practice - No structured approach to guarantee balanced dimensions
2. Type of Indicators	- No limitation on type of indicators - Indicators based on data available and not on type of indicators	- Outcome and process indicators	- Outcome Indicators	- Process Indicators - Implicit outcome indicators	- No limitation on type of indicators - No structured approach to ensure both type of indicators
3. Clinical Practice Levels	- No concept of clinical practice levels	- No concept of clinical levels - Can be defined in cascade: top-down approach	- Focus is at micro level	- Focus is at micro level - Other levels are implicit	- Structured approach to ensure indicators for all levels
4. Data Lineage	- Ad-Hoc tool support - No data lineage	- No data lineage	- Who, what, when, where, and how for data collection by tool	- Who, what, when, where, and how for data collection by tool	- Who, what, when, where, and how for data collection and reports by tool
5. Indicators aligned with care practice goals	- Ad-Hoc - Goals inferred by indicators - Goal not always present	- Indicators mapped to goals by dimensions	- Indicators mapped to patient goals	- Indicators mapped by training area - Implicit goals	- Performance Measurement table to ensure alignment of indicators to goals
6. Care Process Interoperability	- No concept of care process interoperability	- Indicators optimized for a one organizational level - Top-bottom cascade approach to connect indicators across organizational levels	- Only one level: micro	- Indicators optimized for micro an meso level - Optimized for data collection at the micro level	- Indicators for all practice levels - Structured approach to link data collection and reports across all practice levels

BSPS and CanMEDS frameworks are developed around various performance dimensions. Goals and indicators are defined by dimension to ensure the overall performance management system is well balanced. CDMF and our framework do not use performance dimensions. CDMF goals are based on the patient's goals. Depending on a patient's goals, balance in goals dimensions can be achieved with this framework, but it is not the focus of the work. In our framework, while we map goals to different clinical practice levels, similarly to CDMF, the focus of our framework is not on goal dimensions. While it is possible to design a performance management system, with balanced goal dimensions following our approach, this would be a byproduct as we do not provide a structured approach to guarantee this criterion is met.

For Type of Indicators, BSPS is the only approach that guarantees a balance between process indicators and product indicators. Typically, financial performance measures are outcome indicators. The other dimensions of the BSPS may also include outcome indicators (e.g. customer or stakeholder satisfaction) but will mainly include process indicators. In the case of CDMF, the selection of indicators is primarily outcome indicators, first to determine a baseline and then to measure progress toward achieving a patient's goals. In CanMEDS, although the indicators are defined with the end goal in mind (outcomes) - e.g. patient safety, quality of care, eHealth, etc. -, indicators included in the framework are process indicators to achieve the desired outcome. In our framework and the Ad-Hoc EHR approach, there is no clear definition for the type of indicators. A performance management system that results from using any of these approaches may contain both types of indicators, but there are no clear steps to guarantee this. However,

the fact our framework provides a structured approach to guarantee indicators at the macro-level (regulatory level), it is very likely the resulting performance management system will include outcome measures as demonstrated in SeeMe^{TM} and Discharge Management case studies.

Levels of Clinical Practice are not the focus in Ad-Hoc EHR or CDMF. In Ad-Hoc EHR, indicators are not defined based on data needs for performance management at different levels but based on indicators that can be calculated based on available data or that are already available in a system. In the CDMF framework, indicators are mostly defined at the micro level to monitor the condition for a particular patient. In the case of BSPS, the indicators are defined based on performance dimensions. While clinical practice levels are not explicitly defined, a top-down approach can be followed to include indicators for lower organizational levels, including meso, and micro levels. Finally, our framework offers a systematic approach to ensure indicators are defined at all levels of clinical practice. This does not mean that indicators will be reviewed at all levels, but it allows mapping at what clinical practice level data is collected for an indicator and at what clinical practice level reports are reviewed.

With respect to Data Lineage, the Ad-Hoc EHR and BSPS approaches are not designed to capture, in a structured way, who, what, when, and how data is collected, and reports reviewed for indicators. With CDMF, CanMEDS, and our framework it is possible to track data lineage. In the CDMF approach, tools are selected and used by the clinician for data collection and subsequent review of reports to monitor the patient. Consequently, it is possible to determine for each indicator, who, what, when, and how the data is

collected. In the case of CanMEDS, tools are designed in a way that includes data about who is collecting the information, what data is collected, to measure what process, and using what indicators. Finally, in our framework, who collects data for an indicator, and in what tasks and processes are systematically mapped to each tool for guaranteeing data lineage for indicators.

In BSPS, CDMF, CanMEDS, and our framework, indicators are aligned with the goals. In BSPS, goals are defined by performance dimension and the next step in the framework is to define, for each goal, at least four to five indicators. In CDMF, the indicators (OMs) used to measure performance are closely linked to the patient's goals. CanMEDS start by defining what the final outcomes for the program are (the end in mind), and based on this, indicators are defined. Finally, in our framework, we use the Performance Measurement Model table to guide the process of mapping goals for each process and indicators to each goal. The systematic approach of our framework thus ensures that each process has an associated goal and each goal an associated indicator. In the case of Ad-Hoc EHR, there is no structured approach to ensure the indicators are aligned with goals of clinical practice. Frequently, the selection of indicators is based on what data is readily available or what data can be easily extracted from the EHR system.

Our framework is the only approach that provides a structured way to ensure the interoperability of care processes. The systematic process of defining data collection tasks for each indicator at all levels of the system and report review tasks for each indicator at all levels of the system ensures indicators are available to whoever needs them and when they are needed. In the case of BSPS, there is no a structured approach to ensure that if an

actor needs an indicator, he/she will have access to it in the appropriate process, as indicators are not explicitly linked to a process in the framework. There is also no structured approach to ensure data is collected in the appropriate processes for the indicator. Additionally, since scorecards are defined by organizational level, there is no guarantee that different scorecards for each organizational level will be linked to each other. In the case of CanMEDS, although there is no structured approach to guarantee interoperability, the framework focuses on processes at the micro level and it can be inferred that data collected for the indicators will be reviewed by the supervisory level. In the case of CDFM, this criterion is not relevant since it is the clinician who collects data and reviews the reports. Finally, in Ad-Hoc EHR there are no guidelines to guarantee interoperability.

7.3.2 **Design of Tool Support**

In this section, we use the criteria defined in 4.4.2 to evaluate our framework against related works and Ad-Hoc EHR. We evaluate how each approach meets the criteria to provide good guidance on how to operationalize a performance management strategy – how well is the design of tool support for performance management supported by each approach.

In Table 20, we show for each row to what extend each of the related works provides; a. A structured approach to meet the criteria for operationalizing a performance management strategy, b. An Ad-Hoc approach to address the criteria but that does not represent a barrier for meeting the criteria, or c. No structure for meeting the criteria. We use the following rubric color to evaluate the criteria.

- Green - Indicates a clear structure for meeting the criteria.

- Yellow - Indicates no formal structure for meeting the criteria. Ad-hoc approach but it possible to meet the criteria. Elements to meet the criteria are implicit.
- Red, indicates no structure on or guidance on how to meet the criteria.

Table 20: Design of Tool Support - Evaluation of Framework against Related Works

Criteria	Ad-Hoc EHR	BSPS	CDMF	CanMEDS	Framework
1.Participation of actors	- No structure - Ad-Hoc reports	- Hierarchical approach - Intra-organizational - Intra-departmental	- Clinician - Patient	- Learner - Assessor	- No structure - No limits on who participates - Some guidance based on participation model
2. Compact view of relevant process and actors	- No structure	- Processes by functional area/dimension - Actors can be inferred by functional area - Macro level	- Limited to clinician and patient - Micro level	- Limited to learner and assessor - View by process and learning stage - Focus on learner - Micro level	- Participation View – Map of actors to processes by clinical practice level - Micro, meso, and macro
3. Operationalization of the Performance Management Strategy	- Ad-Hoc - No structure for defining indicators - On as per needed basis	- From business vision to performance dimensions to goals to indicators - Processes and actors inferred	- Iterative process for selection of indicators - From initial set of indicators based on referral data to refined list based on observations and assessments	- Prescriptive - From roles to goals and sub-goals by learning stages to a pre-defined set of indicators	- Selection of an indicator if at least one actor reviews it to monitor a goal of clinical practice and one actor collects data for the indicator
4. Incorporation of Indicators	- Excel or ER - Tools not designed to support indicators	- Ad-Hoc - No guidance for mapping tools to data collection and review reports	- Structured approach for selecting tools	- Tools mapped to data collection tasks by performance area - No clear approach for review reports tools (can be inferred)	- Tools (existing, potential or missing) mapped to tasks types across all clinical practice levels
6. Tool support	- Ad-Hoc - Limited to Excel and EHR	- No guidance on how to integrate tool support	- OMs – Scales and Rubrics - One level of clinical practice (patient assessment)	- Scales and rubrics - Assessment tools by role and learning stage - Limited to training	- Indicator mapped to processes by clinical practice level - Support of multiple tools across clinical practice levels

For participation of actors, in CDMF and CanMEDS all actors are involved at the micro-level in the selection and customization of tool support. BSPS follows a hierarchical structure. There are no guidelines on who participates in the design of tool support, but actors can be inferred by functional area. In our framework, while there are no clear guidelines on who should participate, this could be inferred from actors mapped to each clinical practice level. Finally, in the Ad-Hoc EHR approach, participation in the design of tool support ranges from no participation (when the use of tools is limited to reports available in EHRs) to full involvement of actors when tools are fully designed by actors that will use the tools.

When we evaluate the second criterion, compact view of relevant actors and processes, our framework is the only approach that provides a structured approach to represent relevant actors and processes and relationships between them in a compact graphical view that includes all clinical practice levels. CanMEDS provides a graphical view of processes by actor type (learner stage) but the compact view is limited to only one level of clinical practice – micro. It can be inferred though, that a supervisory level will review the performance of all processes included at the micro-level. CDMF involves only two actors: clinician-patient. BSPS provides a compact view of multiple processes (based on functional areas), but only at the macro level. While actors are not explicitly represented in the view, they can be inferred by functional area. Finally, with the Ad-Hoc EHR approach, it is not possible to get a whole view of processes and actors for tool support.

With regard to the operationalization of the performance management strategy, CDMF, CanMEDS and our framework follow a structured approach for decomposing a

strategy into indicators that operationalize it. CDMF starts with an initial selection of possible indicators that best matches what needs to be measured based on known variables. The initial set of indicators is reduced to a final list following an iterative process where additional information is gathered during observations and patient assessments (e.g. physical evaluations). CanMEDS uses a prescriptive approach. One selects a performance area (role), goal and sub-goals, and learning stage, and the framework provides a set of indicators that meet the selected criteria. In our framework, indicators in a performance management strategy are implemented only if there is one actor, at any clinical practice level, that reviews the indicator for monitoring a process goal, and if there is at least one actor that collects data for this indicator. BSPS offers a structured approach to select indicators to operationalize the strategy by defining goals by dimension and indicators to measure each goal. The issue is that defining indicators only at a conceptual level is no guarantee that the right data for the indicators will be collected, and the right actors will have access to the right indicators. Moreover, by not being able to visualize what actor reviews what data and at what process level, may lead to redundant or too vague indicators.

For incorporation of indicators, CDMF and our framework provide a structured approach for mapping indicators to tool support. CDMF leverages content from two other frameworks, one is for identifying categories of tests and indicators and the second framework is for selecting specific tests and indicators. The clinician is the actor that collects data for the indicators and reviews these indicators with the patient. There is no disconnect between data collection and report reviews with this approach as the tool selected is used by the same actor. In our framework, tables are linked in a way that ensures there are at least one data collection task and one review report task per indicator, and there

is only one tool mapped to each task. The approach ensures there is no redundancy in tool support for tasks, and that all tasks are supported by a tool. CanMEDS provides a set of tools for collecting data for indicators by performance area (role). However, it is not clear how actors at other clinical practice levels review reports and what tools support this task type. While BSPS does not provide a structured approach for ensuring tool support for data collection and review report tasks, the structured approach for defining indicators by performance dimension allows for the mapping of tools to indicators. Finally, in Ad-Hoc EHR, tools are not mapped to indicators but instead, indicators are limited to data available in EHR systems or based on ad-hoc data collected and reported in spreadsheets.

Finally, CDMF, CanMEDS, and our framework all provide a structured approach for tool support. In CDMF the approach focus is on how to select the correct tool (tests, scales, and rubrics) for the patient's specific condition and goals. Tools, however, are mapped only at one clinical practice level. CanMEDS uses scales and rubrics mapped by performance area (learner role), but these tools are limited to one clinical practice level – micro.

7.4. Assumptions, Limitations and Threats to Validity

7.4.1 **Assumptions**

Our framework assumes Data Collection and Report Reviews are the essential tasks for Performance Management. We also assumed using indicators is the only way to measure goals and manage performance. We acknowledge there could be other tasks and approaches to manage performance, such as how to motivate teams using of rewards and incentives or training.

We also assumed that a clinical practice (actors that participated in processes and tasks) was able to effectively articulate its goals, processes, and performance management tasks.

Another assumption we made was that the clinical practice could effectively spot inconsistencies, incompleteness, and inaccuracies in its performance management system by manually reviewing the diagram and tables of our framework. In practice, though, results from the case studies made evident this was increasingly difficult to achieve as the size and complexity of the tables increased non-linearly as the numbers of rows in the tables increases.

Finally, we assumed that the only way to collect data and review reports for performance management was in tasks performed by people or that it could be characterized that way. We did not fully investigate how the role of sensors or wearable technologies, e.g. a Fitbit device worn by a patient to collect health data, and technologies for reports, e.g. Artificial Intelligence to raise alerts, would be modeled as a Data Collection task by a patient and the alert would have been a Report Review task a person receives.

7.4.2 **Limitations**

A limitation of our framework is that there is no reference to the frequency in which reports should be generated for an indicator. This limitation was evident in the stakeholders' evaluation of the case study Residents Training. The stakeholders suggested that it is important to determine how frequent reports should be reviewed to establish the right balance in the amount of data reported, as too much information can cause overload in the system. In our framework, it is clear who collects data for an indicator, what reports are

reviewed for an indicator, and what actor and in what process and task reports are reviewed, but the frequency with which the indicators should be reviewed is not part of our framework. We suggest as future work to include and evaluate the frequency of indicators as part of the Performance Measurement model in our framework.

Our framework provides a structured approach that uses diagrams and tables for mapping indicators to data collection tasks and review report tasks. We realized ensuring consistency between data in diagrams and tables ad between tables, proved to be challenging for participants without the right tool support. Our framework involves manual work to populate tables and this approach is prone to errors and inconsistencies. We found inconsistencies in the spreadsheets templates reason why we had to clean up the tables and diagrams we presented in this thesis to ensure data consistency and clarity of the arguments exposed. This is a clear limitation of our framework. Without the use of an application for populating tables and diagrams, that validate consistency of data between tables, it is not clear whether another group can use our framework without our guidance.

Another limitation of this work is that we did not consider issues related to semantic or technology interoperability between tools and with respect to existing EHR systems. Interoperability, adoption and other evaluation criteria are only considered with respect to a single tool on its own in the context of our Tool Support Design Methodology.

Lastly, we acknowledge there is no guarantee our framework will improve clinical practice, and this outside the scope of our thesis.

7.4.3 Threats to validity

One threat to the validity of this work is that all three case studies we used for evaluation of our framework are limited to community care clinical practice. More case studies need to be conducted to confirm our framework can be applied to any other type of clinical practice, e.g. design of tool support for performance management of ICUs.

Another threat to this thesis's validity is that the researcher of this thesis was the only interviewer during the stakeholders' feedback sessions. Also, the researchers were the only facilitators in the three case studies. We acknowledge this introduces bias to the research. As such, we suggest more case studies need to be conducted in where our framework is used with the participation of other facilitators, and review and feedback sessions are conducted by more than one interviewer.

7.5. Chapter Summary

In this chapter, we presented the different methods we use to assess the validity of our framework. In the first section of the chapter, we described results from review and feedback sessions carried out with healthcare stakeholders and participants for each of the case studies. Then, we evaluated our framework across the three case studies to determine whether there is enough evidence our framework addresses the criteria described in section 4.4. Finally, we compared our framework with current practice and related works, described in section 2.4., to determine to what extend our framework represents an improvement to the current situation or related works. Finally, we stated what our assumptions were in doing this research, the limitations of our framework, and identify the main threats to validity in our work.

Chapter 8. Conclusions and Future Work

Our framework provides a systematic and structured approach, guided by a set of tables and diagrams, to reduce the complexity of clinical practice into a sequence of steps for defining and validating how performance management of a clinical practice is operationalized with tool support.

Based on our understanding of the current practice and review of the literature, we identified gaps for instrumentation of PMS for clinical practice; namely lack of adequate tool support for performance management, issues related to data collection and data sharing in healthcare organizations, lack of a systematic approach to translate the strategy into performance indicators to improve processes, use of standard data definitions, poor coordination between processes for performance management across different units, and lack of a common view on the quality of care, how to assess performance, and who is to assess performance.

Based on the gaps identified, we proposed a list of evaluation criteria that we used to evaluate our framework and related works. We used three case studies to validate each of the evaluation criteria had been a focus area in at least one of the case studies, and therefore, that we could use the evaluation criteria to evaluate our framework. We also used the evaluation criteria to compare our framework against related works.

Based on the comparison with related works, we can conclude our framework is a better approach to address care process interoperability issues and ensure the information

needs of all actors across all clinical practice levels have adequate tool support to operationalize a PMS.

Our framework also provides an approach to help understand the complexity of a clinical practice using a list of relevant components for the operationalization of the performance management strategy. The clinical practice is represented in a compact way - what actors in what task and process of clinical practice need tool support to perform a PM task that supports indicators to measure goals of the clinical practice.

Our framework was well accepted by clinicians and administrators that participated in the three case studies. All participants in the three case studies found the Performance Management Participation diagram useful as a visual tool to depict a complex whole system. The use of a sequence of diagrams and tables was also reported as useful to develop the complete picture of the clinical practice in terms of a performance management system and to gain consensus on the terminology used, use of indicators, and tool selection to operationalize the system. However, participants of the three case studies all agreed it is not easy to navigate the tables and keep consistency between data in tables without having appropriate tool support. Finally, all participants of the case studies agreed our framework is very useful to structure the communication amongst team members responsible for the design of the tool support.

8.1.1 **Future Work**

Considering the effort required to maintain consistency of the information between the Performance Management Participation View and Performance Measurement View tables, we suggest as future work to develop better tool support for creating and

maintaining the information in the diagrams and tables of our framework. The tool should be designed in such a way that ensures consistency between the information in the tables and facilitates navigation between tables.

Also, we suggest as future work to conduct more case studies where our framework is applied to different types of clinical practice, e.g. management of an ICU. We also suggest conducting more case studies where the framework is applied to a clinical practice that involve multiple organizations. This will help validate the transferability of our framework and confirm our findings.

Finally, and as suggested by the stakeholder in one of the case studies, we suggest exploring adding a “Meta” level as a new level of Clinical Practice. Actors at this level of Clinical Practice will be responsible for the review of the performance management system including the efficacy and appropriateness of tool support. This would be necessary to complete the picture of tool support for performance management of a clinical practice.

References

Acito, Frank, and Vijay Khatri. 2014. “Business Analytics: Why Now and What Next?” *Business Horizons* 57: 565–70.

American Physical Therapy Association. 2016. “Guide to Physical Therapist Practice.” 2016. http://guidetoptpractice.apta.org/.

Anderson, Ruth A., Benjamin F. Crabtree, David J. Steele, and Reuben R. McDaniel. 2005. “Case Study Research: The View from Complexity Science.” *Qualitative Health Research* 15 (5): 669–85.

Avison, D. E., R. M. Davison, and J. Malaurent. 2018. “Information Systems Action Research: Debunking Myths and Overcoming Barriers.” *Information & Management* 55 (2): 177–87.

Avison, David, and Terry Young. 2007. “Time to Rethink Health Care and ICT?” *Commun.ACM* 50 (6): 69–74.

Ayrinen, Kristiina H ¨, Kaija Saranto, Pirkko Nykänen, and Nyk¨ Nykänen. 2007. “Definition, Structure, Content, Use and Impacts of Electronic Health Records: A Review of the Research Literature.”

Azvine, B, D Nauck, and C Ho. 2003. “Intelligent Business Analytics-a Tool to Build Decision-Support Systems for EBusinesses.” *BT Technology Journal* •. Vol. 21.

Backman, Chantal, Anne Harley, Craig Kuziemsky, Jay Mercer, and Liam Peyton. 2020. “MyPath to Home Web-Based Application for the Geriatric Rehabilitation Program at Bruyère Continuing Care: User-Centered Design and Feasibility Testing Study.” *JMIR Formative Research* 4 (9): e18169.

Bauer, Kent. 2004. “KPIs - The Metrics That Drive Performance Management.” *Information Management* 14 (9): 63.

Belfield, Clive, Hywel Thomas, Alison Bullock, Rebecca Eynon, and David Wall. 2001. “Measuring Effectiveness for Best Evidence Medical Education: A Discussion.” *Medical Teacher* 23 (2): 164–70.

Benson, Tim. 2012. “Principles of Health Interoperability HL7 and SNOMED. Chapter 2: Why Interoperability Is Hard.” In . Principles of Health Interoperability HL7 and SNOMED. Springer Science & Business Media.

Bhaskaran, Sabishaw, Girish Suryanarayana, Amarnath Basu, and Roshan Joseph. 2013. “Cloud-Enabled Search for Disparate Healthcare Data: A Case Study.” In *2013 IEEE International Conference on Cloud Computing in Emerging Markets (CCEM)*, 1–8. IEEE.

Bourne, M, A Neely, J Mills, and K Platts. 2003. “Implementing Performance Measurement Systems: A Literature Review.” *Int. J. Business Performance Management*. Vol. 5.

Brooks, Michael. 2005. “Defining and Measuring KPIs and Metrics.” *Business Intelligence Journal* 10 (3): 44–50.

Campbell, S. M., M. O. Roland, and S. A. Buetow. 2000. “Defining Quality of Care.” *Social Science and Medicine* 51 (11): 1611–25.

Canadian Institute for Health Information. 2013. *A Performance Measurement*

Framework for the Canadian Health System (Updated November 2013). Canadian Electronic Library. Canadian Health Research Collection. Canadian Institute for Health Information.
Cappelli, Peter, and Anna Tavis. 2016. "The Performance Management Revolution." *Harvard Business Review*, 2016.
Cate, Olle ten. 2013. "Nuts and Bolts of Entrustable Professional Activities." *Journal of Graduate Medical Education* 5 (1): 157–58.
Chamney, A, P Mata, G Viner, D Archibald, and L Peyton. 2014. "Development of a Resident Practice Profile in a Business Intelligence Application Framework." In *The 4th International Conference on Current and Future Trends of Information and Communication Technologies in Healthcare (ICTH-2014)*.
Chamney, Austin, Pilar Mata, Gary Viner, Doug Archibald, and Liam Peyton. 2014. "Development of a Resident Practice Profile in a Business Intelligence Application Framework." *Procedia Computer Science* 37 (0): 266–73.
Chan, Kitty S, Jinnet B Fowles, and Jonathan P Weiner. 2009. "Electronic Health Records and the Reliability and Validity of Quality Measures: A Review of the Literature." *Reviews Medical Care Research and Review* 67 (5): 503–27.
Chen, Chiang. 2010. "Business Intelligence and Analytics: From Big Data To Big Impact." *MIS Quarterly* 36 (4): p.1165-1188.
College of Family Physicians of Canada. 2020. "Standards of Accreditation for Residency Programs in Family Medicine." Mississauga, ON:
Crabtree, Benjamin F., and William L. Miller. 1999. *Doing Qualitative Research*. 2nd. CA: Thousand Oaks; Sage Publications.
Curtright, J W, S C Stolp-Smith, and Es Edell. 2000. "Strategic Performance Management: Development of a Performance Measurement System at the Mayo Clinic." *Journal Of Healthcare Management; J.Healthc.Manag.* 45 (1): 58–68.
Davies, H T O, and J Lampel. 1998. "Trust in Performance Indicators?" *Quality in Health Care* 7: 159–62.
Dicianno, Brad E, Bambang Parmanto, Andrea D Fairman, Theresa M Crytzer, X Yu Daihua, Gede Pramana, Derek Coughenour, and Alan A Petrazzi. 2015. "Perspectives on the Evolution of Mobile (MHealth) Technologies and Application to Rehabilitation." *Physical Therapy* 95 (3): 397–405.
Dixon, Brian E, Daniel J Vreeman, and Shaun J Grannis. 2014. "The Long Road to Semantic Interoperability in Support of Public Health: Experiences from Two States." *Journal of Biomedical Informatics* 49: 3–8.
Doerr, J. 2018. *Measure What Matters: How Google, Bono, and the Gates Foundation Rock the World with OKRs.* Penguin.
Donabedian, Avedis. 1988. "The Quality of Care: How It Can Be Assessed?" *JAMA* 260 (12): 1743.
Dresner, Howard. 2008. *The Performance Management Revolution: Business Results through Insight and Action*. John Wiley & Sons.
Esmail, Nadeem, and Maureen Hazel. 2009. "Hospital Report Card: Ontario 2009." www.fraserinstitute.org.
Ferenchick, Gary S, David Solomon, Jami Foreback, Basim Towfiq, Kevin Kavanaugh, Larry Warbasse, James Addison, Frances Chames, Alvin Dandan, and Asad Mohmand. 2013. "Mobile Technology for the Facilitation of Direct Observation and

Assessment of Student Performance." *Teaching and Learning in Medicine* 25 (4): 292–99.
Ferreira, Aldónio, and David Otley. 2009. "The Design and Use of Performance Management Systems: An Extended Framework for Analysis." *Management Accounting Research* 20 (4): 263–82.
Foshay, Neil, and Craig Kuziemsky. 2014. "Towards an Implementation Framework for Business Intelligence in Healthcare." *International Journal of Information Management* 34 (1): 20–27.
Frank, Jason R, and Deborah Danoff. 2007. "Medical Teacher The CanMEDS Initiative: Implementing an Outcomes-Based Framework of Physician Competencies The CanMEDS Initiative: Implementing an Outcomes-Based Framework of Physician Competencies." *Medical Teacher* 29 (7): 642–47.
Frank, Jason R, Linda S Snell, Olle Ten Cate, Eric S Holmboe, Carol Carraccio, Susan R Swing, Peter Harris, Nicholas J Glasgow, Craig Campbell, and Deepak Dath. 2010. "Competency-Based Medical Education: Theory to Practice." *Medical Teacher* 32 (8): 638–45.
Gartner. 2013. "IT Glossary - EHR."
Gaynor, Mark, Feliciano Yu, Charles H Andrus, Scott Bradner, and James Rawn. 2014. "A General Framework for Interoperability with Applications to Healthcare." *Health Policy and Technology* 3 (1): 3–12.
Geert Bouckaert, John Halligan. 2007. "Performance Management." In *Managing Performance: International Comparisons*, 1st Editio, 100–127. London: Routledge Taylor & Francis Group.
Gerring, John. 2006. *Case Study Research: Principles and Practices*. New York: Cambridge University Press.
Goddard, M, H T Davies, D Dawson, R Mannion, and F McInnes. 2002. "Clinical Performance Measurement: Part 1--Getting the Best out of It." *Journal of the Royal Society of Medicine* 95 (10): 508–10.
Goh, Swee C., Christopher Chan, and Craig Kuziemsky. 2013. "Teamwork, Organizational Learning, Patient Safety and Job Outcomes." *International Journal of Health Care Quality Assurance* 26 (5): 420–32.
Gregor, Shirley, and Alan R. Hevner. 2013. "Positioning and Presenting Design Science Research for Maximum Impact." *MIS Quarterly* 37 (2): 337–355.
Gunter, Tracy D, and Nicolas P Terry. 2005. "The Emergence of National Electronic Health Record Architectures in the United States and Australia: Models, Costs, and Questions." *Journal of Medical Internet Research* 7 (1): e3.
Gurd, Bruce, and Tian Gao. 2008. "Lives in the Balance: An Analysis of the Balanced Scorecard (BSC) in Healthcare Organizations." *International Journal of Productivity and Performance Management* 57 (1): 6–21.
Hancock, Dawson R., and Bob Algozzine. 2017. *Doing Case Study Research: A Practical Guide for Beginning Researchers - Dawson R. Hancock, Bob Algozzine - Google Books*. 3rd Editio. New York and London: Teachers College Press.
Hevner, Alan. 2010. *Design Research in Information Systems: Theory and Practice*. Springer US.
Inamdar, Noorein ;, Robert S; Kaplan, and Kimberly Reynolds. 2002. "Applying the Balanced Scorecard in Healthcare Provider Organizations / Practitioner's Respons."

Journal of Healthcare Management 47 (3): 179–95.
Jeston, John, and Johan Nelis. 2008. *Management by Process | A Roadmap to Sustainable Business Process Management*. *ScienceDirect*. Elsevier Ltd.
Kadri, Nour El, and Liam Peyton. 2017. "A Systematic Literature Review Comparing Primary and Community Health Care Indicators and Measurement Frameworks." *Procedia Computer Science* 113: 384–91.
Kahn, James G., Joshua S. Yang, and James S. Kahn. 2010. "'Mobile' Health Needs and Opportunities in Developing Countries." *Health Affairs* 29 (2): 254–61.
Kannampallil, Thomas G., Guido F. Schauer, Trevor Cohen, and Vimla L. Patel. 2011. "Considering Complexity in Healthcare Systems." *Journal of Biomedical Informatics* 44 (6): 943–47.
Kaplan, R. S., R. E. Kaplan, D. P. Norton, T. H. Davenport, and D. P. Norton. 2004. *Strategy Maps: Converting Intangible Assets Into Tangible Outcomes*. Harvard Business Press.
Kaplan, Robert S, and David P Norton. 1992. "The Balanced Scorecard--Measures That Drive Performance." *Harvard Business Review* 70 (1): 71–79.
———. 1996. "Linking the Balanced Scorecard to Strategy." *California Management Review* 39 (1): 53–79.
Kronz, Andreas. 2006. "Managing of Process Key Performance Indicators as Part of the ARIS Methodology." In , 31–44. Springer Berlin Heidelberg.
Kuziemsky, C. E., H. Monkman, C. Petersen, J. Weber, E. M. Borycki, S. Adams, and S. Collins. 2014. "Big Data in Healthcare - Defining the Digital Persona through User Contexts from the Micro to the Macro. Contribution of the IMIA Organizational and Social Issues WG." *Yearbook of Medical Informatics* 9 (01): 82–89.
Kuziemsky, C. E., and L. Peyton. 2016. "A Framework for Understanding Process Interoperability and Health Information Technology." *Health Policy and Technology* 5 (2): 196–203.
Kuziemsky, Craig. 2016. "Decision-Making in Healthcare as a Complex Adaptive System." *Healthcare Management Forum* 29 (1): 4–7.
Lebas, Michel J. 1995. "Performance Measurement and Performance Management." *International Journal of Production Economics* 41 (1): 23–35.
Lilford, Richard, Mohammed A Mohammed, David Spiegelhalter, and Richard Thomson. 2004. "Use and Misuse of Process and Outcome Data in Managing Performance of Acute Medical Care: Avoiding Institutional Stigma." *The Lancet* 363 (9415): 1147–54.
Lvaro Rebuge, A ´, Diogo R Ferreira, Hospital De S ~ Ao Sebasti, and ~ Ao. 2012. "Business Process Analysis in Healthcare Environments: A Methodology Based on Process Mining." *Information System* 37 (2): 99–116. http://prom.sourceforge.net.
Mannion, Russell, and Huw T. O. Davies. 2002. "Reporting Health Care Performance: Learning from the Past, Prospects for the Future." *Journal of Evaluation in Clinical Practice* 8 (2): 215–28.
Mant, Jonathan. 2001. "Process versus Outcome Indicators in the Assessment of Quality of Health Care | International Journal for Quality in Health Care | Oxford Academic." *International Journal for Quality in Health Care* 13 (6): 475–80.
Marcotte, Leah, Janhavi Kirtane, Joanne Lynn, and Aaron McKethan. 2015. "Integrating Health Information Technology to Achieve Seamless Care Transitions." *Journal of*

Patient Safety 11 (4): 185–90.
Marshall, Martin N., Paul G. Shekelle, Huw T.O. Davies, and Peter C. Smith. 2003. "Public Reporting On Quality In The United States And The United Kingdom." *Health Affairs* 22 (3): 134–48.
Mata, Pilar, Aladdin H Baarah, Craig Kuziemsky, and Liam Peyton. 2014. "An Application Meta-Model for Community Care." In *Procedia Computer Science*, 37:465–72.
Mata, Pilar, Austin Chamney, Gary Viner, Douglas Archibald, and Liam Peyton. 2015. "A Development Framework for Mobile Healthcare Monitoring Apps." *Personal and Ubiquitous Computing* 19 (3–4): 623–33.
Mata, Pilar, Craig Kuziemsky, and Liam Peyton. 2016. "A Development Methodology for a Stroke Rehabilitation Monitoring Application." In *HEALTHINF*, 400–405.
———. 2019. "A Framework for Performance Management of Clinical Practice." In *12th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2019)*, 286–93.
Mata, Pilar, and Liam Peyton. 2015. "A Methodology for Development of Clinical Performance Monitoring Applications." University of Ottawa.
Mitchell, P. H., Ferketich, S., & Jennings, B. M. 1998. "Quality Health Outcomes Model." *The Journal of Nursing Scholarship* 30 (1): 43.
Mouttham, A, C Kuziemsky, D Langayan, L Peyton, and J Pereira. 2012. "Interoperable Support for Collaborative, Mobile, and Accessible Health Care." *Information Systems Frontiers* 14 (1): 73–85.
Neely, Andy, Mike Gregory, and Ken Platts. 2005. "Performance Measurement System Design A Literature Review and Research Agenda." *International Journal of Operations & Production Management* 25 (12): 1228–63.
Neely, Andy, John Mills, Ken Platts, Huw Richards, Mike Gregory, Mike Bourne, and Mike Kennerley. 2000. "Performance Measurement System Design: Developing and Testing a Process-Based Approach." *International Journal of Operations and Production Management*.
ng, G., Grossman, J. H., Compton, W. D., & Reid, P. P. (Editors). 2005. "The Tools of Systems Engineering." In *Building a Better Delivery System: A New Engineering/Health Care Partnership*, edited by P. P. Fanjiang, G., Grossman, J. H., Compton, W. D., & Reid. National Academies Press.
Nilsen, Per. 2015. "Making Sense of Implementation Theories, Models and Frameworks." *Implementation Science* 10 (1).
Niven, Paul R., ed. 2012. "Performance Measurement and the Need for a Balanced Scorecard." In *Balanced Scorecard Step-By-Step*, 1–29. Wiley Online Books. John Wiley & Sons.
Nixon, Judith M. 2006. "Quality and Total Quality Management." In *Encyclopedia of Management*, edited by Marilyn M. Helms, 5th ed., 735–41. Gale.
Ontario. Ministry of Health and Long-Term Care; University of Toronto; Canadian Institute for Health Information; Ontario Hospital Association. 2006. "A Joint Initiative of the Ontario Hospital Association and the Government of Ontario Hospital Report." https://secure.cihi.ca/free_products/OHA_2006_e.pdf.
Parsons, Amanda, Colleen Mccullough, Jason Wang, and Sarah Shih. 2012. "Validity of Electronic Health Record-Derived Quality Measurement for Performance

Monitoring." *J Am Med Inform Assoc* 19: 604–9. https://academic.oup.com/jamia/article-abstract/19/4/604/2909209.
Peffers, Ken, Tuure Tuunanen, Marcus A Rothenberger, and Samir Chatterjee. 2007. "A Design Science Research Methodology for Information Systems Research." *Journal of Management Information Systems* 24 (3): 45–77.
Perlin, Jonathan B, Robert M Kolodner, and Robert H Roswell. 2004. "The Veterans Health Administration: Quality, Value, Accountability, and Information as Transforming Strategies for Patient-Centered Care." *The American Journal of Managed Care* 10 (11 Pt 2): 828.
Porter, Michael E. 2010. "What Is Value in Health Care?" *New England Journal of Medicine* 363 (26): 2477–81.
Potter, Kirsten, George D Fulk, Yasser Salem, and Jane Sullivan. 2011. "Outcome Measures in Neurological Physical Therapy Practice: Part I. Making Sound Decisions." *Journal of Neurologic Physical Therapy* 35 (2): 57–64.
Reid, Proctor P, W Dale Compton, Jerome H Grossman, Gary Fanjiang, National Academy of Engineering (US) and Institute of Medicine, and Committee on Engineering and the Health Systems Care. 2005. "A Framework for a Systems Approach to Health Care Delivery." In *Building a Better Delivery System*. National Academies Press (US).
Riley, William J., John W. Moran, Liza C. Corso, Leslie M. Beitsch, Ronald Bialek, and Abbey Cofsky. 2010. "Defining Quality Improvement in Public Health." *Journal of Public Health Management and Practice*.
Roth, Carol P, Yee-Wei Lim, Joshua M Pevnick, Steven M Asch, and Elizabeth A Mcglynn. 2009. "The Challenge of Measuring Quality of Care From the Electronic Health Record." *American Journal of Medical Quality* 24 (5): 385–94.
Rowland, Caroline, and Roger Hall. 2014. "Management Learning, Performance and Reward: Theory and Practice Revisited." *Journal of Management Development* 33 (4): 342–56.
Royal College of Physicians and surgeons of Canada. n.d. "CanMEDS: Better Standards, Better Physicians, Better Care." Accessed February 3, 2021. https://www.royalcollege.ca/rcsite/canmeds/canmeds-framework-e.
Royal College of Physicians and Surgeons of Canada. 2015. "CanMEDS // Guide." 2015. http://canmeds.royalcollege.ca/guide.
———. 2020a. "CanMEDS // Milestones." 2020. http://canmeds.royalcollege.ca/en/milestones.
———. 2020b. "The Royal College of Physicians and Surgeons of Canada :: About CanMEDS." 2020. http://www.royalcollege.ca/rcsite/canmeds/about-canmeds-e.
———. 2020c. "The Royal College of Physicians and Surgeons of Canada :: EPAs and CanMEDS Milestones." EPAs and CanMEDS Milestones. 2020. http://www.royalcollege.ca/rcsite/cbd/implementation/cbd-milestones-epas-e.
Royal College of Physicians and Surgeons of Canada, Jason R Frank, Linda Snell, and Jonathan Sherbino. 2015. "CanMEDS 2015 Physician Competency Framework." 2015. http://canmeds.royalcollege.ca/uploads/en/framework/CanMEDS 2015 Framework_EN_Reduced.pdf.
Sadeghi, Payam, Morad Benyoucef, and Craig Kuziemsky. 2012. "A Mashup Based Framework for Multi Level Healthcare Interoperability." *Information Systems*

Frontiers; A Journal of Research and Innovation 14 (1): 57–72.
Sadeghi, Payam, Craig Kuziemsky, and Morad Benyoucef. 2011. "Towards a Readiness Model for Health 2.0." In *Proceedings of the International Conference on Management of Emergent Digital EcoSystems*, 202–9. ACM.
Sebastian-Coleman, Laura. 2013. "Data Management, Models, and Metadata." In *Measuring Data Quality for Ongoing Improvement*, 27–37. Elsevier.
Shortell, Stephenm, James L O'brien, James M Carman, Richard W Foster, Edward F X Hughes, Heidi Boerstir, and Edwardj O'connor. 1995. "Assessing the Impact of Continuous Quality Improvement/Total Quality Management: Concept versus Implementation." *Health Services Research* 30 (2): 337.
Smith, Peter C, Elias Mossialos, and Irene Papanicolas. 2008. "Performance Measurement for Health System Improvement: Experiences, Challenges and Prospects." http://www.euro.who.int/pubrequest.
Sullivan, Jane E, A Williams Andrews, Desiree Lanzino, Aimee Peron, and Kirsten A Potter. 2011. "Outcome Measures in Neurological Physical Therapy Practice: Part II. A Patient-Centered Process." *Journal of Neurologic Physical Therapy* 35 (2): 65–74.
Sunnybrook, Health Sciences Centre. 2018. "Sunnybrook's Strategic Balanced Scorecard." https://sunnybrook.ca/uploads/1/welcome/strategy/balanced_scorecard_june-2018-release.pdf.
System, National Academy of Engineering (US) and Institute of Medicine (US)Committee on Engineering and the Health Care, Proctor P Reid, W Dale Compton, Jerome H Grossman, and Gary Fanjiang. 2005. "A Framework for a Systems Approach to Health Care Delivery."
The Perley and Rideau Veteran's Health Center. n.d. "Goals of Care & Future Health and Personal Care Preferences." The Perley and Rideau Veteran's Health Center. Accessed October 24, 2020. http://www.perleyrideau.ca/upload/documents/goals-of-care-seeme.pdf.
The Perley and Rideau Veteran's Health Centre. 2019. "SeeMe Conference Agenda." 2019. http://www.perleyrideau.ca/upload/documents/care-conference-agenda-seeme.pdf.
The Perley and Rideau Veterans' Health Centre. 2019a. "The Perley and Rideau Veterans' Health Centre - SeeMe: Understanding Frailty Together." 2019. http://www.perleyrideau.ca/seeme.
———. 2019b. "What Is Frailty?" Ottawa, Ont. www.PerleyRideau.ca.
The Royal College of Physicians and Surgeons of Canada. 2011. "CanMEDS Framework: Better Standards, Better Physicians, Better Care." 2011. http://www.royalcollege.ca/rcsite/canmeds/canmeds-framework-e.
Viner, Gary, Eric Wooltorton, and Douglas Archibald. 2014. "Evaluating Field Notes in a Canadian Family Medicine Residency Program Competency-Based Residency Interviews for Family Medicine at University of Ottawa View Project Development of Family Medicine Resident Benchmarks (Learning Outcomes) View Project."
Voelker, Kathleen E., Jonathon S. Rakich, and G. Richard French. 2001. "The Balanced Scorecard in Healthcare Organizations: A Performance Measurement and Strategic Planning Methodology." *Hospital Topics* 79 (3): 13–24.

Wachtel, T L, C E Hartford, and J A Hughes. 1999. “Building a Balanced Scorecard for a Burn Center.” *Burns* 25 (5): 431–37.
Walliman, Nicholas S. R. 2011. *Research Methods: The Basics*. Edited by Routledge. London: Taylor and Francis.
Walsh, Judith, Kathryn M McDonald, Kaveh G Shojania, Vandana Sundaram, Smita Nayak, Sheryl Davies, Robyn Lewis, et al. 2005. “Methods.” *Closing the Quality Gap: A Critical Analysis of Quality Improvement Strategies* 3 (Hypertension Care)).
Weske, Mathias. 2012. *Business Process Management*. Berlin, Heidelberg: Springer Berlin Heidelberg.
Wongrassamee, S., J. E.L. Simmons, and P. D. Gardiner. 2003. “Performance Measurement Tools: The Balanced Scorecard and the EFQM Excellence Model.” *Measuring Business Excellence*.
World Health Organization. n.d. “Quality of Care.” Accessed November 4, 2020. https://www.who.int/health-topics/quality-of-care#tab=tab_1.
———. 2019. “WHO | International Classification of Functioning, Disability and Health (ICF).” 2019. https://www.who.int/classifications/icf/en/.

APPENDIX I: Discharge Management Framework Combined table

Actors (Who?)	Tasks/ Processes (What?)	Where /When?	Tools/ documents (How?)	Task type	Goals (Why?)	Indicators
Research Assistant	**ONBOARDING / REGISTRATION** • Obtains paper-based consent from patient and/or caregiver to participate in study • Registers patient and/or caregiver to Path to Home	On admission to geriatric rehabilitation	Patient registration: • Landing page link • Generic Bruyère email address for study purposes?	Registration	To access Path to Home	# of users (and type- patient, informal caregiver)
Patient or caregiver *(can be done with research assistant or volunteer)*	• Patient or caregiver logs into the system • Research assistant or volunteer provides training on Path to Home • Patient or caregiver complete socio-demographic questionnaire • Patient or caregiver completes "My needs" checklist • Patient views geriatric rehabilitation information after completing the survey and checklists	On unit during the first week	• Socio-demographic questionnaire • Technology readiness index assessment • My needs checklist • Information for patient once surveys are completed	Data collection	To obtain patient information about their needs and preferences	Types of needs identified
Research Assistant and Patient or caregiver	• Research assistant provides access to the patient's health care providers (names, roles, and email addresses) *(i.e., Physician, Nurse, Social worker, Pharmacist, Physiotherapist, Occupational therapist, and Primary care provider)*	On unit during the first week	• Names, roles, and email address of providers (drop down menu)	Data collection	To give access to members of the healthcare team	# of users (by provider type)
Team	**Nurse or primary team contact** reviews and presents the Patient's "My needs" checklist during rounds • Identify primary team contact (SW, OT, or PT) • Enters expected discharge date • Enters patient specific goals of care • Discharge destination	Interprofessional team rounds (week 1)	• Rounds follow-up form	Data collection	To provide specific discharge and transition information to patient and informal caregiver	# of patients with expected discharge data # of patients with goals of care identified # of patients with discharge destination identified
Primary team contact (with patient)	• Meets with patient and/or informal caregiver to follow-up on patient and informal caregiver needs identified on checklist and discuss established goals (from rounds) • Identifies resources (available in the application) specific to the patient's established goals and needs	On unit after rounds	• List of resources based on established goals	Review and print report Track progress on goals	Usability	% of goals achieved
Patient/ caregiver	• Reviews specific resources based on their needs • Updates "My Needs" checklist as needed	On unit during their stay		View	To access specific resources identified by health care team	# of logins # of resources viewed # of completed learning resources
Physiotherapist	• Home exercise program (?pdf or take photo and upload or checklist) • Equipment needed at home	On unit during their stay	• Equipment, list of suppliers and exercise	Pdf and images upload		

Actors (Who?)	Tasks/ Processes (What?)	Where /When?	Tools/ documents (How?)	Task type	Goals (Why?)	Indicators
	• Type of equipment (2-wheel walker, wheelchair, commode chair, bath chair, etc), Where to get it (rental vs. purchase) – list of suppliers, How to use it •		program (checklist with data entry fields)	Weblinks Updated list to equipment rental or equipment purchasing companies		
Occupational therapist	• Changes to home environment (ramp, stair lift, furniture) • Activities of daily living	On unit during their stay	• Home accommodations and ADL (checklist with date entry fields)	Data collection or pdf upload		
Social Worker	• Transportation (Para transpo) • Helpline • Meal delivery • Medical supplies needed (dressing changes) • Primary care outreach • Other services and resources (Facilities, Day Programs in their Area, Home Care, Discharge Transportation, Discharge Destination Information, etc.)	On unit during their stay	• Community resource list and referrals (checklist with date entry fields)	Data collection or pdf upload Website links		
Nurse	Nurse provides information and ongoing teaching/resources on established goals: • Daily care needs (bathing, eating, personal hygiene, dressing, etc) • Medications issues • Safety at home (falls prevention) • Pain management • Diet/nutrition (if relevant) • Specific co-morbidities (Parkinson, diabetes, chronic kidney disease, urinary tract infection, cognitive impairment, Alzheimer, pressure ulcers, edema) • Other?	On unit during their stay	• Revise/modify previous list of resources based on established goals	Data collection		
Patient/ caregiver	Patient and/or caregiver review and confirm that they understand • Exercise program, equipment needs, and changes to home environment • Diet (if applicable) • Medications • Daily care needs • And identifies any questions for any health care provider	Prior to discharge	• Confirmation checklist?	Review and print report Track progress on goals	Usability	% of goals achieved
Team	Nurse (or primary team contact) shares patient questions from Path to Home app Primary team contact/Social worker: • Arranges the home and community care coordinator • Referral to Champlain LHIN • Referral to Geriatric Day Hospital (if applicable)	Interprofessional team rounds (prior to discharge)	• Discharge Checklist (discharge summary for primary health care provider)			

Actors (Who?)	Tasks/ Processes (What?)	Where /When?	Tools/ documents (How?)	Task type	Goals (Why?)	Indicators
	• Discusses caregiver's health Provides: • Discharge instructions • Community resources as needed (grocery delivery, etc) • Pain management • Medication management • When to call the doctor (Name and number) • Follow-up appointment • Community referrals • Follow-up tests					
Patient/ caregiver	Patient or caregiver review and confirm that: • Home destination is prepared and ready • Equipment and medical supplies are in place (ordered and delivered) • Final medication list is received • Patient understands • Discharge and transition plan • Patient will have access to self monitoring (pre-existing in application)	Prior to discharge	• Confirmation checklist?	Review and print report Track progress on goals	Usability	% of goals achieved # of resources and self-monitoring tools used in application
Champlain LHIN home care provider (if applicable)	• provide information about a home care plan. This information is necessary to support the discharge for many patients	Prior to discharge		Pdf upload		# of patients with home care plan
Patient/ caregiver	• Access discharge and transition information • Access patient specific resources	At home		View and modify as needed	To access specific resources identified by health care team	# of logins # of resources viewed
Primary Health Care Provider	• Reviews patient discharge and transition information • Reviews patient's "My Needs" checklist • Follow-up appointment with primary care provider: • Is notified of discharge and receives a copy of the discharge summary • Can access the patient's progress on discharge and transition plans during the follow-up appointment • **(If applicable)** Referral to geriatric day hospital: • Is notified of discharge and receives a copy of the discharge summary • Can access the patient's progress on discharge and transition plans during the follow-up appointment	During follow-up appointment in primary care office or Geriatric Day Hospital		View and print report	To access and follow-up on patient's geriatric rehabilitation summary	# of logins from primary health care providers
Patient/ caregiver	• Completes a brief follow-up survey	Community at 30-day post discharge	• Follow-up survey	Data entry	To evaluate the feasibility and acceptability of Path to Home	

APPENDIX II: SeeMe™ Frailty Informed Care Framework Combined table

Performance Management Participation, Measurement Model and List of Data Collection/Reporting Tools								
Org. level	**Actor**	**Process**	**Tasks**	**Goal**	**Indicator**	**Tool**	**Task Type** (e.g. Data Collection; Review Report /Report Notification)	**Comments**
Micro	Nurse	See Residents	Care Conferences- Complete tool Goals of Care 1.	Adoption	% care conferences with GoC tool completed	Audit Tool	Data Collection	
	Physician	See Residents	Before Care Conferences- Complete Comprehensive Frailty Inform Assessment 2	Adoption	% care conferences with CFA tool completed	Audit Tool	Data Collection	
	Nurse	See Residents	Before Care Conferences- Complete Comprehensive Frailty Informed Assessment 3	Adoption	% care conferences with CFA tool completed	Audit Tool	Data Collection	
Meso	Mentors	Mentoring	Complete the Evaluation Form for Trainees 4	Adoption	% training with evaluation form completed	Master Frailty Schedule Spread Sheet	Data Collection	2
	Daniela (MESO)	Mentoring	Follow up Goals of Care Audit Notes (feedback to staff) 5	Timely correction – Done within a month of audit	% of corrections completed within a month of audit	Audit Tool	Review Report	3b Daniela seeks staff and provides feedback based on staff availability (staff may be busy).
	Daniela (MESO)	Mentoring	Follow up w/Trainees needing additional Training for Frailty Informed Assessment and create reports for managers 6	Staff competency	% Independent after training (green) % Supervision (yellow) % More training (red) # of training hours required to achieve independence (green)	Master Frailty Schedule Spread Sheet	Review Report/Data Collection	4 Green=proficient Yellow=some support needed (work needs to be reviewed) Red=Significant support needed
	Daniela	Mentoring	Create/Maintain Training Schedule 7	To organize and ensure completion of training	All identified staff has been mentored by the end of the two month cycle.	Master Frailty Schedule Spread Sheet	Data Collection	1

Performance Management Participation, Measurement Model and List of Data Collection/Reporting Tools								
Org. level	**Actor**	**Process**	**Tasks**	**Goal**	**Indicator**	**Tool**	**Task Type** (e.g. Data Collection; Review Report /Report Notification)	**Comments**
	Andrea	Oversees Clinical Tools	Goals of Care Audit (quality) 8	Quality assurance	% Follow up needed % Follow up NOT needed	Audit Tool	Report Notification	3a (Andrea's audit)
	Daniela	See Residents	Before Care Conferences – Complete Comprehensive Frailty Informed Assessment 9	Adoption	% care conferences with CFA tool completed by assigned due date (approx. 2 weeks)	Audit Tool – CFA tab		Nurse (Tentative: Andrea to coordinate with Daniela
	Andrea	Oversees Clinical Tools	Review Comprehensive Frailty Informed Assessment usage 10	Quality assurance	% Physician Initially Completed - Follow up needed % Physician Initially Completed - Follow up NOT needed % Nurse Initially Completed - Follow up needed % Nurse Initially Completed - Follow up NOT needed	Audit Tool	Report Notification	4
	Andrea	Oversees Clinical Tools	Collect data for three outcome indicators 11	Reduce unwanted/unnecessary transfers to the ER	% Residents who prefer not to be transferred to the ER Level of Frailty % DNR (CPR)	Audit Tool	Data Collection	
Macro	SeeMe Steering Committee	Operations Management	Review Audit Results 12	Monitoring progress and impact	% care conferences with GoC tool completed % Residents who prefer not to be transferred to the ER Level of Frailty % DNR (CPR) Correlation between frailty level and health care preference % of hospital transfers with a NO ED decision % of ED decisions changed to No transfers *pre-post care conference level of care preference change	Audit Tool – Stats tab	Reporting	Consult with Liam and Pilar how to present/report information to the SeeMe Steering Committee. Consult what is meant by Report Notification
	SeeMe Steering Committee	Operations Management	Review Training Implementation Process 13	Track progress	% green, yellow, red at end of two month roll-out period Average # hours per roll-out phase that it took for all RNs, RPNs, to become green; Minimum and Maximum # hours for becoming 'green' per roll-out phase	Master Frailty Schedule Spread Sheet	Reporting	