Business Intelligence:
Assimilation and Outcome Measures for the Health Sector

by

Elizabeth (Liz) M. Loewen
Bachelor of Fine Arts, University of Manitoba, 1989
Bachelor of Nursing, University of Manitoba, 1995
Masters of Nursing, University of Manitoba, 1999

A Dissertation Submitted in Partial Fulfillment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

in the School of Health Information Science

Business Intelligence:
Assimilation and Outcome Measures for the Health Sector

by

Elizabeth (Liz) M. Loewen
Bachelor of Fine Arts, University of Manitoba, 1989
Bachelor of Nursing, University of Manitoba, 1995
Masters of Nursing, University of Manitoba, 1999

Supervisory Committee

Dr. Abdul Roudsari, Supervisor
School of Health Information Science

Dr. Karen L. Courtney, Departmental Member
School of Health Information Science

Dr. Kathryn Hannah, Outside Member
School of Nursing

Abstract

Increased adoption of health information systems in clinical practice has set a foundation for use of this data for Business Intelligence (BI). BI is the use of specialized tools to collect, analyze, and present organizational data to operational leaders in user-friendly formats to support organizational objectives. This is a routine component of management practice in sectors such as finance and manufacturing but has not yet reached its full potential in the health sector where limited availability of BI systems and factors such as data quality, complexity, and access to data have been identified as barriers. Correspondingly, there are no established conceptual models for measuring successful adoption of BI in the health sector. This dissertation study proposes a *Business Intelligence Benefits Model for Health* derived from frameworks used in other sectors and establishes health sector measures for two foundational constructs, *BI Assimilation* and *Health System Organizational Performance*. Through an online Delphi consensus process involving 25 Canadian health leadership panelists from four provinces, the study establishes a total of 30 concept measures for these constructs. Only seven (23.3%) of the concepts identified by the panelists in the study are reflected in an established non-health sector framework, the Business Value of BI Model, validating the need for sector specific measures. The study also compares priorities between leadership groups: top management team versus operational managers; and, leaders with a nursing related portfolio versus those without. The comparisons demonstrate variations among these groups but consistency in requirements overall. Establishing these BI constructs for healthcare is a precursor to measuring BI success and informs priorities and approaches for BI implementation as well as further instrument development.

Keywords: health care, business intelligence, nursing, performance outcomes, decision making, framework

Table of Contents

List of Tables

List of Figures

List of Abbreviations

BI – Business Intelligence

BICC – Business Intelligence Competency Centres

CIO – Chief Information Officer

CEP – Complex Event Processing

CI – Competitive Intelligence

DWSM – Data warehouse success model

EMR – Electronic Medical Record

ETL – Extraction, Transformation and Loading

GIGO – Garbage In/Garbage Out

IT – Information Technology

IQR – Interquartile Ratio

KPI – Key Performance Indicator

NonNP – Panelists without a nursing related portfolio

NP – Panelists with nursing related portfolio

OLAP – Online Analytical Processing

OM – Operational Managers

RDBMS – Relational Database Management Systems

QI – Quality Improvement

TAM – Technology Acceptance Model

TMT – Top Management Team

USA - United States of America

Acknowledgements

My thanks to the School of Health Information Science at University of Victoria for the pleasure of having access to a learning environment dedicated to health informatics and for the student support available. I have appreciated and benefited from the financial support of the University of Victoria, the Denis and Pat Protti Scholarship, and the Michael Miller Scholarship all of which made student life a little bit easier.

My sincere thanks to my committee members for sharing their knowledge and time and for supporting me through this undertaking: Abdul for your feedback throughout this process and unending enthusiasm and encouragement; Karen for inspiring the beginnings of this framework and your support in navigating our PhD cohort throughout the entire academic process; and Kathryn for your detailed feedback that kept the study (and me) grounded both in practice and in the nursing informatics perspective.

A special thanks to my colleagues in Manitoba for their ongoing support of digital health solutions and for continually challenging me to find new ways to better meet the needs of the health care system. You are my inspiration for taking this on - I am fortunate to have benefitted from the vision and knowledge of many mentors and strong leaders throughout my career. It is my hope this work contributes to moving the agenda for business analytics forward as a next step in improving health care services for Canadians.

Most importantly, words can’t express my appreciation for my family and friends who have supported me in this adventure - as you have in many others, and for the thousands of ways you make my life better every day.

Chapter 1 – Research Context and Background

"The accumulation of data has outpaced our capacity to use it to improve operating efficiency, clinical quality and financial effectiveness" (Ferranti, Langman, Tanaka, McCall, & Ahmad, 2010, p. 136).

Introduction

Access to real-time information can enable front line managers and health system leaders to make informed decisions about management priorities such as resource allocation, quality management, and patient flow. In many organizations, information is not just a by-product of process documentation but rather a tangible asset for use in setting strategic directions, managing processes, and even as a valuable commodity for resale as contemplated in commercial healthcare markets (Foshay & Kuziemsky, 2014; Foshay, Mukherjee, & Taylor, 2007; Safran et al., 2007; Wixom & Watson, 2001). This concept, referred to as Business Intelligence (BI) or Business Analytics, is a routine management practice in sectors such as finance and manufacturing and is an identified priority for corporate information system investments. There is limited evidence demonstrating the effect of BI solutions in the health sector and no sector specific frameworks for measuring these (Loewen & Roudsari, 2017b, 2017c). This dissertation study proposes a health sector framework and sector specific measures of expected BI use. This will inform future measurement of BI and, ultimately, supports optimized use of BI within the sector for both health service delivery and administration of the system overall.

Business Intelligence Systems

The term Business Intelligence System was first coined by Hans Peter Luhn (1958) to describe work underway at IBM® to establish a system that would allow for "automatic" sharing of organizational information stored, at that time, electronically in documents. BI as an

organizational service has undergone significant transformation since this early vision. A mature BI technical platform is now comprised of multiple data sources, data movement or streaming engines, data warehouse servers, mid-tier servers and front-end applications and typically involves significant organizational investment (Bonney, 2013; Chaudhuri, Dayal, & Narasayya, 2011; Negash, 2004). Information and data are presented through a variety of output mechanisms such as dashboards and scorecards as well as more interactive and dynamic tools such as visualization and modelling (Chandler, 2014). Many of the elements now automated by BI systems only recently required specialized technical or analytical skills to extract information. As a result, BI is now shifting from a back room function to the concept of "BI for the masses" bringing direct access to a broader population within the organization in response to the increasing need for faster and on-demand information (Naghdipour, 2014; Negash, 2004). Development of reports and preparation of data still require knowledgeable expertise to ensure that underlying data are being appropriately represented to avoid incorrect assumptions. These may be drawn from data holdings within a single organizational entity or provide linkages across multiple entities to establish a distributed data network capable of broader analytics in support of activities such as surveillance (Popovic, 2017).

BI encompasses a range of analytical approaches from descriptive (what happened?) to diagnostic (why did it happen?) to predictive (what will happen?) to prescriptive (what should be done now?) (Chandler, 2014). In non-health settings, BI investments have been shown to deliver organizational benefits through faster access to information for decision making, competitive advantage, improved performance, and improved customer satisfaction (Côrte-Real, Oliveira, & Ruivo, 2014; Elbashir, Collier, & Davern, 2008; Hočevar & Jaklič, 2008; Wixom & Watson, 2012; Wixom, Watson, & Werner, 2011). While there are few empirical studies examining the

effect of BI in the health sector, there are numerous articles identifying the gap in information and the anticipated benefits of BI such as: easier access to data (Bonney, 2013; Ferranti et al., 2010; Horvath, Cozart, Ahmad, Langman, & Ferranti, 2009; Karami, Fatehi, et al., 2013); time savings (AlHazme, Rana, & De Lucca, 2014; Bonney, 2013; Ferranti et al., 2010); improved decision making (Bonney, 2013); improved clinical outcomes (Ferranti et al., 2010); operational efficiencies (Ferranti et al., 2010); compliance with regulatory requirements (Van De Graaff & Cameron, 2013); and improved financial performance (Glaser & Stone, 2008).

Business intelligence definition. As an emerging practice, there is no primary definition of BI used consistently in the literature. Definitions used typically reflect an ability to collect data from multiple sources within an organization and present this data to end users in a way that reinforces strategic business objectives to inform decision making and achieve strategic outcomes. Definitions typically reflect system features including: underlying and specialized technologies to capture and aggregate electronic data from distributed sources (Chang, Hsu, & Wu, 2015; Chen, Chiang, & Storey, 2012; Elbashir, Collier, Sutton, Davern, & Leech, 2013; Foshay & Kuziemsky, 2014; Işık, Jones, & Sidorova, 2013); the application of analytics to transform data into information (Bhatnagar, 2009; Ferranti et al., 2010); and the ability to present it in a contextually meaningful way for business users/decision makers (Chandler, Hostmann, Rayner, & Herschel, 2011; Hočevar & Jaklič, 2008; Luhn, 1958; Nagy et al., 2009). Definitions vary in the way in which expected organizational outcomes are presented, suggesting a level of immaturity in this area. These range from general references to actionable information for improved, informed or timely decision making (Moore, Eyestone, & Coddington, 2012), to broader concepts such as improved performance (Işık et al., 2013), strategy formulation (Bhatnagar, 2009), and organizational transparency and culture change (Nagy et al., 2009). This

variability reflects one of the primary challenges of realizing BI value. Without a broader organizational strategy, the system and information itself will not result in organizational improvements beyond, perhaps, the vision of each individual information recipient or manager. The definition of BI used for this study is: **the use of specialized tools to collect, analyze, and present organizational data to operational leaders in user-friendly format(s) to support organizational objectives**.

Business intelligence infrastructure. As the definition suggests, BI is not a single Information Technology (IT) system but rather a set of interdependent organizational assets and competencies. Being rich in organizational data does not correlate directly to good information and despite best intentions, "the problem is that most companies are not succeeding in turning data into knowledge and then results" (Davenport, Harris, De Long, & Jacobson, 2001, p. 118). Literature on BI systems typically identify the following interrelated elements: standardized underlying infrastructure, multiple data sources, query/reporting tools, organizational and process factors, and data governance (Bonney, 2013).

System architecture. The underlying infrastructure to support BI is consistent across sectors despite the unique data sources and information requirements in each. While analytics and data processing can occur using common toolsets and manual processes (such as entry into an Excel spreadsheet), these are not scalable for the level of organizational use contemplated in the definitions of BI found in the literature. A mature BI technical platform is comprised of multiple data sources, data movement or streaming engines, data warehouse servers, mid-tier servers and front-end applications and typically involves significant organizational investment (Bonney, 2013; Chaudhuri et al., 2011; Negash, 2004).

Multiple data sources. Unlike a stand-alone application which may have internal analytic capabilities, BI systems are designed to receive and present data from multiple source databases within or external to the organization to provide a broader organizational view of information. In the health sector, these can include facility utilization data, clinical documentation systems, financial systems, diagnostic related groups data, and health indicators (AlHazme et al., 2014; Nagy et al., 2009). These data sources typically will have different formats and varying levels of quality (Chaudhuri et al., 2011). It is a challenge to integrate the volume and variety of data seen in healthcare (clinical, laboratory, administrative, finance/insurance, other sectors) much of which is at varying levels of maturity and on heterogeneous platforms (Schaeffer, 2016; Schaeffer, Booton, Halleck, Studeny, & Coustasse, 2017; Wang, 2013).

Data movement and streaming engines. To deal with the variation between the multiple heterogeneous sources, the data needs to be integrated, cleaned and standardized into a structure that supports analysis. The technologies that support data preparation are called Extraction, Transformation, and Loading (ETL) tools (AlHazme et al., 2014; Chaudhuri et al., 2011; Nagy et al., 2009; Wang, 2013). This is critical to ensure systematic normalization or semantic interoperability of the data to allow for data from disparate systems to retain meaning when combined (Chute, Beck, Fisk, & Mohr, 2010). Data are also typically pulled from databases that are used for day-to-day business activities so extraction of data needs to occur on an ongoing basis and increasingly is needed in real-time which requires Complex Event Processing (CEP) engines (Chaudhuri et al., 2011).

Data warehouse servers. Data warehouse is a term often used incorrectly as synonymous with the BI system overall. The data warehouse is the repository which stores data making it available for querying. This will involve one or more relational database management systems

(RDBMS) scaled to support the volume of data and processing needed for queries (Chaudhuri et al., 2011; Wang, 2013). Health sector data warehouses share the same underlying technical components as other sectors; however, the volume of health data can be significant even in one organization. In their description of BI at the Mayo Clinic, Chute et al. (2010) report over 70 million unique patients linked to 64 million diagnoses statements, 268 million laboratory results and 60 million clinical documents accumulated over a period of 15 years. Service-orientated or cloud based computing options are increasingly being considered to support analytic capabilities. Demirkan and Delen (2013) examine service-orientated decision support systems to reduce the need for in house expertise to manage data centres. These can, in theory, result in lower costs as cloud computing offers economy of scale and quick access to additional storage and memory for analytics processing (Demirkan & Delen, 2013). Cloud computing for analytics requires controls for data accuracy, data security, information governance, intra- and inter-organizational business semantics, and synchronous data coordination (Demirkan & Delen, 2013).

Mid-tier servers. The mid-tier servers provide functionality to support the analytics processes needed in BI. This includes online analytical processing (OLAP) servers that can allow for a multidimensional view of the data and support analysis through filters, aggregation, and the ability to drill-down into selected elements (Chaudhuri et al., 2011). It includes enterprise search engines to allow for searches of structured and unstructured data and reporting servers and tools to establish parameters for presentation of data (such as by fiscal quarter or by division) (AlHazme et al., 2014; Chaudhuri et al., 2011). Lastly, these include data mining engines which support data analysis that extends beyond structured reporting and can set the stage for predictive modelling (Chaudhuri et al., 2011). BI systems typically draw data from multiple sources and require significant processing power which, if not optimized, can diminish system success. A

study examining use of an adverse drug reporting and monitoring system identified user frustration and system avoidance when reports were running too slowly due to multiple users accessing reports simultaneously (Horvath et al., 2009).

Front-end applications. A BI system requires access to analytical tools for end users to present and manipulate data and a range of software products exist for this purpose. These may be in the form of dashboards or other visual tools that present pre-determined data in easy to interpret formats such as trends over time, against expected targets, as heat maps or even geographically enabled (AlHazme et al., 2014; Bonney, 2013; Chaudhuri et al., 2011; Nagy et al., 2009). Software tools may also include search tools that allow users to explore or pull specific information they need using ad hoc queries (Chaudhuri et al., 2011).

Business Intelligence in Healthcare

Within Canada, electronic information systems are increasingly in place for most aspects of health service delivery including clinical service documentation, supply chain, financial tracking, and human resource management. Clinical information systems, such as electronic medical records, have been shown to improve healthcare delivery through legible documentation, the ability to share information between care settings, and tools to alert users to potential safety concerns such as drug interactions (Buntin, Burke, Hoaglin, & Blumenthal, 2011; Han et al., 2016). The adoption of health information systems results in a corresponding increase in data accessible for health system management.

Despite increasing data held electronically within organizations, the value of BI has not yet been fully realized in the health sector where limited availability of BI systems and factors such as data quality, system complexity, and access to data have been identified as barriers (Schaeffer et al., 2017; Ward, Marsolo, & Froehle, 2014). Better use of available data for health

system planning and management has been identified as a priority among Canadian Deputy Ministers of Health (Canadian Institute for Health Information, 2013). This is also reflected in the most recent Canadian statement on health principles (Health Canada, 2017). Within Canada, BI, once optimized, has the potential for significant benefit given provincial health expenditure accounts for over 40% of government annual spending in Canada (Canadian Institute for Health Information, 2013). The health sector, if not able to quickly harness the power of its inherent data assets risks a continued loss of returned value through improved system management. In addition, there is limited means for measuring progress towards BI optimization.

Study Aim and Objectives

While there is current momentum and support for the establishment of BI capacities in the healthcare sector, the lack of established frameworks for measuring BI success in healthcare, paired with the considerable expense required to establish BI systems, poses a risk to realizing a return on investment. This study aims to address this gap through identifying a health sector framework to measure BI system success. The objective of this research study being reported herein is to establish health sector specific measures for two foundational constructs for BI success, *BI Assimilation* and *Organizational Performance* within the framework of a proposed *Business Intelligence Benefits Model for Health.* Defining concepts to measure these constructs will allow for future use of this framework to measure BI success in this sector. This study also examines variations in the reported relevance of these measures between distinct leadership groups reflected in the framework: 1) senior leadership versus operational managers, and 2) leaders with a nursing related portfolio versus those without. It is important to understand the extent to which organizational perspectives on BI objectives differ significantly among common leadership groups given the key role played by leadership in overall BI success. Understanding

expected measures of BI success can inform implementation of health information systems generally to ensure systems are designed to accommodate future BI use. BI, once optimized in the health sector, has significant potential to result in improvements in both health service delivery and health system sustainability and contribute to improved return on investment in health information systems overall.

Conclusion

Given the emerging state of work in this area, this dissertation focuses on developing consensus around suitable measures for the constructs of *BI Assimilation* and *Organizational Performance* in the healthcare environment. In addition, the dissertation explores variations between general leadership and nurse leadership perceptions of BI. The study addresses four questions:

1. What are the measures representative of BI Assimilation in the health sector?
2. What are the measures representative of Organizational Performance as an expected outcome of BI System implementation in the health sector?
3. To what extent do leaders with a nursing related portfolio differ from those without a nursing related portfolio in their overall scoring of measures of BI Assimilation and Operational Performance?
4. To what extent do senior leaders differ from operational managers in their overall scoring of measures of BI Assimilation and Operational Performance?

The following chapters outline the current state of knowledge related to these questions, the methods used, and the results of this study. Chapter two provides the current context for BI knowledge through the results of a systematic review and scoping review. Chapter three proposes the conceptual framework for this study in the context of other related conceptual

frameworks and models. Chapter four outlines the research questions in detail and study design and methods used. Chapter five presents the results of the study and chapter six provides discussion and context for these results. Chapter seven provides the conclusion and the impact of the research.

Chapter 2 – BI Current Context

This chapter outlines current knowledge about BI with a focus on health sector BI. A systematic literature review was undertaken to identify current evidence for the effect of BI on health system decision making and organizational performance. As well, the review identifies success factors for health sector BI implementations. Findings from this review were then extended to include a scoping review looking at BI in other sectors and to include other literature sources.

Systematic Review: BI Impact on Decision Making and Outcomes

Objectives. The objective of the systematic literature review was to identify current evidence for the effect of BI on health system decision making and organizational performance as well as to identify success factors for health sector BI implementations with findings from this review now published (Loewen & Roudsari, 2017a, 2017b). The review focused on the following questions:

- What evidence exists that use of BI improves nurse or other health system manager decision making in healthcare?
- What evidence exists that use of BI improves organizational performance in healthcare?
- What are implementation success factors for BI in healthcare?

Methodology. The PRISMA method was used to structure the search strategy and to structure the screening and analysis of results (Elo & Kyngäs, 2008; Moher, Liberati, Tetzlaff, & Altman, 2009; Seuring & Gold, 2012). The review included articles published between 2000 and July 2015 and an inductive content analysis approach was used for qualitative analysis to identify themes and concepts found in the included literature. The articles found did not have sufficient data to undertake a quantitative meta-analysis. In addition to a structured search of databases,

additional articles from other sources were reviewed including those found in reference lists and identified through hand search when retrieving articles for the study (Moher et al., 2009).

Search strategy. In keeping with the PRISMA method, the search followed a predetermined structured approach (Kable, Pich, & Maslin-Prothero, 2012; McGrath, Brown, & Samra, 2012; Moher et al., 2009). Search terms were based on key concepts within the review questions and related articles from other sectors and were: health care *or* medicine; BI *or* business analytics *or* big data; decision making – manager *or* nurse manager; organizational performance/outcomes; and implementation success factors. Databases were selected in consultation with an academic librarian and subject matter experts to identify those common to the health sector, business and informatics. Database searches were completed in July 2015 with identification of articles from other sources included up to March of 2016 resulting in 2,836 returned results (see Table 1).

Exclusion and inclusion criteria. As this is an emerging concept, search terms and criteria were intentionally broad and included: written in English; publication year (>2000 to 2015 search date) to reflect mature underlying health information systems; evidence based (research based) and/or existing systematic review; and, health sector/health system management related. Exclusion criteria were: clinical decision support (e.g. diagnostic aids, alerts used for clinical guidance, surveillance); general decision making or use of information for decision making that did not reference or consider the underlying information

Table 1

Databases and Search Engines with Results Returned

Database/Search Engine	Number of Results Returned
CINAHL with full text EBSCO	391
Medline with full text EBSCO	962
PubMed	265
Business Source Complete EBSCO	70
Web of Science Core Collection	577
IEEE Xplore Digital Library	407
Science Direct	139
Health Technology Assessments EBSCO	14
ACM Digital Library	12
Total	**2,837**

systems (BI); secondary or retrospective analysis; and articles without a research basis. Of the latter, numerous articles indicated a case study methodology however these were excluded if formal methods or controls for bias were not documented in the article.

Screening. Searches were imported into a reference management software for review. Once all searches were added, the databases were merged and reviewed for duplicates using automated features and then manually screened to remove remaining duplicates (n=547 removed as duplicates). Given the large number of returned results (n=2,290 unique articles) articles were initially screened by title and abstract against inclusion criteria which reduced the number of possible articles to 342. These articles were retrieved and underwent a detailed review for inclusion including a scan of references. Ultimately, six articles found through the primary search met the inclusion criteria with two additional articles subsequently added from the reference scans. Articles not retrieved through the online search were then sought through other mechanisms; however, ultimately 48 were never found for full article review. A second reviewer (Roudsari) scanned excluded articles and reviewed included articles with final determination based on consensus between the reviewers.

Data collection and quality assessment. Quality assessment of the articles and collection of data from the articles followed a structured process:

- The initial review screened articles at abstract level for likely suitability (removed n=1,948);
- A second review screened the article content and searched actively for missing articles through library resources (n=378);
- Articles that could not be located were excluded from the review (n=48);
- Relevant references and other articles identified through hand search were added (n =36);

- Remaining articles moved forward for inclusion with a total of 8 articles included in the final analysis (see Figure 1).

Data analysis. Articles were reviewed critically for quality and underlying bias. Reported results were analyzed using a qualitative inductive content analysis approach. Key themes were marked manually on individual note sheets and attached to articles as they were identified. These were then grouped and reviewed again for missing themes.

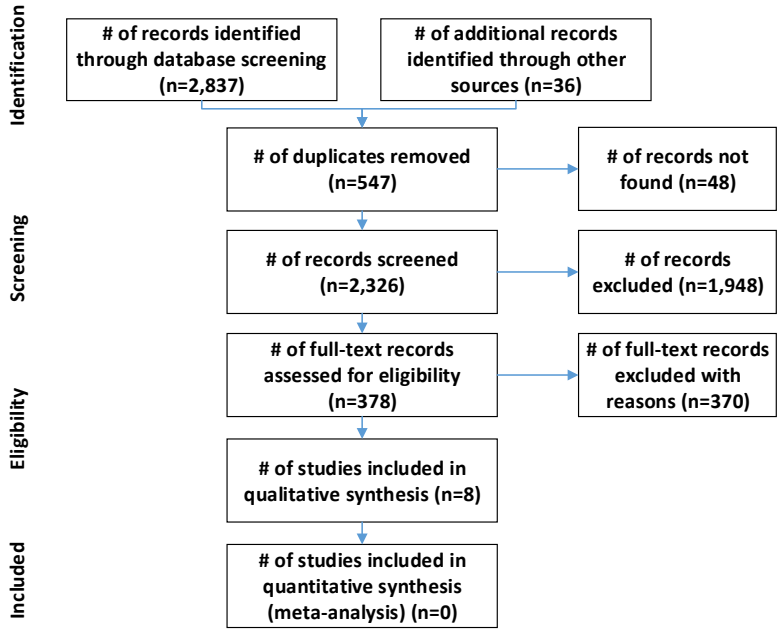


Figure 1. Search summary.

Findings were then transcribed into a graphical format to create a mindmap and arranged in categories with colour coded markings to identify the originating article (see Appendix A). The quantitative results that were presented in the articles were not directly attributed to the presence of BI. As a result, the analysis focused on general themes and did not differentiate between anticipated versus actual effects nor quantitative or qualitative results.

Results

Characteristics of selected publications. Following screening, eight articles met inclusion criteria. The articles predominantly included descriptive results or reported anticipated or perceived benefits. Of the eight articles, seven directly examined health sector findings while

one included survey data which combined the health sector respondents along with other service industries. Methods were predominantly qualitative and included: descriptive survey (n=1) (Barkley, Greenapple, & Whang, 2014); framework development methodology supported by case study (n=1) (Brooks, El-Gayar, & Sarnikar, 2015); mixed methods (n=2) (Elbashir et al., 2008; Ruland & Ravn, 2003); case study (n=3) (Foshay & Kuziemsky, 2014; Ghosh & Scott, 2011; Ward, Morella, Ashburner, & Atlas, 2014); and systematic literature review (n=1) (Wilbanks & Langford, 2014). Four were published in 2014, and one in each of 2003, 2008, 2011 and 2015. Journals included: Communications of the Association for Information Systems; CIN: Computers, Informatics, Nursing; Journal of Ambulatory Care Management; Journal of Nursing Management; Journal of Oncology Practice; International Journal of Information Management (n=2); and International Journal of Accounting Information Systems.

Three papers looked at the effect of BI and capacity needed for BI adoption (Barkley et al., 2014; Foshay & Kuziemsky, 2014; Ghosh & Scott, 2011). Findings included: reported lack of proficiency in use of data analytics with limited access to tools with barriers including: lack of staffing/skills; siloed information; limited communication; limited care coordination (Barkley et al., 2014). Foshay and Kuziemsky (2014) also looked at perceived effects resulting from the lack of BI systems and similarly reported a lack of skilled personnel, limited manager experience with information, the need for work arounds and poor data quality. Ghosh and Scott (2011) examined the effect of an established analytics program within the Veterans Health Administration and reported on measurable decreases in cost although with limited discussion of possible confounding factors.

Two papers looked at measurement frameworks to assess BI. Brooks et al. (2015) worked to develop a maturity model for BI in health care and identified four primary process areas:

organizational, people and team; technology and health specific processes. Elbashir et al. (2008) also focused on measurement frameworks and demonstrated relationship between business process performance and organizational performance with this being stronger in non-service sectors (with health falling under service sectors).

The remaining two papers examined the effect of analytics and measures on nursing administration in particular (Ruland & Ravn, 2003; Wilbanks & Langford, 2014) and while both were only weakly tied to the review questions due to passing reference to underlying information systems, they highlight the effect of user friendly analytical tools for decision making and the ability of these to support nursing managers in monitoring performance indicators at the health unit level.

Data analysis – content themes. Qualitative analysis of themes was undertaken using inductive content analysis. This resulted in six high level groupings: information needs/system indicators; information system quality; demonstrated/anticipated benefits; barriers to getting/using information; decision making; and factors affecting BI adoption (see Table 2). While not all articles were reflected in each of the theme groupings, each grouping contained concepts from at least four of the articles (see Table 2).

- **Information needs or system indicators:** These ranged from the very specific (total drug costs) to high level (operational). These were further classified as *patient centric* (satisfaction, access, communication with providers); *process* (length of stay, wait times); *clinical indicators* (mortality rates, adverse events); and *economic/administrative* (imaging costs, total drug costs, resource utilization, patient cost share). This concept reflects content from four articles (Barkley et al., 2014; Brooks et al., 2015; Ghosh & Scott, 2011; Ward, Morella, et al., 2014).

Table 2

Summary of Themes from Literature Review

Information needs or system indicators (Barkley et al., 2014; Brooks et al., 2015; Ghosh & Scott, 2011; Ward, Morella, et al., 2014)
• *patient centric* (satisfaction, access, communication with providers); • *process* (length of stay, wait times); • *clinical indicators* (mortality rates, adverse events); and • *economic/administrative* (imaging costs, total drug costs, resource utilization, patient cost share).
Information system quality (Barkley et al., 2014; Brooks et al., 2015; Ghosh & Scott, 2011; Wilbanks & Langford, 2014)
• *data quality* (validation approaches, effect of aggregation); • *health system factors* (timely documentation affecting real-time reporting, business processes); • *standards* (data definitions, lack of standardized terminology, lack of standardized key performance indicators); • *interoperability* (between systems and for data collection/aggregation).
Benefits (demonstrated and anticipated) (Barkley et al., 2014; Elbashir et al., 2008; Ruland & Ravn, 2003; Wilbanks & Langford, 2014)
• *economic benefits* (supplier relationships, economic awareness by managers); • *performance benefits* (organizational performance, individual job performance, efficiency and quality, ease of use); • *process benefits* (internal process efficiency, performance metrics, documentation improvements); • *system coordination* (ability to see gaps and better coordinate between settings); • *clinical benefits* (complying with national quality/reporting initiatives); and • *meeting external driver obligations* (future and current payment and delivery models, quality reporting, and participation in specific mandated initiatives).
Barriers to getting and using information (Barkley et al., 2014; Foshay & Kuziemsky, 2014; Ruland & Ravn, 2003; Wilbanks & Langford, 2014)
• *lack of standards* (standardized measures, currency and accuracy of data, limited operational data quality); • *limited access to user friendly tools* (data hard to retrieve, in manual formats, disconnected systems); • *capacity* (lack of skilled resources, general skill with analysis, end user time required to manipulate existing reports, limited manager knowledge to exploit data assets); and • *organizational culture* (silos within organizations, lack of transparency, lack of coordinated care to drive adoption, concerns that BI focus on economic measures will shift focus from care quality to cost containment).
Decision making (Foshay & Kuziemsky, 2014; Ghosh & Scott, 2011; Ruland & Ravn, 2003; Ward, Morella, et al., 2014; Wilbanks & Langford, 2014)
• *timeliness* (perceived lack of timeliness in decisions due to limited BI capacity); • *confidence* (limited confidence in decisions without data supports, ability to improve decisions, explain variances and receive data specific to individual roles); and • *outcomes* (increased awareness of economic consequence of decisions, reduced overtime costs, ability to link resources to actions, ability to measure effect of processes, promotion of data driven decision making, and ability to measure effect on patient outcomes as well as coordinate care).
BI adoption factors (Barkley et al., 2014; Foshay & Kuziemsky, 2014; Ghosh & Scott, 2011; Ruland & Ravn, 2003; Ward, Morella, et al., 2014; Wilbanks & Langford, 2014)
• *capacity* (information overload, need for human and financial resources); • *timeliness* (getting started with available data, balancing timeliness of reports with sufficiency of data, ability to provide ad hoc reports to meet user needs); • *usefulness* (reporting on relevant target populations, high perceived usefulness by users, use of KPIs that users feel they can change, recognize context may vary between settings); • *ease of use* (ability to customize dashboards, easy to interpret formats); • *accuracy* (user trust in accuracy of data); • *culture* (organizational commitment at high levels, data driven organizations, address and recognize anxiety about visibility into performance, use of communities of practice to build data quality).

- **Information system quality:** Factors in this category were most frequently presented as a negative element needing improvement or a barrier to full optimization and these included measures of *data quality* (validation approaches, effect of aggregation); *health system factors* (timely documentation affecting real-time reporting, business processes); *standards* (data definitions, lack of standardized terminology, lack of standardized key performance indicators); and *interoperability* (between systems and for data collection/aggregation). This concept reflects content from four articles (Barkley et al., 2014; Brooks et al., 2015; Ghosh & Scott, 2011; Wilbanks & Langford, 2014).
- **Benefits (demonstrated and anticipated):** This reflected a wide range of sub-concepts suggesting that BI systems, perhaps unrealistically, are a solution to many health system challenges. These included *economic benefits* (supplier relationships, economic awareness by managers); *performance benefits* (organizational performance, individual job performance, efficiency and quality, ease of use); *process benefits* (internal process efficiency, performance metrics, documentation improvements); *system coordination* (ability to see gaps and better coordinate between settings); *clinical benefits* (complying with national quality/reporting initiatives); and *meeting external driver obligations* (future and current payment and delivery models, quality reporting, and participation in specific mandated initiatives). This concept reflects content from four articles (Barkley et al., 2014; Elbashir et al., 2008; Ruland & Ravn, 2003; Wilbanks & Langford, 2014).
- **Barriers to getting and using information:** Barriers were closely related to business adoption and included *lack of standards* (standardized measures, currency and accuracy of data, limited operational data quality); *limited access to user friendly tools* (data hard to retrieve, in manual formats, disconnected systems); *capacity* (lack of skilled resources,

general skill with analysis, end user time required to manipulate existing reports, limited manager knowledge to exploit data assets); and *organizational culture* (silos within organizations, lack of transparency, lack of coordinated care to drive adoption, concerns that BI focus on economic measures will shift focus from care quality to cost containment). This concept reflects content from four articles (Barkley et al., 2014; Foshay & Kuziemsky, 2014; Ruland & Ravn, 2003; Wilbanks & Langford, 2014).

- **Decision making:** Identified effects on decision making included *timeliness* (perceived lack of timeliness in decisions due to limited BI capacity); *confidence* (limited confidence in decisions without data supports, ability to improve decisions, explain variances and receive data specific to individual roles); and *outcomes* (increased awareness of economic consequence of decisions, reduced overtime costs, ability to link resources to actions, ability to measure process results, promotion of data driven decision making, and ability to measure effect on patient outcomes as well as coordinate care). This concept reflects content from five articles (Foshay & Kuziemsky, 2014; Ghosh & Scott, 2011; Ruland & Ravn, 2003; Ward, Morella, et al., 2014; Wilbanks & Langford, 2014).
- **BI adoption factors:** This concept reflected a mix of actual or anticipated factors which also echoed some of the barriers identified for information access. These included *capacity* (information overload, need for human and financial resources); *timeliness* (getting started with available data, balancing timeliness of reports with sufficiency of data, ability to provide ad hoc reports to meet user needs); *usefulness* (reporting on relevant target populations, high perceived usefulness by users, use of key performance indicators (KPIs) that users feel they can change, recognize context may vary between settings); *ease of use* (ability to customize dashboards, easy to interpret formats);

accuracy (user trust in accuracy of data); *culture* (organizational commitment at high levels, data driven organizations, address and recognize anxiety about visibility into performance, use of communities of practice to build data quality). This concept reflects content from six articles (Barkley et al., 2014; Foshay & Kuziemsky, 2014; Ghosh & Scott, 2011; Ruland & Ravn, 2003; Ward, Morella, et al., 2014; Wilbanks & Langford, 2014).

Data analysis – contribution to the research questions. The articles found through this search, while limited, do contribute to knowledge related to the initial search questions. These findings are presented below in relation to each specific question (see Table 3).

Table 3

Summary of Findings

Question	Findings
Evidence that use of BI improves manager decision making	• Manager reported improvements in decision making, economic awareness, ability to explain variances (Ruland & Ravn, 2003) • Anticipated improvements if BI available: increased confidence in decisions, less subjective, more timely (Foshay & Kuziemsky, 2014)
Evidence that use of BI improves organizational performance in health care	• Improved internal business processes (efficiency, customer intelligence) and ability to realize organizational objectives (enhanced profits, improved inventory turnover, partner relations) in all sectors although weaker in service sectors (Elbashir et al., 2008) • Perception that organizational objectives such as length of stay were not being managed as effectively to improve quality of care and cost (Foshay & Kuziemsky, 2014) • Unit level improvements included reduced overtime and extra staffing hours (as compared with control units); managers reported better understanding of interrelated factors such as patient acuity, staffing, cost of care (Ruland & Ravn, 2003) • Decreased morbidity and mortality, shorter wait times and length of stay and decreased cost (Ghosh & Scott, 2011)
Implementation success factors for BI in health care (often identified as gaps)	• Organizational: lack of skilled analytics resources (Barkley et al., 2014; Brooks et al., 2015; Foshay & Kuziemsky, 2014); leverage drivers such as external compliance or reporting mandates (Barkley et al., 2014); strong organizational vision (Brooks et al., 2015); address organizational silos(Barkley et al., 2014); and, address underlying care coordination factors (Ruland & Ravn, 2003; Ward, Morella, et al., 2014) • Technical: integration across multiple platforms (Barkley et al., 2014; Brooks et al., 2015); and, need for a strong underlying technology platform (Brooks et al., 2015; Foshay & Kuziemsky, 2014) • Data: underlying data quality and semantic interoperability systems (Brooks et al., 2015; Foshay & Kuziemsky, 2014; Ghosh & Scott, 2011) • End user adoption: strong perceived usefulness and ease of use (Ruland & Ravn, 2003; Ward, Morella, et al., 2014; Wilbanks & Langford, 2014); presentation of data that is meaningful and can be changed/controlled by end users (Ruland & Ravn, 2003; Ward, Morella, et al., 2014; Wilbanks & Langford, 2014); and, ability to address fear of measurement and transparent reporting (Ruland & Ravn, 2003; Ward, Morella, et al., 2014; Wilbanks & Langford, 2014)

What evidence exists that use of BI improves nurse or other health system manager decision making in health care? Only two of the articles empirically quantified improved decision making or other related measures such as sustained improvements to organizational outcomes resulting from BI. This question is most directly addressed by the work of Ruland and Ravn (2003) who identified specific improvements in decision making resulting from use of an internally developed analytics application tested on four nursing units. Respondents identified improved decision making, increased economic awareness, and the ability to better explain variances in expected results; however, comparisons within the article lacked control measures.

Foshay and Kuziemsky (2014) used a prospective approach looking at perceived gaps in decision making resulting from a lack of BI tools. Themes that emerged through their interviews included: a perception that decisions without BI tools were subjective, people lacked confidence as there was no data to support them, and that decisions were not as timely as they could be with better access to information. Concerns were also raised by the subjects about the quality of available information and ineffective access to information. Of note, they also report a risk that managers may lack the skills to use the data for decision making even if it was available to them (Foshay & Kuziemsky, 2014). The two articles combined with the underlying gaps identified in the other articles do suggest there is high likelihood that if better information tools were available, health system leaders and managers would have used these for informed (and improved) decision making.

What evidence exists that use of BI improves organizational performance in health care? There is limited evidence that use of BI improves overall organizational performance; however, none are based on statistically proven comparisons. Elbashir et al. (2008) examined the performance effects of BI systems on business processes and the extent to which these are

reflected in organizational performance. Their research only indirectly reflects health care with 10% (n=35) of the respondents from the health sector and with findings for this sector then grouped into service industries generally. They did demonstrate value from BI systems related to both internal business processes (efficiency, customer intelligence) and organizational objectives (such as enhanced profit margins, improved inventory turn over, partner relations). Service organizations (which included health sector) showed a weaker relationship between process performance and organizational performance than non-service sectors. It was also perceived that better information regarding organizational objectives such as length of stay would result in more effective management of these, with corresponding benefits to quality of care and overall cost (Foshay & Kuziemsky, 2014).

The work of Ruland and Ravn (2003) also indirectly addresses this question with findings focused at the clinical unit level rather than the broader organization overall. Unit improvements included reduced overtime and extra staffing hours (as compared with control units) and managers felt they had a better understanding of interrelated factors such as patient acuity, staffing and cost of care. Of note, the application used in that study required manual data entry and the researches recognized use, even among the early adopters in the study, was unlikely to be sustained over the long term indirectly supporting a case for mature BI systems. In their case study review of multisite programs within the Veterans Health Administration, Ghosh and Scott (2011) report decreased morbidity and mortality, shorter wait times and length of stay, and decreased cost among other variables however these are not measured against control groups and occur over time without controlling for confounding factors. The improved results realized in the latter two studies suggest the potential for broad organizational improvements has implications for significant investments in enterprise level institutional BI systems.

What are implementation success factors for BI in health care? The majority of the articles (n=7) included findings related to implementation success factors or anticipated antecedents to BI success given that several of the settings had limited experience with BI. The issues identified were organizational, data, technical, and end user related. Organizational issues included: a lack of skilled resources with knowledge of analytics needed for success (Barkley et al., 2014; Brooks et al., 2015; Foshay & Kuziemsky, 2014); drivers such as external compliance or reporting mandates (Barkley et al., 2014); and the need for a strong organizational vision (Brooks et al., 2015). Two factors in particular are unique to health sector BI and include the need to address organizational silos (Barkley et al., 2014) and underlying care coordination factors that may get in the way of meaningful data use (Ruland & Ravn, 2003; Ward, Morella, et al., 2014). Identified technical success factors included: the need for integration across multiple platforms for meaningful data (Barkley et al., 2014; Brooks et al., 2015) and the need for a strong underlying technology platform (Brooks et al., 2015; Foshay & Kuziemsky, 2014). Data issues primarily related to underlying data quality and the semantic interoperability between data from disparate systems (Brooks et al., 2015; Foshay & Kuziemsky, 2014; Ghosh & Scott, 2011). End user related success factors were identified as: strong perceived usefulness and ease of use for end users (Ruland & Ravn, 2003; Ward, Morella, et al., 2014; Wilbanks & Langford, 2014); selection of data that is meaningful to end users and that they feel they can change (Ruland & Ravn, 2003; Ward, Morella, et al., 2014; Wilbanks & Langford, 2014); and, the need to address resistance at being measured/fear of transparency (Ruland & Ravn, 2003; Ward, Morella, et al., 2014; Wilbanks & Langford, 2014).

Discussion

The limited number of empirical articles found in this search on health sector BI is, in part, because the BI field itself is an emerging area. Jourdan, Rainer, and Marshall (2008) undertook a literature review of this area in the generic business literature and identified 167 articles and found few empirical studies. In that review, the majority of articles were theory or literature reviews followed by primary and secondary field study, and then sample surveys. The primary categories identified include: artificial intelligence, benefits of BI, decision making, implementation factors and business strategies. Only one article in that search reflected the health domain and this was focused on privacy within the health insurance market rather than BI use in practice based health organizations, so did not fit the criteria in this review (Thatcher & Clemons, 2000).

Limitations. The systematic review has a number of limitations. Following consultation on appropriate search databases and search terms, the primary reviewer worked independently on the original reviews and may have missed key articles through the search strategy. This is mitigated somewhat through the inclusion of new articles found through hand search and reference review. Numerous articles identified a case study approach but these were excluded if the article did not specify research questions, an analysis methodology or data collection approach. A total of 48 articles could not be located for review at the abstract or detailed article review level. While the search terms were intentionally broad, it is still possible that articles were missed due to the emerging nature of work in this field and the potential that published research may be using alternative subject key words.

Scoping Review

In addition to the structured literature review, articles from other sectors and those that were excluded from the search criteria were considered to provide insights to a broader breadth of current state information.

Expected benefits of BI. BI investments have been shown to deliver organizational benefits through faster access to information for decision making, competitive advantage, improved performance, and improved customer satisfaction (Côrte-Real, Oliveira, et al., 2014; Elbashir et al., 2008; Hočevar & Jaklič, 2008; Wixom & Watson, 2012; Wixom, Watson, et al., 2011). Exploratory interviews with business leaders delivering BI solutions also identified the following expectations of their customers: faster availability of information to managers, decreased workload collecting data, increased reliability and timeliness of data, and improved information quality and accuracy (Naghdipour, 2014). Despite these expectations, attempts to quantify longer term benefits and link these to BI have been challenging in part due to delayed return on investment when measured against net present value (Hočevar & Jaklič, 2008).

Numerous articles identify information gaps and anticipated benefits of BI in the health sector. Expected benefits echo those found in other sectors and include: easier access to data (Bonney, 2013; Ferranti et al., 2010; Horvath et al., 2009; Karami, Fatehi, et al., 2013); time savings (AlHazme et al., 2014; Bonney, 2013; Ferranti et al., 2010); improved decision making (Bonney, 2013; Wang & Byrd, 2017); improved outcomes (Ferranti et al., 2010; Schaeffer, 2016; Schaeffer et al., 2017); operational efficiencies (Ferranti et al., 2010); compliance with regulatory requirements (Van De Graaff & Cameron, 2013); improved access to care (Schaeffer et al., 2017) and improved financial performance (Glaser & Stone, 2008; Schaeffer, 2016; Schaeffer et al., 2017). A knowledge audit examining the knowledge needs of primary care

managers identified multiple knowledge gaps that could be met through a BI system (De Lusignan, Wells, Shaw, Rowlands, & Crilly, 2005). These include understanding referral pattern variations, measuring effects of different staffing models on waiting times, mechanisms for communicating quality targets to resources, and manager interest in simply having access to "interrogate the system" and run ad hoc queries.

The emerging concepts of organizational capital or intellectual capital are used to describe a hospital's intangible knowledge assets which, in themselves, can be turned into value for the organization and used to gain competitive advantage (Karami, Fatehi, et al., 2013). Duke University Health System is one example of an enterprise level initiative with investments in BI linking their safety reporting system, adverse drug event surveillance, and clinical data repository into an integrated data warehouse for use in all service delivery settings. Unit leaders access user friendly tools to generate real-time time standard or user generated queries to support safety initiatives, quality improvement, research and operational decision making (Ferranti et al., 2010). In the Intensive Care Nursery, they report the ability to identify and address process gaps in their charge documentation and processing to improve revenues for that unit. Improvements through targeted use of vaccines in the communities they serve during an H1N1 outbreak were also reported (Ferranti et al., 2010). Lessons learned included the need to allocate IT budgets for BI, to ensure plans for data integration and sharing are established, and to invest in improved capacity for data visualization and analysis.

Similarly, AlHazme et al. (2014) describe the development of a clinical and BI system for an existing data warehouse to ensure end user access to needed data. They report improvements over the existing request based retrospective reports with end users now able to access up to date reports in minutes and establish standardized reports scheduled to run on a regular basis. In a

Canadian example, Haque, Urquhart, Berg, and Dhanoa (2014) present their experiences establishing a data warehouse and delivering interactive access for reports through an OLAP cube in northern British Columbia. Dashboards, both internal and public facing, that previously updated annually are now updated in real-time, including elements such as available resources and staff, staffing needs of hospitals within the region, hospitals accepting/transferring patients, and ventilator capacity. Anecdotal benefits reported include better allocation of funds and better outcomes (Haque et al., 2014). Garay et al. (2015) describe Cancer Care Ontario's experience with strategic analytics and the successful establishment of a strategic analytics practice. Their initiative links multiple data holdings and delivers a range of tools to end users to enable timely and user-friendly decision-making tools.

BI success factors. Successful implementation of BI requires attention to multiple interrelated factors. These include data quality, organizational factors, human factors and organizational performance.

***Data quality*.** Underlying data quality is a recurring challenge identified in health sector BI literature particularly when clinical information systems are the source of data. Health information systems are first and foremost a documentation tool for direct patient care resulting in a focus on immediate point-of-care requirements which may not align with future use for data extraction. Common clinical information systems gaps are missing/incomplete information, inaccurate information, use of free text and inconsistent use of systems between individual health care providers (Amster, Jentzsch, Pasupuleti, & Subramanian, 2015; Coleman et al., 2015).

Even within a structured system such as Medicaid claims data, the completeness and quality of encounter data, the expected minimum data for claims, was found to be so limited there was little ability to use this for further analytical work (Nysenbaum, 2014). Reader,

Gillespie, and Roberts (2014) describe challenges seen within a single patient complaints database where the lack of a coding taxonomy limited the ability to do even basic monitoring and reporting. Similar challenges were reported in attempts to extract data from an adverse events reporting database where the source was full of free text fields with spelling errors and inconsistent use of the structured codes that did exist (Ferrand, Amyot, & Corrales, 2010). Liaw, Taggart, Yu, and de Lusignan (2013) compared data extraction tools applied to identical datasets and found variations in variables such as number of active diabetic patients and demographics all of which were ultimately traced back to data entry choices by the end users and decisions about where to file clinical documents within the system. This was also replicated in two studies examining accuracy in coding repeated in two settings (surgical and emergency departments) where researchers found comparable error rates in both settings averaging 50% with data prone to subjectivity, variability and error (Nouraei, Hudovsky, et al., 2015; Nouraei, Virk, et al., 2015). Render et al. (2011) describe the use of a dashboard in Veterans Health Administration intensive care units where data was inappropriate for use in quality measurements due to variation in how patients were captured (marked as critical care versus intensive care) and limitations such as normalization of lab results reporting from different labs.

In the BI context, data quality issues are magnified when data are then extracted into a data warehouse and combined with other sources for health system analysis. Ultimately, limitations in data quality can make linking multiple non-homogenous data difficult at best or result in misinformation at worst (Cao, Zhang, Zhao, Luo, & Zhang, 2011). Informatics literature in this area identifies approaches such as use of domain ontologies to address this gap (Assele Kama et al., 2013). Data solutions alone may not be adequate as Foshay, Taylor, and Mukherjee (2014) found when their hypothesized relationship between the quality of metadata and BI

success demonstrated metadata was not a priority for BI end users. This should not be interpreted to mean these foundational data management practices are not important however this does emphasize the challenge for BI systems. The typical health system user at both the management level and clinical source system level may not appreciate the need for adherence to information structures so there is work to be done in establishing an organizational approach to reinforcing strong data quality practices in underlying systems.

Good information through BI systems begins with a strong and planned organizational data collection strategy (Ramakrishnan, Jones, & Sidorova, 2012). This is foundational for BI success given data quality and ease of access to reliable information are two primary requirements from an end user perspective. Data quality issues have been successfully addressed through a number of approaches. The data coding study noted above identified that errors in coding resulted in missed revenues that averaged out to £131 per patient in one study and £91 per patient in the other suggesting opportunities to incent clinician users in improving quality at point-of-care (Nouraei, Hudovsky, et al., 2015; Nouraei, Virk, et al., 2015). Establishing a primary care data feedback loop with strong involvement by clinicians in selecting and validating the data has also been shown to improve quality (Ward, Morella, et al., 2014). In another study, an analytical decision making culture was found to improve the use of information although this did not necessarily have a corresponding improvement on the quality of the information available (Popovič, Hackney, Coelho, & Jaklič, 2012). One indirect benefit of more accessible BI systems may be increased end user awareness of the effect of poor data quality which can contribute to an improvement cycle as users will be motivated to put in place processes to minimize gaps when they see the upstream implications (Sen, Ramamurthy, & Sinha, 2012).

***Organizational factors*.** The organizational context has a direct effect on the success of BI as adoption and returned value are influenced by factors beyond the underlying information technology system. This is not a unique concept in IT system success; however, it is particularly relevant for BI given the need to achieve longer term organizational benefits to full realize value. The complex organizational factors that are a dependency for BI success can be grouped into leadership culture, organizational structure and BI governance.

Leadership culture. BI success requires strong leadership to model and reinforce an information driven culture including a commitment to organizational vision and strategy, an analytics friendly culture, and management support (Holsapple, Lee-Post, & Pakath, 2014; Kao et al., 2016; Wixom & Watson, 2001; Wixom, Watson, et al., 2011). The senior leadership team drive organizational strategy and have been shown to have a direct effect on IT system adoption (Armstrong & Sambamurthy, 1999). Organizational culture is a critical element with 62 percent of managers indicating organizational/cultural factors as the greatest barriers to achieving return on investment on enterprise systems such as BI (Davenport et al., 2001). BI requires organizational leaders to shift their emphasis to knowledge as the primary driver for competitive advantage and future growth opportunities (Siemieniuch & Sinclair, 2004). Internal information sharing may be one of the biggest cultural barriers to resolve as teams may be actively or passively resistant to systems that allow for transparent sharing of performance information between internal units (Agnoletti et al., 2013; Nagy et al., 2009). This has led to “shadow” analytics capabilities in many organizations, established to enable unit level control on information or in response to slow delivery of BI solutions resulting in reduced overall organizational benefit (Glaser & Stone, 2008).

Organizational factors such as top management team (TMT) commitment have been found to strongly effect perceived usefulness along with local management commitment and computer self efficacy effecting perceived ease of use (Lewis, Agarwal, & Sambamurthy, 2003). This reinforces the importance of TMT support and the need to examine BI systems in a larger organizational context. In the BI context, managers may play a dual role as both leader/sponsor and adopter. Typical approaches to measuring adoption may miss the effect of organizational intention which is a stronger driver than individual factors, such as manager personality, in the case of BI (Wang, 2014). Leadership messaging can reinforce BI adoption but can also result in inadvertent resistance among groups such as clinicians when proposed benefits, such as cost savings, are perceived to conflict with clinical care priorities. Health sector TMT can build support for use of information by visibly demonstrating the direct clinical effects (Jeffs, Nincic, White, Hayes, & Lo, 2015). Senior leaders, particularly those with oversight for nursing or practice settings, also have a role in connecting the dots between the information in practice and higher level decision makers such as funders and governance bodies, another key element for realizing overall value (Jeffs et al., 2015). Fundamentally, a leadership focus on organizational strategic goals is as important as the underlying technology and corresponding access to data for realizing BI benefits through organizational action (Shollo, 2015).

Traditional IT leadership roles also have an effect on BI implementation success (Elbashir, Collier, & Sutton, 2011; Elbashir et al., 2013; Lee, Elbashir, Mahama, & Sutton, 2014). Chief Information Officers (CIOs) in the health sector fill multiple roles including: business strategist, integrator, relationship architect, utility provider, information steward, and educator (Smaltz, Sambamurthy, & Agarwal, 2006). Effective CIOs need business and strategic IT knowledge and need to demonstrate political savvy and interpersonal communication. They

must be able to manage demand, helping their organization recognize the value of IT and how to leverage it effectively in addition to managing supply through responsive delivery of IT solutions (Smaltz et al., 2006). This reinforces the importance of looking at BI within the context of the IT/CIO and TMT leadership within a given organization.

Organizational structure. BI itself is a new sector with positions and roles being established to support data analytics within organizations. The skilled workforce needed to support the level of data analysis and interpretation required for the health sector is lacking and workforce requirements must be considered along with the need for technical solutions (Bardsley, 2016). Identified gaps in a recent United Kingdom report include: insufficient numbers of analysts with the needed skills (understand problems being solved, able to access and understand needed data, ability to apply appropriate methods, ability to communicate); limited access to data and tools; fragmentation in organizations/working in silos; lack of TMT recognition of the value of BI; and limited BI leadership (Schaeffer et al., 2017). BI competencies in academic settings are lacking, resulting in few graduates entering the workplace with the multidisciplinary skills needed to successfully support BI practices in their organization (Wixom, Ariyachandra, et al., 2011). These resources need to have a deep business understanding as well as technical skill and organizations may benefit from new roles such as outcome manager, proposed as an individual responsible to ensure that decisions are implemented and outcomes achieved (Davenport et al., 2001). Similarly, Jin and Ju (2014) discuss the concept of competitive intelligence (CI) and the CI practitioner as a resource whose work focuses entirely on CI analysis and production. In this model, CI practitioners are differentiated from information professionals who may also do information orientated work, use

databases, and access internal and external data but the latter may not have the skills to do interpretation and derive meaning from ambiguous or conflicting data.

While the supporting roles are not homogenous, the extent to which the organization has invested in resources to support BI systems has been linked to success ((Kandel, Paepcke, Hellerstein, & Heer, 2012; Kandogan, Balakrishnan, Haber, & Pierce, 2014). An emerging approach is the establishment of BI Competency Centres (BICC) as a multidisciplinary practice team within the organization tasked with improving BI system performance throughout the lifecycle (Chandler et al., 2011; Gárdai, 2013; Miller, Bräutigam, & Gerlach, 2006). The BICC unit is tasked with developing the overarching strategic plan for BI, ensuring information governance structures are in place, supporting end users in interpreting data and defining their information requirements (Chandler et al., 2011). While there is support for the BICC concept in the corporate BI literature, there were no empirical studies found which examined the effect of this approach in the corporate or health business setting.

BI governance. The need for multiple sources of data to inform BI systems raises unique challenges with respect to governance and the related concept of privacy and is where health sector requirements differ from those of other sectors (Bonney, 2013). Governance in this context can be described as the oversight structures needed to interpret and apply rules and enforce them. This encompasses a full BI lifecycle from determining organizational priorities for BI, selecting and implementing systems, ensuring BI applications are compliant with privacy and confidentiality obligations, ensuring appropriate data access, as well as driving underlying data standards and semantic interoperability across an organization (Gray & Thorpe, 2015; Hovenga & Grain, 2013). Without standards, context, and oversight there is a risk BI systems will produce

misinformation (Hovenga & Grain, 2013) or compromise privacy obligations associated with this highly sensitive data (Whitt, Burns, & Gittens, 2015).

Risk management is a cornerstone of data governance in the health sector given the sensitivity of the data assets. The need to consider privacy requirements and establish functional governance is even more critical when accessing health system assets across multiple settings or organizations are combined (Garay et al., 2015). In Canada, health care is governed by a mix of organizations within jurisdictions and as a result, there may be multiple data holders ranging from provincial or federal ministries, health authorities, as well as other providers such as physician offices (Whitt et al., 2015). In practice, there may even be multiple independent applications/data sources within a single organization with varying levels of formal and informal limitations on access often based on organizational structures in addition to differing privacy legislation across Canadian and American jurisdictions (Gray & Thorpe, 2015; Whitt et al., 2015).

While BI systems are typically producing data that is aggregated and de-identified, ensuring this happens consistently and reliably on large data sets can be challenging, particularly given the mix of data quality found in most health data holdings (Gray & Thorpe, 2015). In the context of surveillance and quality initiatives, Gray and Thorpe (2015) discuss a safe harbour method of de-identification with the removal of pre-identified elements such as name, geographic indicator smaller than a state, health/identifier numbers, and photos which may or may not be sufficient in areas with lower population such as some Canadian provinces. This needs to be carefully managed to overcome a general public wariness regarding whether de-identification is truly possible and given the lack of consistent frameworks for patient consent to secondary uses whether deidentified or not (Gray & Thorpe, 2015). Ethics review boards may

also be sceptical about the ability to manage data access in alignment with their criteria when BI user tools are accessed to support research related initiatives (Horvath et al., 2011). There are unintended ethical complexities resulting from de-identification in that context as this also removes the ability to follow up with individuals when an unexpected result is found however, the good may outweigh the bad (Gray & Thorpe, 2015).

Human factors. As BI applications are reliant on end user adoption to realize success, an understanding of user expectations and requirements is needed in the operational setting. As health system managers are busy and have limited time to dedicate to interpreting and reviewing extensive data, success and adoption of BI system tools will be dependent on the extent to which they can provide timely information that is both meaningful and easy to consume (Byrnes, 2012). Relevant human factors include end user skills and capacity as well as quality and reliability of data outputs.

End user skills and capacity. There is mixed evidence regarding whether health system managers as a collective have the skills needed to use sophisticated analysis tools and optimize data driven organizational decision making. Even with relatively simplistic functions such as searching for practice guidelines, clinicians may lack the skills needed for successful searching and information retrieval (De Lusignan et al., 2005; Ingemansson, Bastholm-Rahmner, & Kiessling, 2014). One of the few Canadian studies looking at BI in the health sector concluded,

> The lack of relevant skills and knowledge, particularly as it pertains to the management team, is a significant issue – it implies that even if the district had access to an effective BI platform, they would not be able to exploit it, given that a significant portion of the management team lacked data analysis skills (Foshay & Kuziemsky, 2014, p. 25).

Other examples in the health literature found that health system providers (when data are available to them) use the information to drive change in their environment so this assumption may not bear out in all practice settings (Jeffs et al., 2015; Wilbanks & Langford, 2014). The tactical skills required to generate and use reports within BI systems are learnable. Evidence from other sectors demonstrate these can be reinforced through establishing organizational norms around the use of information for decision making as well as training to increase competence in report development, particularly when reinforced through sharing of reports between managers (Chang et al., 2015). The effect of confidence and baseline knowledge was seen by Carroll et al. (2014) in their systematic review of epidemiological tools, where users identified a lack of confidence and a corresponding fear of misrepresenting the data as barriers. This is not an unfounded concern and may relate to confidence in underlying data quality as summative reporting tools can easily mask errors in data. Data quality and the absence of underlying data sources is a particular issue for examining nursing practice impacts within the health sector (Nagle & White, 2015; Nickel et al., 2017; Welton, 2014; Westra et al., 2015) and reinforces the need to look specifically at nursing leader/manager BI information requirements.

BI system outputs. Output products are the most visible element to the BI end user and selection of the visualization approach is an important consideration in ensuring information meets business needs. These can range from simple tables and bar charts to more complex timelines and GIS mapping techniques, all of which can be a means of conveying information more or less clearly for business users depending on the design (Khan & Khan, 2011). Scorecards and dashboards are frequently identified as an optimal mechanism for presentation of data (Byrnes, 2012; Karami, Safdari, & Rahimi, 2013; Prevedello, Andriole, Hanson, Kelly, & Khorasani, 2010; Ward, Morella, et al., 2014; Wilbanks & Langford, 2014). Jennings (2013)

compared user preferences for dashboards over scorecards and found that users felt that the dashboard with gauges was the easiest to comprehend given the visual cues and better use of whitespace. Of note, respondents also identified missing elements in the presented options such as trends and comparative data which limited use of the data for decision making purposes. Dashboards, through their simplicity, can mask underlying data quality issues or user/developer errors in selecting data sources and the term GIGO (garbage in garbage out) applies here regardless of how easy the results are to visualize (Simpao, Ahumada, Gálvez, & Rehman, 2014). This highlights the importance of tools which allow managers to receive data in a way that supports decision making with meaningful context taking priority over presentation style. Regardless, BI outputs have the potential to greatly simplify information for decision making. Render et al. (2011) describe the use of a dashboard in one health setting implemented to decrease the data overload associated with a previously unusable quality report approach which ranged from 106 to 299 pages.

Beyond dashboards, there are additional elements emerging to make BI system outputs more meaningful. Tomić and Milić (2013) demonstrated the value of a fuzzy logic based system to translate results into natural language to make it more meaningful and therefore more actionable as knowledge and insight for managers. An example would be a descriptor statement indicating an indicator is slightly or significantly larger than the prior fiscal based on pre-determined thresholds to avoid subjective assumptions based on visualizing these on a bar graph. Similarly, Tremblay, Hevner, and Berndt (2012) demonstrated use of an information volatility measure (to show the rate of variability of past change in the information) and benchmarking to improve end user understanding of data. Focus group participants in this study reported increased

confidence in decisions with information volatility measures and identified potential incorrect conclusions that might have been made without this context.

Timeliness of outputs is also a factor in adoption, managers are more likely to use BI tools where value is realized soon after implementation. Ramakrishnan et al. (2012) found that implementations that focused on a problem driven strategy and collected data for a specific business need provided faster results than those attempting to collect, integrate and store all data from the organization in an enterprise wide data warehouse. This was due to delays resulting from the extensive infrastructure, planning and requirements gathering needed before the system was available to users. Both approaches have value however, as the more tactical approach requires replication each time a new problem is identified and the study supported the need to consider both long and short term goals when determining data collection strategy (Ramakrishnan et al., 2012).

Organizational performance. The ultimate outcome of BI investment is achieving improved organizational performance as a result of the focus on strategic objectives, data driven decision making and organizational culture changes expected with BI (Elbashir et al., 2013). As Hočevar and Jaklič (2008) note, "…BI actually involves very little that is new as it solves old problems that managers have always been occupied with. It represents a basic managerial task – analysing a complex business environment in order to make the best possible decisions" (p.89). As a result, BI system implementation success lies in its use as a business transformation tool which is dependent on a wide range of business, operational, organizational and technology factors, many of which operate independently of the BI solution itself (Chandler, 2014). Despite this, BI research has tended to focus on immediate benefits with the majority of published articles focusing on technology choices, implementation factors, and measures of adoption rather

than measuring post-adoption benefits (Côrte-Real, Ruivo, & Oliveira, 2014). Organizational benefit is achieved through a number of interrelated elements which include improvements to: processes, decision making, quality measures, strategic objective realization, clinical outcomes, and financial measures. The expected outcomes will vary by organization and their specific strategic objectives.

Decision making. Health system managers make routine decisions every day that, when combined, can have significant cumulative effect. Davenport (2009) uses the term "decision-making disorder" to describe some of the series of corporate decisions that had significant and widely known negative outcomes including: subprime mortgages; General Motors product lines; and Time Warner's decision to buy AOL. The underlying premise is that organizations are plagued by decision making that is in the hands of individuals who often lean on experience informed intuition rather than sound data (Davenport, 2009). While BI and analytics will increase the likelihood of rigour and presumably, correct decisions, Davenport cautions the risk remains that decisions may still be based on incorrect assumptions due to human, organizational, data and process factors. He emphasizes the need for a framework to improve decision making through: identification of decisions needed; inventory of the factors and information needed; intervention through examining options and taking action; and institutionalization of the tools and approaches to decision making. Similarly Niu, Lu, Zhang, and Wu (2013) also identify common mistakes in decision making such as plunging in, frame blindness, overconfidence, short-sighted shortcuts, group failure, and failure to audit your decision process which can be overcome with structured approaches to decision making.

While operational decision making is multi-factorial, there is evidence that access to data for decision making can be linked to outcomes in the health sector. Agnoletti et al. (2013)

describe use of a rudimentary analytics approach to support decision making in a surgical operating suite in Italy. Access to the data, which was primarily process and patient flow related, was found to result in decisions that improved efficiency and decreased cost through reduced unscheduled procedures and overtime events without reducing measures of quality and productivity. Similarly, Carter and Cox (2000) compared labour cost per patient day between nursing managers with and without access to a nursing resource focused decision support system and were able to show improved control over per patient day hours and costs on intervention units versus control units. In this study, it is noteworthy that broader factors such as nursing comfort with computers and competing/confounding factors outside of nurse manager control were identified as limitations.

Where common decisions can be quantified into discrete elements and business rules, BI can be used to support automated decision making. This has been shown to be of value in other sectors such as insurance where risk models can be applied to determine driver eligibility and pricing. There is less evidence of acceptance of this in more complex and variable environments such as health service delivery where challenges include credibility and difficulty in demonstrating predictions against outcomes (Caro & Moller, 2014). Resource allocation is a common function in health service delivery where modelling has been applied, yet many models assume unlimited or predictable system loads, such as all patients arrive at once and that all patients are heterogeneous which do not reflect reality (Caro & Moller, 2014). For areas where there is less variability, radiology departments for example, this has promise and may explain the relatively high volume of BI related articles in that sector.

Process improvements. Ariyachandra and Frolick (2008) discuss business process management as a component of BI as it allows the results of changes in process to be more

readily tracked. As a precursor to BI, process meta-models, such as structured care plans, can be used to establish a process map and set the basis for key information to be produced and tracked with BI systems (Behnam & Badreddin, 2013). This approach has the benefit of providing end users with information of value to them quickly thus avoiding the disenchantment that can result when BI reports focus only on higher level system indicators. In a complex clinical setting, process improvements are often one of the primary drivers for use of BI. Successful examples include Caspers and Pickard (2013) who describe an initiative undertaken at 14 hospitals to reduce the cost of nursing care using value based resource management approaches. This successfully shifted reporting from retrospective analysis of nursing resource utilization to providing real-time trends in patient census and acuity as well as individual patient level care hours. Using the Nursing Outcomes Classification taxonomy, they were able to focus on safety elements targeting those that should not occur and ultimately reported increased patient satisfaction and cost savings through reduced overtime and length of stay. Nagy et al. (2009) describe use of a dashboard for managing radiology operations tracking time from arrival to procedure, time from orders to procedures for urgent requests, time waiting more than one hour, image reject reasons, percent of images peer reviewed (and outcome), unsigned reports, and speech recognition software error rates. They report improvements including improved radiology report turn around time, outpatient waiting times, and stat order turnaround. Their anecdotal results reinforce the need to consider broad organizational elements when measuring the effect of BI. They were not able to attribute the change to the dashboard alone however and note the resulting culture of transparency through the open discussion of results at regular team meetings may have been a factor (Nagy et al., 2009).

Quality improvement. Quality improvement (QI) is an common health sector focus that benefits from BI solutions to identify and track areas for improvement. Durham, Rokoske, Hanson, Cagle, and Schenck (2011) identified factors affecting use of QI in hospice settings and found issues with limited resources and support for data gathering particularly in community settings which are not as well resourced as acute care facilities or academic centres. The lack of sufficient electronic systems to support automated reporting was identified as an underlying issue in community based settings. Typical QI tools that benefit from BI systems include balanced scorecards (Grigoroudis, Orfanoudaki, & Zopounidis, 2012), data mining for patient flow (Isken & Rajagopalan, 2002), quality dashboards (McLaughlin, Afsar-Manesh, Ragland, Buxey, & Martin, 2014), and adverse event reporting (Ferrand et al., 2010; Nickel et al., 2017).

Health sector information requirements. In addition to more typical organizational information, health sector BI users apply an additional lens to analytics to examine discipline specific contributions as well as clinical and practice outcomes.

Clinical outcomes. A review of the long term care sector in the Netherlands identified the following information requirements from a BI system: customer experience; indicators related to care intensity mix (staffing, business unit level, prognosis); staffing for operations/by care intensity, indicators related to critical incidents (number, type, causes), and production information (Spruit, 2014). While these elements were desired, not all of these could be met due to data limitations such as data gaps (lack of data) and lack of standardization. While BI literature tends to focus on organizational and health system management use, there are examples of clinical benefits also (Moore et al., 2012). Marino (2014) talks about the need for better information to support clinically integrated networks and identifies four levels of clinically focused BI uses: population health analytics (risk factors, modelling future demand, comparisons

with other populations); risk-based cost analysis (stratification of cost drivers such as specific chronic diseases); performance analytics (patient outcomes, results against a target); and care management (support navigators in managing patient care along defined pathways). Similarly, use of a data warehouse for neonatal intensive care data across a multiple settings (340 hospitals in 34 states) has been reported to result in improved documentation and the ability to compare standard treatment approaches (Spitzer, Ellsbury, & Clark, 2015). One case example presented by Spitzer et al. (2015) describes a comparison between two antibiotic treatments for septicemia which were thought to be equivalent but on review against the fuller data set available within the warehouse, a 100% greater association with mortality based on gestational age was found with one of the options resulting in a practice change for septicemia management. Other case examples include adverse drug event surveillance and providing broad clinician user access to reports for practice inquiries (Horvath et al., 2009; Horvath et al., 2011). Davidson (2015) identifies opportunities for policy and system level planning through clinical data linkages with other available data such as census. It allows for assessment of disparities across populations and the ability to link these to other determinants of health and can also be used to scan for emerging communicable disease outbreaks.

A recent dissertation examining the state of evaluation of health data warehouse implementations reported a general lack of formal evaluation but informants, who were senior leaders responsible for the data warehouses, described opportunities to realize business goals related to health care reform, clinical research and meeting reporting needs (Leenaerts, 2015). Respondents reported improved efficiency, waste reduction, process improvement, improved patient and lab throughput, and occupancy rates. Respondents also indicated that nursing and finance sectors were found to yield fewer discernable results which was attributed to less mature

projects, lack of resources and a lack of data driven culture reinforcing the need to look at nursing expectations of BI systems specifically (Leenaerts, 2015).

Nursing information requirements. Nursing practice is identified as a sector with a high need for data and limited access to information (Welton & Harper, 2015; Westra et al., 2015). Welton and Harper (2015) identify the need to find financial and analytic models that reflect nursing care, given that nursing is one of the largest expenditures in the health care system. In hospital settings in the United States, inpatient nursing care is typically charged as daily per diem with no relationship to actual care hours per patient and in other settings it is often embedded in overhead for procedure codes or fee for service payments (Welton & Harper, 2015). In the Canadian context, nursing resource and workload measures are similarly embedded in non-distinct cost centres (Nickel et al., 2017). This gap reinforces the need to examine nursing specific requirements for BI systems so efforts to address gaps in available data can be targeted at the information needed to meet strategic organizational performance objectives. Understanding these gaps can support efforts such as work to align the Nursing Minimum Data Set to outcomes (Pruinelli, Delaney, Garciannie, Caspers, & Westra, 2016).

There are efforts underway in both Canada and the United States (USA) to achieve consensus on standards and approaches for capturing comparable nursing specific information within clinical information systems (Nagle & White, 2015). Welton and Harper (2015) describe efforts to come to consensus on how to measure nursing intensity at the patient level and develop nursing specific BI and analytic tools (to track financial, clinical, operational and quality/safety and outcomes). They propose there is a need to shift the focus from nursing as a staffing model to one where each nurse is uniquely identified as a provider of care. This is particularly critical as practice models shift from discipline specific to interdisciplinary (Salmond & Echevarria, 2017).

Westra et al. (2015) describe efforts underway in the USA to determine standardized terminologies and common data and information structures within electronic health systems. They note challenges include: a lack of knowledge of the gap and limited ability to teach nursing in this way; the need for practice level support for the use of standard terminologies as many electronic systems are based on a medical model versus nursing workflow; policies and resources; and standards. Drivers for this change are not unique to the USA and include cost, lack of standards/too much variability, misdirected incentives and the need to respond to health disparities, aging, and increased chronic illness (Salmond & Echevarria, 2017).

Barton (1994) looked at the data needs of Chief Nursing Executives and found an emphasis on financial data requirements but also included clinical, human resource, and environmental data. These reflect the Institute for Healthcare Improvement Triple Aim of improved patient experience, improved health, and reduced cost however achieving these will require big data approaches to support personalized care and predictive approaches (HIMSS, 2015). Unique approaches to use of BI can result in direct system improvements such as the opportunity to tie nursing schedules to competency based assessments as a unique approach to distributing novice nurses across shifts to pair with more expert or experienced nurses to enhance care (Spitzer & Miranda, 2017). Gaps in available nursing indicators will be exacerbated with the shift to big data initiatives if nursing specific data remains absent from enterprise systems (Brennan & Bakken, 2015). Nursing sensitive outcome data points are notably absent from most current electronic health records (Sousa, Reeder, Bondy, Ozkaynak, & Weiss, 2017). As a result of these gaps, data analytics has been identified as a nursing trend of the future and a required part of nursing curriculums “educating the nurses of 2025” (Risling, 2017).

Related Trends. Two concepts that relate closely to BI are big data and predictive analytics. Where these differ from BI is typically through the focus on information assets internal to the organization, direct alignment with organizational key performance indicators/strategies in report generation, and the presentation of historical information.

Big data. Big data is an emerging concept that is expected to drive a fundamental paradigm shift in data driven endeavours in most sectors including analytics, research and policy development and big data has the potential to drive revenues or fundamentally change the business environment for those who use it well (Chang, Kauffman, & Kwon, 2014; Han, Yonggang, Tat-Seng, & Xuelong, 2014). Even within the literature, the concepts of BI and big data are occasionally used interchangeably however there are differences in the fundamental architectural frameworks (see Table 4). Traditional BI can be accessed on an analyst's desktop with tools becoming increasingly ubiquitous and user friendly whereas big data still requires complex and distributed processing with complex tools requiring specialized skills (Raghupathi & Raghupathi, 2014). There is also a fundamental variation in purpose. Big data has an inherent tolerance for variability where BI requires a level of assurance that data are suitably cleaned and normalized to ensure indicators represent true organizational patterns (Shneiderman & Plaisant, 2015). The big

Table 4

Comparison of Big Data and Traditional Data

Feature	Traditional Data	Big Data
Volume	Gigabyte	Constantly updated (Terabyte or petabyte currently)
Generated Rate	Per hour, per day, ….	More rapid
Structure	Structured	Semi-structured or un-structured
Data Source	Centralized	Fully distributed
Data Integration	Easy	Difficult
Data Store	RDBMS – relational database management systems	HDFS (Hadoop Distributed File System), NoSQL (non SQL, non relational database); SQL=structured query language (used to communicate with a database)
Access	Interactive	Batch or near real-time

Note. From Han et al., 2014, p. 654.

data paradigm poses many technical challenges primarily relating to the distributed nature of the data, the use of massive and heterogeneous datasets and the need to mine massive datasets in real-time (Han et al., 2014). As a result, traditional relational database management approaches are inadequate.

Big data is typically characterized by a "multi-V" model which varies depending on the reference source however three are consistently included: volume, variety, and velocity (Assunção, Calheiros, Bianchi, Netto, & Buyya, 2015). Volume refers to the sheer amount of data which is typically not definitively defined as the metric for comparatively large data continues to grow (Assunção et al., 2015; Manyika et al., 2011; Shneiderman & Plaisant, 2015). Variety reflects the growing range of types of data available for analysis, including social media and other unstructured forms not traditionally used in business analytics (Assunção et al., 2015) and velocity refers to the processing speed and variability in processing speeds needed (Assunção et al., 2015). Other emerging concepts include veracity and value with veracity referring to variability in the level of reliability in data and value referring to the worth or profitability to be attained by use of big data (Fosso Wamba, Akter, Edwards, Chopin, & Gnanzou, 2015; Manyika et al., 2011).

It has been suggested that effective use and acceptance of BI is a precursor to use of big data (Chang et al., 2015) and indeed many of the opportunities for big data use mirror those seen in BI including surveillance, cost savings through identification of inefficiencies, fraud abuse, inform strategic policies, clinical or operational research, and epidemiology (Raghupathi & Raghupathi, 2014; Sukumar, Natarajan, & Ferrell, 2015). Data quality becomes even more complex with the opportunity to draw data from an even wider and diverse base of sources for big data. Big data brings inherent challenges in accommodating both structured and unstructured

data, standardizing analytic procedures, and the risks of misinterpretation and unrecognized blind spots when performing analysis (Kuo, Sahama, Kushniruk, Borycki, & Grunwell, 2014). Big data, like BI, also has the potential to miss data and patterns within health systems particularly areas where electronic documentation still lags behind. Sensmeier (2015) looked at big data for nursing and identified potential gaps due to the lack of consistent documentation limiting the ability to leverage electronic records, and ultimately big data, for improving care. Nursing workload information has also been identified as a gap within Manitoba's data assets (Nickel et al., 2017). This reinforces the need for nursing to establish data standards and terminology that will be used consistently for data to be readily available within a big data context to avoid underreporting of nursing's contribution to care (Sensmeier, 2015). BI end users cannot be expected to understand the sophisticated modelling needed to populate analytical models and yet, their input is needed to ensure sources are validated. As with big data, this will be an ongoing challenge in an active BI environment and adds complexity to usability testing and data validation in preparing systems for non-technical end users (Zechmeister-Koss, Schnell-Inderst, & Zauner, 2014). It is expected that big data will play an increasing role in meeting the future needs of the health care system including prediction and knowledge generation (Krumholz, 2014).

Predictive analytics. Opportunities for predictive analytics are often identified along with big data in the health sector with predictive or forecasting models using existing historic information to project future expected performance (Hadavandi, Shavandi, Ghanbari, & Abbasian-Naghneh, 2012; Helm-Murtagh, 2014). Other sectors, such as the airline industry, have demonstrated tangible benefits from predictive tools where ground crew assignment shifted from scheduled arrival times to predictive estimates of actual arrival time (weighing multiple factors

such as weather, wind, and other ground factors) resulting in efficiency benefits and cost savings in the millions (McAfee & Brynjolfsson, 2012). The health sector, with an equally complex set of variables may realize similar benefits. Helm-Murtagh (2014) describes the experiences of Blue Cross and Blue Shield of North Carolina using big data to measure new models of care; obesity prediction to identify patients needing outreach; risk analysis for other health risks; and to identify individuals likely to use emergency inappropriately although it is unclear from the article the extent to which the data sets in use would fall under big data or BI. Raghupathi and Raghupathi (2014) identify the potential of big data analytics for surveillance to allow early detection of outbreaks and predictive analytics looking at indicators for prolonged length of stay across datasets. Similar examples can be seen in the use of directed analytics reporting to improve care for coronary artery disease management (Graf, Erskine, & Steele, 2014).

Predictive analytics combined with big data can be a powerful combination to improve accuracy as demonstrated by Srinivas et al. (2017) who demonstrated predictors for graft loss and mortality in patient cohorts post transplant. Predictive analytics may use the same general infrastructure however, BI systems and the organizational culture shift to fully assimilate data driven decision-making are a likely precursor to fully optimizing systems for predictive analytics. There is no question that value can be derived from a predictive analytics approach and it requires a similar organizational culture to realize these benefits as those companies who describe themselves as data driven were found to be measurably more productive and profitable (McAfee & Brynjolfsson, 2012).

Conclusion

These findings reinforce untapped potential benefits to establishing BI systems within the health sector provided the organizational culture and underlying data quality limitations are

addressed in addition to the technology solution. The literature supports the need for research looking at the effect of BI in the health care sector specifically given the unique nature of health service delivery and the correspondingly complex and diverse organizational structures. Of note, few articles controlled for broader organizational context beyond general references to information gaps, end user capacity and effects of data visibility. While there is limited empirical evidence within the current literature, the articles provide compelling arguments for the potential for BI to add value to health system manager practice through the delivery of information in a timely and meaningful format for use in decision making. The literature also reinforces the need for research approaches that extend beyond implementation and user acceptance to look at organizational factors and the realization of organizational performance improvements. These findings support the approach of this study and the need to address the gap in evidenced based approaches to measuring BI system success in the health sector.

Chapter 3 - Conceptual Framework

There were no mature conceptual frameworks or theoretical models for analysis of BI in the health care sector found and only two focused specifically on BI in other sectors. As BI is an emerging domain for research, the theoretical framework for this study has been drawn from models looking at typical IT implementations as well as BI models from other sectors.

Existing Frameworks

Data warehouse success model. The Data Warehouse Success Model (DWSM) is one of the earliest models examining BI systems and focuses on the effect of technical and human factors on implementation success (Wixom & Watson, 2001). The model builds on earlier work by Delone and McLean (2003) reflecting the multifaceted nature of successful information systems implementation. While focused primarily on the implementation of data warehouse infrastructure, the DWSM recognizes the unique organizational context in which these are being undertaken with success factors reflecting organizational, project and technical aspects (Wixom & Watson, 2001). With an end state of perceived net benefits, the model does not extend into end user acceptance. When tested, perceived net benefits were found to be positively correlated with system and data quality (Wixom & Watson, 2001). System quality was positively affected by organizational, project and technical implementation success; however, data quality was not (presumably because the data from source systems was not enhanced through the implementation project). Organizational implementation success was most affected by management support and resources. Project implementation was most affected by resources and team skills as well as resources and user participation to a lesser extent. Technical implementation was most affected by development technology and, to a lesser extent source systems (Wixom & Watson, 2001). This model, while well accepted and tested in industrial settings, falls short of capturing the

extent to which desired organizational objectives are achieved through data warehouse implementation. It does however reinforce the value of considering BI in a broad organizational context.

Technology acceptance model. The technology acceptance model (TAM) shifted the focus in IT models from technology to end users and their adoption of IT systems. TAM is not health or BI specific although has been demonstrated to be an acceptable model in the health care context (Holden & Karsh, 2010). The model focuses on variables that measure the effect of factors such as end user perceptions and behaviours on adoption of an IT related intervention (King & He, 2006). The model was first developed in the 1980s in response to IT implementations that, while technically successful, did not result in sustained use (Davis, 1989). The model presents three foundational concepts: *perceived usefulness* and *perceived ease of use* which effect *behavioural intention* which is ultimately demonstrated through *usage* (Venkatesh & Davis, 2000). The model is widely used with many variations found in the literature, in part because it has not been shown to be consistently replicated across all studies that have used it (King & He, 2006; Venkatesh & Davis, 2000). King and He (2006) were able to demonstrate high reliability between perceived usefulness and behavioural intention while the relationship between ease of use and these constructs was less consistently strong. This theory lacks measures of the broader organizational context, thus limiting usefulness in examining BI.

Information system success model. Delone and McLean (2003) first published their information system success model in 1992. This model reflects a broader organizational context for information system implementation examining the effect of system quality and information quality on use/user satisfaction and organizational benefit. Timing and context are important in interpreting this model (and others) in that many were established before significant

advancements in personal computing when all IT systems were operated centrally and typically by technical experts. Most valuable in this model, for the BI context, is the reflection of IT success as a multidimensional and interdependent construct (Delone & McLean, 2003). The model reflects a process approach versus a causal model across three primary components: create a system, use a system, and realize consequence. Quantification of use in this model is problematic for BI in that use extends beyond measures of volume of events and use alone does not necessarily achieve desired organizational change as is required to realize organizational performance improvements. This is another model that overlooks the broader organizational context needed to fully assess BI implementation.

Business value of BI model. The models above form a strong foundation for this area of study but do not fully reflect the unique nature of BI applications with their intended outcome of improved organizational performance and strategic alignment. Work by Elbashir, Collier, Davern and Leach (Elbashir et al., 2008; Elbashir et al., 2011; Elbashir et al., 2013) over the last decade has established and tested a credible theoretical framework to describe the effect of BI in organizations within the finance and manufacturing sectors. The most recent model proposed in 2013, demonstrates strong associations (although not yet causation) between five key concepts, shown here in italics (Elbashir et al., 2013). Three of these concepts can be described as human resource and organizational structure factors. *Chief Information Officer (CIO) Business Knowledge* which enhances *Top Management Team (TMT) Strategic IT Knowledge*. Both of these enhance *Operational Managers' Shared Knowledge* which is an antecedent to *BI Assimilation* leading ultimately to the intended outcome of *Organizational Performance*. The strength of this model is the broader organizational context and the identification of the relationships and cross functional knowledge between IT and business leaders. The applicability

of this is reinforced in the maturity model identified through the systematic review where Brooks et al. (2015) identified four primary process areas as indicative of maturity: organizational; people and team; technology; and those specific to healthcare related complexities.

The concept of assimilation has been established previously to describe the extent to which IT systems are being used to achieve business strategy and delivering a benefit to the business organization (Armstrong & Sambamurthy, 1999). In the BI context, the concept of assimilation has been defined as "the extent of use of BI Systems to support business strategies and value chain activities in the organization" (Elbashir et al., 2013, p. 89). A related preceding concept is absorptive capacity, described as use of strategic technologies in a way that is integrated with operational processes and ultimately provides strategic benefit (Elbashir et al., 2011; Manfreda, Kovacic, Stemberger, & Trkman, 2014). Assimilation as a concept considers more than just adoption of IT systems and extends into a focus on outcomes within organizations. IT assimilation is defined "as the effective application of IT in supporting, shaping, and enabling firms' business strategies and value-chain activities" (Armstrong & Sambamurthy, 1999, p. 306). Realizing outcomes requires a relationship between senior leadership team members, both business and technical defined as, "the organizational collective consisting of the firm's CEO, COO, CIO, and other senior business executives who are formal members of the top management team" (Armstrong & Sambamurthy, 1999, p. 306). The measures used to capture BI Assimilation in the context of the *Business Value of BI Model* in other sectors are not specific to the health sector (M. Elbashir, personal communication, February 20, 2015). The measures, such as reduction of lost sales or improved competitive advantage, are unlikely to resonate with health system leaders based on the literature findings

(Elbashir et al., 2013; Manfreda et al., 2014). This limits direct transferability of this model to the health sector, particularly in the Canadian publicly administered system.

The construct of organizational performance can be described as realized business value or the extent to which organizational strategies are being achieved through use of BI (Davern & Kauffman, 2000; Elbashir et al., 2013) and is the ultimate objective of BI initiatives. The achievement of strategic objectives can be challenging to measure even within a single organization. Particularly in complex organizations such as those found in healthcare, there may not be alignment on priority performance and organizational objectives. Davern and Kauffman (2000) propose that mediating concepts, called conversion contingencies, effect the transfer of value from potential (or expected) value to realized value. In the corporate context, conversion contingencies include controlled and uncontrolled variables such as market conditions, business processes, workgroup functioning or individual user elements. To measure the concept of business value, Elbashir et al. (2013) leveraged their prior work, reusing survey questions originally developed by Armstrong and Sambamurthy (1999) asking users to compare themselves to others in their industry (Elbashir et al., 2008). This approach introduces some potential bias as organizations may skew towards a positive vision of their performance however it provides an equivalent baseline measure within organizations. This also mitigates the risk that the model may not translate between sectors. The measures used for organizational performance in this model may not fit with Canadian health sector priorities as they include lost sales, geographic distribution of sales, and competitive advantage which are not typical concerns for health system leadership in Canada.

Business Intelligence Benefits Model for Health

In the absence of models that sufficiently consider health sector specific uses of BI, this study proposes a new framework, the *Business Intelligence Benefits Model for Health* which focuses on the organizational environment required for BI success through the realization of organizational objectives (Loewen & Roudsari, 2017c). The foundation of this framework is the Business Value of BI Model proposed by Elbashir et al. (2013) and validated in other sectors. The framework has been modified for application to health sector BI however, as the measures of business value (*BI Assimilation* and *Organizational Performance*) are drawn from manufacturing and finance sectors and do not reflect the objectives for health sector organizations identified in the literature. Control variables are drawn from other established frameworks demonstrating data warehouse (underlying BI infrastructure) success (Wixom & Watson, 2001), and technology acceptance (TAM2) (Davis, 1989; Venkatesh & Davis, 2000). Through five key concepts and six control variables, the framework depicts organizational, technological, and information factors and their interrelationship in achieving health system performance objectives (see Figure 2).

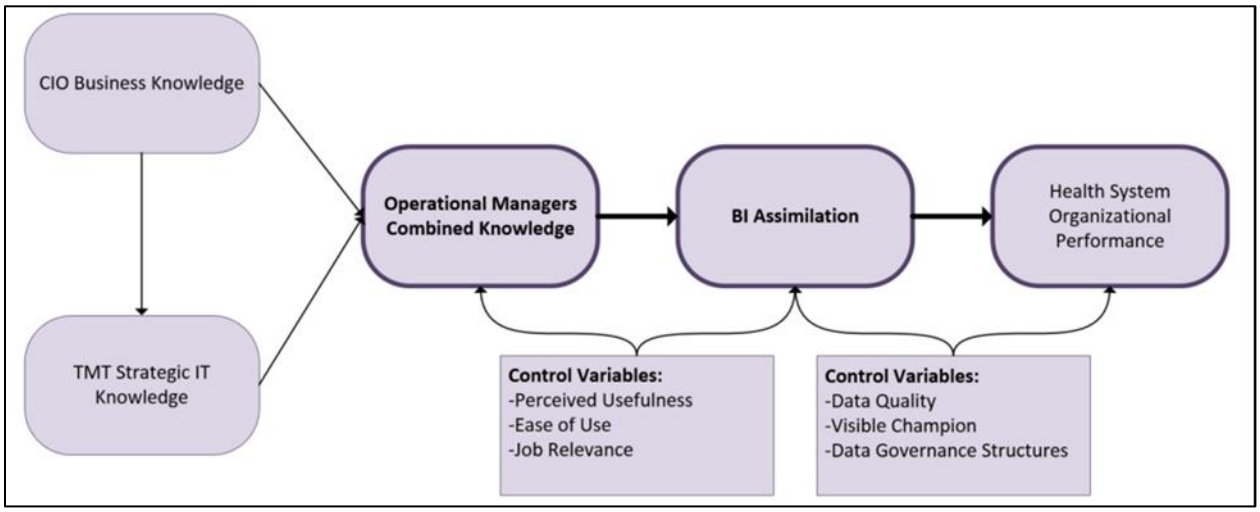


Figure 2. Business Intelligence Benefits Model for Health.

This study focuses on the two end state constructs within this model - *BI Assimilation* and *Health System Organizational Performance* as relevant health sector measures for these constructs need to be established before this model can be tested within a healthcare setting. The overall model provides the framework for participant selection and the proposed analysis approach.

Benefits Realization Constructs

BI Assimilation and *Health System Organizational Performance* are required for organizations to realize the benefits from BI investments.

BI assimilation. *BI Assimilation,* achieved through *Operational Managers' Combined Knowledge* is the central concept of this model and a precursor to achieving desired performance gains. This framework defines BI Assimilation as the use of BI Systems to support business strategies and processes within the organization (Elbashir et al., 2013). The established measures for this construct, validated by Elbashir and drawn from an adapted version of earlier work by Armstrong and Sambamurthy (1999) establishing a generic measurement tool for assimilation, do not fit the health system context however as the measures are not reflective of service sectors.

Health system organizational performance. *Organizational performance* is the ultimate objective of BI initiatives and reflects realized business value or the extent to which organizational strategies are being achieved through use of BI (Davern & Kauffman, 2000; Elbashir et al., 2013). Achievement of organizational performance objectives requires a clearly defined organizational vision or target state to ensure measures truly reflect priorities and not just what is easily measured. As with *BI Assimilation,* the construct of organizational performance has resonance but the measures within the existing model proposed by Elbashir are targeted at

non-service sectors and need to be established for the health sector before they can be tested in the health context.

Organizational Constructs

Organizational structures and human factors are fundamental to BI success and are reflected in the proposed model through three primary constructs: *Operational Managers' Combined Knowledge*, *CIO Business Knowledge* and *Top Management Team (TMT) Strategic IT Knowledge* as well as within the control variables. These constructs, reflective of the leadership alignment within the organization, are foundational to realizing BI success and form a framework for subject selection in this study.

Operational managers' combined knowledge. *Combined knowledge* is an extension of shared knowledge reflecting the extent to which technology and business managers understand and appreciate each others' contributions. Furthermore, *combined knowledge,* is the foundational antecedent to achieving BI Assimilation (Elbashir et al., 2011; Elbashir et al., 2013; Nelson & Cooprider, 1996). Combined knowledge occurs when managers combine their respective expertise to create new knowledge resulting in mutual understanding and collaborative work between teams (Wagner, Beimborn, & Weitzel, 2014). The concept has resonance, given that BI operations require technology, business analyst, clinical, and management resources to work together and ultimately take action on the information presented as a result of the BI system. In other sectors, the ability to achieve Operational Managers' Combined Knowledge was demonstrated to be positively influenced by both CIO Business Knowledge and TMT Strategic IT Knowledge (Elbashir et al., 2013).

CIO business knowledge. The success of information technology has been correlated with a strong understanding of the business environment by the most senior IT leader, typically

the Chief Information Officer (CIO) (Bassellier & Benbasat, 2004; Leidner, Preston, & Chen, 2010; Smaltz et al., 2006). *CIO business knowledge* reflects the extent to which TMT members perceive the most senior IT leader in an organization to understand the broader business context of the organization (Elbashir et al., 2013). Consistent with the relationship proposed in this conceptual framework, Preston and Karahanna (2009) demonstrated shared understanding between the CIO and TMT as a significant antecedent of IT strategic alignment, ultimately resulting in successful use of IT systems. Approaches to measuring this construct need to consider that TMT may not have the ability to judge CIO effectiveness in all areas particularly their role in those functions where they do not have visibility such as in direct service care (Smaltz et al., 2006).

TMT strategic IT knowledge. This concept reflects the CIO's perception of the extent to which the TMT understands and can identify the ways in which IT is a strategic resource within their organization. The TMT are the leadership group within a given organization as the organization defines it. Typical roles include Chief Officers (Executive, Operations, Information) and other senior business executives (Armstrong & Sambamurthy, 1999). As organizational leaders, they have a strong influence on organizational priorities and vision and therefore a direct link to BI implementation success (Armstrong & Sambamurthy, 1999; Bassellier & Benbasat, 2004; Leidner et al., 2010; Wixom, Watson, et al., 2011). While the concept of *TMT strategic IT knowledge* has been demonstrated in general IT assimilation frameworks, it is particularly important for this study given the direct linkage between organizational strategy and BI system outputs. These aspects of the model are reflected in the study participant selection and the subgroup analysis which includes both senior and operational leadership groups as well as those with responsibilities for clinical, technical and operational services.

Control Variables

The control variables in the *BI Benefits Model for Health* differ from those in the Elbashir model to better reflect the healthcare sector and are drawn from TAM2, and DWSM (Elbashir et al., 2013; Venkatesh & Davis, 2000; Wixom & Watson, 2001). The first group, drawn from the Technology Acceptance Model (TAM2), reflect human factors affecting BI Assimilation by Operational Managers. These are *Perceived Usefulness (*the extent to which it is perceived that use of an IT system will enhance job performance), *Ease of Use* (the extent to which the system is user friendly and fits into daily workflow) and *Job Relevance (*the extent to which the system is perceived to be applicable to their job) (Chismar & Wiley-Patton, 2002; Venkatesh & Davis, 2000). The second group is drawn from the Data Warehouse Success Model and effects the extent to which BI Assimilation will achieve *Organizational Performance*. These are *Data Quality (*completeness and accuracy of available data), and *Visible Champion (*the presence of leadership to sponsor and model expected use of BI) (Foshay & Kuziemsky, 2014; Wixom & Watson, 2001; Yeoh & Koronios, 2010). A third variable in this group, *Data Governance Structures,* has been introduced to control for the extent to which the health sector's unique privacy requirements and organizational structures impede or enable access to data by operational managers.

Conclusion

The *Business Intelligence Benefits Model for Health* provides a foundation for the study and is reflected in both the research questions and underlying approach used in the study. The model requires measures specific to the health sector for the key constructs of BI Assimilation and Health System Organizational Performance. As a result, these two key constructs are the primary focus of this dissertation work. The model has shaped the methodology for addressing

the deficiencies in the model through the nature of the questions and the study participant selection. The proposed model also provides a framework for analysis of the results. The following chapter details the study objectives and methodology used.

Chapter 4 – Methodology and Study Design

Introduction

The systematic and scoping reviews revealed a dearth of conceptual frameworks and limited empirical evidence regarding the effect of BI systems on health system performance outcomes. The research approach of leveraging models from other sectors was initially considered: however, the literature review identified the measures used in other sectors did not align to health sector specific expectations. As a result, and given the emerging state of work in this area, this study focuses on developing consensus around suitable measures for the constructs of *BI Assimilation* and *Organizational Performance* in the healthcare environment. The study also provides early validation of the theoretical framework overall by considering variations between leadership groups in perceptions of BI with a specific focus on nursing leaders as individuals responsible for sizable resource allocations in health service delivery budgets.

Research Objectives

The objective of this study is to establish health sector specific measures for two foundational constructs for BI success within the framework of the Business Intelligence Benefits Model for Health. The primary objective is to establish conceptual measures for the constructs of *BI Assimilation* and *Organizational Performance* to inform future measurement of BI use as well as application of the proposed model within the healthcare sector. The second objective is to compare perspectives of distinct respondent groups differentiated within the model and within the sector: 1) top management team (TMT) versus operational managers (OM), and 2) leaders with responsibility for a nursing portfolio (NP) and those without (NonNP). Understanding expected measures of BI success can inform implementation of health information systems generally to ensure systems are designed to accommodate future BI use. It

is also important to understand the extent to which organizational perspectives on BI objectives differ significantly among common leadership groups given this may be a contributing factor in overall BI success.

Research Questions

Given the emerging state of work in this area, the research questions focused on developing consensus around suitable measures reflective of the constructs of *BI Assimilation* and *Organizational Performance* in the healthcare environment and also variations between general leadership and nursing leader perceptions of BI (see Table 5).

Table 5

Summary of Research Questions and Methods

Full Group Consensus Process		
Objective 1	**Research Questions**	**Methods**
Establish representative measures for BI Assimilation (Q1) and Organizational Performance (Q2) as determined by an expert group representing health system TMT and OM from a variety of disciplines reflective of health sector leadership.	**Question 1 (Q1).** What are the measures representative of *BI Assimilation* in the health sector?	Delphi consensus process (3-4 rounds)
	Question 2 (Q2). What are the measures representative of *Organizational Performance* as an expected outcome of BI System implementation in the health sector?	
Sub-group Analysis		
Objective 2	**Research Questions**	**Methods**
Analyze and describe variations in scoring between NP and NonNP *Panel Members* (QA) and between TMT and OM *Panel Members* (QB) to inform standardization approaches and possible factors affecting implementation success.	**Sub-question A (QA).** To what extent do *Panel Members* with a nursing related portfolio differ from those without a nursing related portfolio in their overall scoring of concepts of BI Assimilation and Operational Performance?	Comparative analysis of initial concept identification and final concept rankings between and within sub-groups
	Sub-question B (QB). To what extent do TMT and OM *Panel Members* differ from each other in their overall scoring of concepts of BI Assimilation and Operational Performance?	

The two primary questions establish representative measures for BI Assimilation (Q1) and Organizational Performance (Q2) as determined by an expert group representing health system leadership including TMT and OM from a variety of disciplines reflecting the range of leadership roles in the health sector.

Question 1 (Q1). *What are the measures representative of BI Assimilation in the health sector?* In the absence of an empirically tested BI assimilation framework for the healthcare

sector, a Delphi consensus process with health system leaders was used to establish appropriate concepts reflective of measures for this construct as a precursor to use in future studies.

Question 2 (Q2). *What are the measures representative of Organizational Performance as an expected outcome of BI System implementation in the health sector?* Improved Organizational Performance is the ultimate objective of BI system implementation and use however measures for this construct have not been established for the health sector. Both Q1 and Q2 were addressed in parallel using a Delphi consensus process to establish appropriate concepts representative of measures for this construct.

The two sub-questions were analyzed for variations in identification (**Round 1**) and scoring of concepts between the specific sub-groups (Final Round) to consider implications for the proposed framework and possible factors affecting implementation success.

Sub-question A (QA). *To what extent do Panel Members with a nursing related portfolio (NP) differ from those without a nursing related portfolio (NonNP) in their overall scoring of measures of BI Assimilation and Operational Performance?* This is an important area of exploration as the role of nursing within the TMT of health organizations is still emerging in some organizations (Wells et al., 1999). In addition, there are recognized gaps in standardized nursing information within current clinical information systems (Sousa et al., 2017; Westra et al., 2015) and as a result, nursing requirements for BI may not be well understood or may not even be achievable within existing underlying clinical documentation systems. Nurse managers typically manage the largest budget area for human resources and oversee a sizable proportion of staff whose work directly influence the patient experience (Institute of Medicine, 2011; Nickel et al., 2017). Given the complex and sometimes divergent strategic directions found in healthcare organizations, a study to compare nursing leader measures of BI Assimilation and Organizational

Performance against general TMT perceptions is an important foundation given the role of the larger TMT in setting the direction that underpins BI success.

Sub-question B (QB). *To what extent do TMT and OM Panel Members differ from each other in their overall scoring of measures of BI Assimilation and Operational Performance?* Operational Managers play a key role in realizing BI Assimilation and Organizational Performance while the TMT set overarching organizational objectives and requirements for BI system implementation. If the perspectives of these two groups are not aligned, it will inform the need for additional control variables within the proposed conceptual framework as well as identify organizational alignment issues that must be addressed prior to fully realizing BI implementation success.

Approach

Research access and ethics approvals. Ethics approval was received from the University of Victoria Human Research Ethics Board (February 4, 2017) (see Appendix B). As recruitment involved a broad range of settings and the Researcher was blinded to respondent organizations, research access was not sought proactively from individual institutions except for the employer organization of the Researcher. In this case, access approval was requested and approved by the Winnipeg Regional Health Authority (January 30, 2017). As panelists are drawn from senior to middle leadership roles, it was expected that most would be autonomous in determining their daily activities. During recruitment, only one organization identified the need for access approval which was sought but not provided in time for individuals from that setting to be included given the study was already underway.

Delphi method. This study uses a multi-round Delphi method to structure and organize data collection as this approach allows for data collection from diverse expert groups and

provides a framework for consensus. The Delphi method has been widely applied particularly in health related research (de Meyrick, 2003; Hubner-Bloder & Ammenwerth, 2009). Core characteristics of Delphi studies include: anonymous expert input through individual iterative question cycles (called rounds); predetermined thresholds for determining consensus and stability; and controlled feedback to the group including quantitative and qualitative inputs with a statistical measure of group response (Dalkey & Helmer, 1963; de Meyrick, 2003; von der Gracht; Wool, 2015). The Delphi method is well suited to this research problem and has been widely applied and accepted as a research technique for gaining consensus on specific topics and for instrument development as is required in this study (London et al., 2015; McMillan, King, & Tully, 2016; von der Gracht; Wool, 2015). In addition, the study undertook separate sub-group analysis of the results of the first and final Delphi rounds (Nakatsu & Iacovou, 2009). Three to four rounds of input were anticipated with the final determination based on stability and consensus measures as described below.

The Delphi method draws on collective knowledge of experts by establishing a consensus based iterative process which allows for multiple perspectives to be triangulated to a final consensus (Cantrill, Sibbald, & Buetow, 1996; de Meyrick, 2003). The anonymity of the process allows expert groups to build on each others' knowledge (de Meyrick, 2003) by comparing their perspectives with those of other participants while avoiding the risk of group think which can occur in focus group or nominal techniques (Cantrill et al., 1996). In addition, as demonstrated in other studies, the data collected can also be used for concurrent analysis of sub-group perspectives (Nakatsu & Iacovou, 2009) an approach used in this study to examine variations in the ranking of measures between TMT and OMs as well as nursing and non-nursing participants.

Participant Selection and Recruitment

Recruitment of participants. Participants in Delphi studies are called Panel Members or Panelists to reflect the expert nature of their contributions and the consensus based objectives (McMillan et al., 2016; Wool, 2015). Panel Members were recruited using a snowball technique with the Researcher engaging a total of 26 contacts (*Snowball Recruiters*) from within her existing professional network using reminders until recruitment was completed. The *Snowball Recruiters* were contacted by the Researcher directly via email and invited to support this project by forwarding a provided invitation to participate to individuals who fit the criteria from within their professional and/or organizational networks (see Appendix C for Snowball Recruiter Invitation and Appendix D for Participant Information and Study Invitation). The Researcher was blinded as to whether the *Snowball Recruiters* distributed the invitations. As there was potential for overlap between networks, *Snowball Recruiters* were asked not to participate as *Panel Members,* even if they received an invite from other colleagues.

Potential *Panel Members* (participants) were provided with a summary of the study and instructions on how to participate (see Appendix D). *Snowball Recruiters* were blinded to who ultimately decided to participate. *Panel Members* expressed their consent to participate by contacting the project Research Assistant directly. The *Research Assistant* confirmed potential *Panel Member* contact information and assigned a participant number before sending a link to the Study Information and Consent Form (see Appendix E) and the Participant Profile Survey (see Appendix F) both of which were completed online.

Selection of subjects. In keeping with accepted Delphi methods, formal criteria for subject selection were established in advance and potential *Panel Members* were evaluated based

on their responses to the Participant Profile Survey (see Appendix F) to ensure they met the criteria (see Table 6). There is no definitive method for determining sample size in Delphi studies. While a larger panel provides a wider perspective, it is recognized that a large group will result in diminishing returns at some point given the expert nature of the feedback (McMillan et al., 2016). Following consultation with the University of Victoria Statistical Consultation Service (M. Lesperance, personal communication, June 16, 2016) and given the limited evidence base to draw on for precedent for this study, a sample size of at least 40 and up to 60 *panelists* was targeted with a minimum of at least 15 in each of the possible subgroups. This was adjusted during the study due to a slow response rate despite expanding the *Snowball Recruiter* group and three rounds of reminders. Recruitment was halted as there was a risk of losing participants who consented early in the recruitment phase and the minimum in most sub-groups was achieved. Ultimately, a total of 37 individuals responded to the call for participation resulting in a total of 34 *panelists* screened for inclusion and all sub-groups except the NP (n=14) category achieved 15 or more members. Panelist selection criteria were established to reflect participants with a balance of perspectives, with current related knowledge, and who are impartial to the final

Table 6

Study Inclusion Criteria

Criteria	Rationale
Currently employed in a leadership role (either TMT or Manager) within a health service delivery organization holding an operational role which can be direct service delivery or supporting services (e.g. clinical delivery, financial, human resource). Sample titles include CEO, COO, CFO, CMO, CNO, Director, Manager.	Current leaders within health service delivery organizations to represent perspectives from a broad range of health system settings
Working within a publicly funded Canadian health sector service delivery organization. Examples of organizations include: hospitals, primary care clinics, regional health authorities.	Focus on Canadian health sector assumes all participants consider BI from a similar paradigm (publicly funded health services, Canada Health Act obligations)
Panel Members should have an interest in BI solutions for their setting but are not required to have an existing enterprise BI application in use	Limiting participation to only sites with enterprise BI solutions in place will significantly limit the potential participants
Excluded: Individuals from organizations or in roles whose main focus is not health service delivery. Such as health policy, oversight or funding, and/or consulting.	These organizations are likely to have different and less operationally driven business intelligence and analytics requirements.

outcome (Bloor, Sampson, Baker, & Dahlgren, 2015; Powell, 2003). Expertise from a variety of settings across the Canadian Healthcare sector was targeted.

Data Collection Methods

Data collection tools. All data were collected using the University of Victoria's approved online survey tool (FluidSurvey™) including the initial consent form. FluidSurvey™ servers were located in Canada at the time of data collection and program settings were adjusted to ensure responses were not tracked through Google Analytics.

Participation throughout rounds. Consistent with approaches used in other Delphi studies, *Panel Members* were invited to participate in all Rounds, even if they did not complete a prior Round provided they had not formally withdrawn from the study (Nakatsu & Iacovou, 2009). This was established to mitigate some of the risk of attrition inherent in a study of this duration and in consideration for the other professional demands on the *Panel Members*.

Controlled feedback. Controlled feedback was applied in this study and is a common element in most Delphi studies allowing panelists insights into the average response of the group and gauge their perspectives against this (von der Gracht, 2012). The use of controlled feedback may compel some panelists to normalize their responses to align to the median or, alternatively, provide a more extreme response to push the median towards a strongly held opinion although this has been inconsistently demonstrated in other studies (Campbell, Hann, Roland, Quayle, & Shekelle, 1999; Hsu & Sandford, 2007; Scheibe, Skutsch, & Schofer, 2002). The selection of experts, those actively working as leaders in this sector, who are presumably confident in their perspectives and the anonymous nature of the responses, mitigated the risk of either normalization or extremism. The use of measures of central tendency for the controlled feedback was also applied to avoid having a single strong opinion skew the group direction. While the

provision of feedback can be considered “moulding” of opinion (Hsu & Sandford, 2007), the Delphi process is intended to be consensus based. Ultimately this study proposes to establish a consensus group perspective and, as a result, feedback will intentionally be used in this study to achieve that consensus.

SME Reviewer Group. A *Subject Matter Expert (SME) Reviewer Group* was assembled to review of the initial survey instruments and group comments summarized by the Researcher (presented to them with deidentified raw data) following Rounds 1 and 2. This step was established to mitigate any bias or misinterpretation the Researcher may have introduced. It also provided content validity given the focus of a Delphi approach is consensus on what are fundamentally qualitative constructs versus measurement of discrete concepts. The invited SME Reviewer Group was comprised of four individuals with experience working as leaders in health service delivery organizations representing each of the following roles; nursing, medicine, and information communication technologies. SME Reviewer Group participation was invaluable in providing feedback however participation was inconsistent with no more than two respondents to each call for feedback.

Data collection in each round. During **Round 1**, *Panel Members* were orientated to the constructs of BI Assimilation and Organizational Performance in the context of this study through descriptions provided in the **Round 1** Survey (see Appendix G). In keeping with accepted variations on the Delphi technique, *Panel Members* were provided with example measures identified from the existing literature to assist in clarifying the intent of the construct given they may have not previously considered it in this context (de Meyrick, 2003). *Panel Members* were asked to identify at least five and up to 10 measures that are most reflective of each of the study constructs drawing from the provided measures or adding new measures. In

addition to identifying measures, *Panel Members* were asked to provide a description and brief rationale for identification of that measure to clarify their intended meaning. Once received, all responses were collated by the Researcher with overlapping measures combined and summary definitions and rationale prepared.

During **Round 2** the *Panel Members* received the combined group measures identified in Round 1. These were presented as concept measure name, summarized description, measures suggested by the panelists, other terms used to describe that concept, and rationale all summarized from **Round 1** responses. The percentage frequency for each measure was also provided indicating the percent of panelists who identified this measure. Panelists ranked these on a 9-point Likert scale ranging from *1=not at all relevant* to *9=very relevant* with an option to add comments. An open-ended section allowed panelists to add additional constructs they feel are missing or comment on any aspects of the study (see Appendix H). In **Round 3**, *Panel Members* received the concept measures from **Round 2** with definitions and rationale (with updates from **Round 2** highlighted) and were provided with the Median and Interquartile Range for each concept. Panelists then scored these measures again. While an additional Round was contemplated in the research plan, data collection was completed at the end of **Round 3** as measures of stability and consensus were reached as described in more detail in the analysis section below.

Measurement instruments. The study used three different data collection instruments all of which were delivered via the on-line survey tool: 1) a Participant Profile Survey for screening and describing the panel group (see Appendix F); 2) a semi-structured survey to collect initial measures and descriptions in **Round 1** (see Appendix G); and 3) a 9-point Likert Scale for subsequent Rounds to respond to the concept summaries from prior Rounds (see Appendix H).

These were all administered online for ease of access for panelists and to reduce the time needed for data collection and analysis (Wool, 2015). For all Rounds except the first, the survey included a 9-point Likert scale versus a ranking approach as the concept measures were determined to be amenable to an ordinal or interval measure and ranking has not consistently resulted in consensus with this method (McMillan et al., 2016; Paré, 2014; Scheibe et al., 2002).

For Delphi studies, measures to determine instrument reliability and validity such as inter-rater reliability or construct validity are not achievable given the instrument content is derived from the participants as it develops through the feedback and group consensus process (Okoli, 2004). To balance recommendations that measurement instruments be pilot tested for clarity and readability against the need to actively reflect the panelist's comments in each survey iteration, the SME Reviewer Group were used to review and informally pre-test content for each instrument (Okoli, 2004; Skinner, Nelson, Chin, & Land, 2015).

Data analysis. There are two key elements in analysis of Delphi findings, those of consensus and stability which can be determined through a number of differing approaches depending on how the Delphi method is applied (de Meyrick, 2003; von der Gracht, 2012). This study applied the recommended approach of establishing these measures prior to beginning the study to ensure rigour and avoid subjective determinations by the Researcher during or post data collection (McMillan et al., 2016).

Measures of consensus. As the Likert scale would result in ordinal data, the median was the primary measure of group ranking and it was determined, based on other studies, that the interquartile range (IQR) would reflect the level of consensus (Murphy, 1998; von der Gracht, 2012). As recommended by McMillan et al. (2016) for a 9-point Likert measure, a strong positive ranking was assumed if median was greater than or equal to 7 and strong negative

ranking if the median was lower than or equal to 3. For consensus within rounds, an IQR of 2 or less was determined to indicate the predetermined measure of consensus (von der Gracht, 2012).

Measures of stability. A common misconception is that consensus is the appropriate measure for determining how many successive rounds are needed in a Delphi process. In fact, it is group stability that is the necessary antecedent to consensus and consistency of responses between successive rounds will determine when additional rounds will result in decreasing benefit (von der Gracht, 2012). This is determined through group stability versus individual stability and a predetermined threshold of a 15% change or less in the median on any two distributions was considered stable for this study (von der Gracht, 2012).

Data analysis plan for each round. In **Round 1**, responses were collated by the Researcher with substantively similar measures combined and summarized as concept measure name, summarized description, performance indicators suggested by the panelists, other terms used to describe that concept, and rationale. Similar responses were grouped and the number of times each individual measure was identified was summarized to provide a frequency (percentage of respondents who identified the same or a similar concept). These were presented to the panel along with the text for the summarized concept in **Round 2**. In **Rounds 2 and 3**, responses to the 9-point Likert scale were analyzed for measures of central tendency and distribution (median and IQR) and additional text based responses were summarized following the same process as in **Round 1** (see Table 7).

The **subgroup analysis** was undertaken to explore variations in priority BI constructs between subgroups: nursing portfolio panel members versus non-nursing, and TMT versus OMs. Sub-group members were defined based on the Participant Profile Survey and variations were

Table 7

Data Analysis Approach

	Round 1	Round 2 and Subsequent Rounds	Final Round
Analysis of Qualitative Responses	Collate responses, combine those with similar meaning and summarize descriptive content for each. Validate analysis with SME Reviewer Group.	Summarize and integrate panelist comments. Validate analysis with SME Reviewer Group.	Summarize and integrate panelist comments.
Consensus Measures (within Rounds)	Calculate rate of response for each (percentage of respondents identifying each concept).	Calculate median and IQR for each measure **Positive Consensus within Rounds:** Median >=7 and IQR <=2 **Negative Consensus within Rounds:** Median <4 and IQR <=2 (exclude items if negative consensus met)	Calculate median and IQR for each measure **Positive Consensus within Rounds:** Median >=7 and IQR <=2 **Negative Consensus within Rounds:** Median <4 and IQR <=2
Stability Measure (between Rounds)	n/a	n/a	Stability represented by <=15% change in overall concept median from prior Round
Sub-Group Responses	Calculate rate of response for each (percentage of respondents identifying each concept) by subgroup and compare using Pearson's chi-square.	Calculate median and IQR for each measure by subgroup to provide feedback measures to panelists.	Calculate median, mean, and IQR for each measure by subgroup. Compare means through analysis of variance (ANOVA).

considered following **Round 1** (initial open-ended responses) and **Round 3** (scoring of concepts).

The analysis approach was determined based on similar prior studies and in consultation with the University of Victoria Statistical Consultation Service (M. Lesperance, personal communication, July 26, 2017). **Round 1** responses (percent of panelists identifying the measure) were compared using a Pearson's chi-square analysis and the **Round 3** mean ranking was compared for each concept using ANOVA given the ordinal nature of the Likert scale (Meijering, 2016; von der Gracht, 2012). Both analyses assumed a null hypothesis and a non-directional alternative hypothesis when comparing the variation within the sub-groups.

Strengths and Weaknesses of the Design

The Delphi method has both strengths and weaknesses which were considered in the design of this study (see Table 8). The Delphi method is well suited to this research problem as a

Table 8

Delphi Risk Mitigation Strategies

Risks	Mitigation
Panel attrition	Panelists can rejoin throughout process if a Round is missed. Plan for reminder messages.
Panel apathy	Watch for indications responses are not being considered (e.g. No variation between rounds, no feedback). Plan for options to encourage panel as a group.
Unclear responses	Plan for option to seek clarifying correspondence with individual contact via email through the Research Assistant
Instrument reliability and validity	Engage an expert group to serve as a SME Reviewer Group to review and pilot test instruments as well as review analysis of qualitative survey responses.
Off topic, unusable responses	Allow for rejection by Researcher with summary and explanation to panelists for transparency
Time consuming	Use set time periods, proceed with available responses knowing *Panel Members* can rejoin in next round
Panel selection bias	Use a broad recruitment approach leveraging senior contacts at facilities but seeking representation from outside of known network
Researcher bias	Use a non-participating SME Reviewer Group to review and critique qualitative analysis elements for any bias or omissions

means to gaining consensus on relatively unstudied topics and to inform future instrument development (London et al., 2015; McMillan et al., 2016; von der Gracht; Wool, 2015). The anonymity also avoids group driven perspectives or group decisions based on power differentials among participants (Dalkey & Helmer, 1963; McMillan et al., 2016). To provide meaningful feedback, panelist selection targeted an expert group who were knowledgeable and able to provide relevant and meaningful inputs. The use of online surveys allowed participation of experts from diverse locations (de Meyrick, 2003). The risk of panelist recruitment bias was mitigated through the snowball recruitment techniques (Bloor et al., 2015). A high rate of attrition, particularly given the professional obligations of the panelists was mitigated through allowing panelists to participate in all Rounds even if one was missed (Bloor et al., 2015). The research design avoided the one pitfall of Delphi seen in the urge to simplify responses on behalf of the Researcher by involving the SME Reviewer Group to provide a second level of validation (de Meyrick, 2003). Fundamentally despite these risks, the Delphi method provided a structured

process for creating new knowledge and credibility was strengthened through use of a clear decision trail throughout the study (Powell, 2003).

Timeline

Overall, the project took five months to complete with recruitment and data collection beginning in February 2017 and ending in June 2017. The use of online survey tools and email streamlined data collection and reduced the response effort for panelists. Average total time on the survey instruments ranged from 20:17 minutes (**Round 3**) to 36:36 minutes (**Round 1**) based on metrics available from within the online survey tool both of which fell within the timelines suggested to potential participants during recruitment.

Ethical Considerations

Panelists were drawn from experts who primarily hold leadership positions so while the population is not considered vulnerable, measures were established to allow for participant privacy and to avoid any potential power dynamics. The Researcher would be known to the *Snowball Recruiters* professionally and may also have been known to the potential panelists (participants) who received the subsequent invitation to participate. To mitigate this, the Researcher was blinded to both the identity of the actual participants and to the extent to which the *Snowball Recruiters* followed through on contacting potential participants. The *Research Assistant* tracked the assignment of study numbers blinding the Researcher to individual identity and initiated all direct mailings to or from participants. Participant responses to the surveys, seen by the Researcher, were identified by subject number only and not available to the research assistant. Through this, participant anonymity was maintained.

Data retention and destruction. Post study, files that link respondent identity to study number were provided to the Researcher's Advisor by the Research Assistant for secure storage

in a hard copy file in a sealed envelope. These will be maintained in a secure location until the final study defence is completed and accepted in case this is needed for study validation purposes. At this point the respondent identity information will be destroyed through secure methods. The Researcher removed all data from the online survey servers once data collection was complete and will maintain the de-identified raw data in password protected files for a period of three more years in case further validation is required following publication after which the data will be destroyed through secure deletion processes.

Conclusion

This chapter outlined the methods used in this study and the approach taken to ensure study integrity and subject recruitment and data collection. The following chapter provides the results of the study along with aspects of the methodology that have implications for the results.

Chapter 5 – Research Results

Response Rate

A total of 37 individuals responded to the call for participation. Three of these were excluded based on the participant criteria resulting in a total of 34 panelists who consented to participate and completed the demographic questionnaire. Of these 34, one withdrew before responding to **Round 1** and eight did not respond to any rounds after providing demographic information resulting in a total of 25 panelists each of whom participated in at least one round. The participation rate varied between rounds with the highest participation in **Round 2** (n=21; 84% participation) and the lowest in **Round 3** (n=16; 64% participation). A total of 11 panelists (44.0%) participated in every round (see Appendix I).

Participant Characteristics

Work settings. Panelists represented four provincial work settings. The majority were from Manitoba (n=13; 52.0%) and Ontario (n=8; 32.0%) with additional panelists from Nova Scotia (n=2; 8.0%), and Saskatchewan (n=1; 4.0%) with an additional panelist identifying a National role (n=1; 4.0%). A majority of respondents indicated their primary work location as a Regional Health Authority or Local Health Integration Network (n=12; 48.0%); followed by Hospital (n=9; 36.0%); Primary Care/Physician Office (n=1; 4.0%); Community Services/Home Care (n=1; 4.0%) and Other (n=2; 8.0%). The primary area of responsibility was divided across the group with equal numbers reporting one of three main categories: Clinical Service Delivery Leadership, Executive Leadership, and Business Operations (n=7; 28.0% each). Four additional panelists indicated other roles (n=4; 16.0%) which were either a combined role or in support of business operations (privacy, health information or analytics) (see Table 9).

Table 9

Panelist Demographic Profiles

	No. of Panelists (n=25)	Percentage of Panelists
Province		
MB	13	52.0
ON	8	32.0
SK	1	4.0
NS	2	8.0
Other (National)	1	4.0
Work Setting		
RHA/LHIN	12	48.0
Hospital	9	36.0
Primary Care/ Physician Office	1	4.0
Community Services/ Home Care	1	4.0
Other	2	8.0
Primary Area of Responsibility		
Executive Leadership	7	28.0
Clinical Service Delivery	7	28.0
Business Operations	7	28.0
Other	4	16.0
Years of Experience		
<1-5 years	12	48.0
6-10 years	4	16.0
11-15 years	6	24.0
16-20 years	1	4.0
>20	1	4.0
Missing	1	4.0
Annual Budget Size		
<$1M	7	28.0
$1M-$50M	11	44.0
$51M-$100M	1	4.0
$101M - $500M	3	12.0
$500M - $1B	1	4.0
Missing	2	8.0
Number of Indirect Reports		
<50	7	28.0
51-100	1	4.0
101-500	6	24.0
501-1000	1	4.0
>1000	3	12.0
Missing	7	28.0
Access to BI Currently		
Yes	18	72.0
No	7	28.0

Professional profiles. The panelists self reported work titles included Chief "x" Officer (n=6); Vice President/Executive Vice President (n=3); Director/Executive Director (n=7); Manager/Regional Manager (n=8); and Other (n=3) with 5 identifying multiple titles spanning two of these categories (see Appendix J).

A majority of panelists indicated a nursing related professional designation (n=10; 40%) which did not directly correlate with responsibility for a nursing portfolio as only eight of the 11 panelists included in the NP sub-group indicated a nursing related designation. The next most frequent designation was health administration related (MBA, MPA) (n=4; 16%), three panelists indicated a health information management designation (12%), two each (8%) indicated: a medical designation; other academic credentials

(PhD, MSc); or rehabilitation related designations (see Appendix K). Four did not respond to this question and four identified at least two designations, both of which are reflected in this analysis. Almost half of the panelists had been in their current role for five years or less (n=12; 48%), four had been in their role for six to 10 years (16.0%); six for 11 to 15 years (24%) and two for greater than 16 years (8%) (see Table 9).

Span of responsibility. Just under half of the panelists were managing a budget in the $1-$50 Million range (n=11; 44%) with seven (28%) managing a budget of less than $1 Million. The remaining panelists who responded to this question were managing budgets of greater than $50 Million (n=5, 20%) (see Table 9). When asked to quantify the number of staff reporting directly to them, eight panelists reported less than five (n=8, 32%) with an additional seven reporting six to ten direct reports (28%) and two reported more than 25 direct reports. When panelists were asked to indicate the number of indirect reports, seven (28%) indicated less than 50, seven indicated 51 to 500, and one indicated 501 to one thousand, with three (12%) indicating greater than one thousand indirect reports. Seven panelists did not respond to this question (see Table 9).

IT system access. A majority of panelists indicated they had direct access to a BI system (n=18; 72.0%) although the BI systems listed were not all BI specific applications (see Appendix K). BI systems identified through the open-ended response included: Canadian Institute of Health Information, Electronic Medial Records, Business Objects, Crystal Reports, jurisdictional or local built performance indicator systems, dashboards and portals, Oculus, QlikView, and Radiology systems. Other local information management systems reported to be in use in panelist settings included clinical documentation (n=21, 84.0%); financial management (n=20, 80.0%); human resource management (n=17, 68.0%); and logistics management (n=13, 52.0%).

Other systems listed included: admission discharge transfer, “BI”, case costing, customer relationship management, incident management, and research data systems.

Concepts Identified Within Each BI Construct

In **Round 1** panelists responded to an open-ended question for each of the three constructs asking them to identify:

1) The business activities or processes they expect BI systems to support in their organization;
2) The business strategies they expect their organization to achieve through BI system implementation; and
3) The organizational performance objectives that will be enabled through BI system implementation.

Open-ended responses were grouped and summarized by the Researcher to establish a concept description statement, performance indicators for the concept, other terms used to describe the concept, and a summary of the rationale from each panelist (see Appendix L). A total of 30 concepts were identified under the three constructs, 11 in each of the BI Assimilation constructs (Business Activities/Processes and Business Strategies) and 8 in the Organizational Performance construct. In subsequent rounds, panelists scored the concepts and suggested changes to any of the descriptor information which were then integrated by the Researcher into the content provided in the subsequent round. The Researcher’s summary work was validated by the SME Reviewer Group following Rounds 1 and 2 before presenting it back to the panelists. While the scoring and descriptions evolved through the three Delphi Rounds, the core concepts identified did not change from **Round 1** as no new concepts were added and none were removed.

Throughout this chapter concepts are identified by name and by an identifier. The first two letters of the identifier indicate the section they were grouped under (BA=Business Activities and Processes; BS=Business Strategies; and OP=Organizational Performance Objectives) and the number indicates the order in which it was presented on the survey based on random placement following **Round 1**.

Concepts Representative of BI Assimilation

The first research question explored the measures representative of BI Assimilation in the health sector. BI Assimilation is central to the conceptual model for this study as it is a precursor to achieving organizational benefits from BI implementation and is represented by the two construct groupings: *Business Processes and Activities*, and *Business Strategies*.

Business processes and activities. By the completion of **Round 3**, panelists had identified 11 concepts to represent the construct *Business Processes and Activities*. These were primarily action focused concepts looking at processes and activities being managed at the senior or middle management level (see Table 10). The concepts represented a mix of clinically focused processes such as patient flow and clinical outcomes as well as more generic organizational processes such as finance and human resource management. There was typically good alignment between panelists as demonstrated through the open-ended comments. In Rounds 2 and 3, panelists ranked these for relevance in their organization on a 9-point Likert Scale which ranged from *1=not at all relevant, not an activity or process in our organization* to *9=very relevant, most relevant measure, direct relationship to organizational activities* (see Appendix H). Consensus, defined as those items with an IQR of less than or equal to two (IQR<=2), was achieved on eight (72.7%) concepts in **Round 3**. Seven of these were ranked as highly relevant (median >=7) and one was ranked as medium/neutral relevance (median >=4 and <7). The three

Table 10

Business Process and Activity Concepts with Description Statements

Consensus Concepts (IQR <=2)	
Highly Relevant (median >=7)	**BA1: Patient/Client Flow Management:** Use of business intelligence/analytics to monitor and manage patient/client flow and transitions within and between settings/departments. **BA4: Resource Utilization Management (Diagnostic and Pharmaceutical):** Use of business intelligence/analytics to manage diagnostic (lab, imaging) and pharmaceutical resource utilization and status to manage demand, ensure appropriate use and improve client/patient safety through reconciliation processes. **BA3: Financial Management:** Use of business intelligence/analytics to manage key financial data to increase awareness of economic drivers, associate costs to activities, and support managers to manage to budget. **BA6: Clinical Outcomes Management:** Use of business intelligence/analytics to better understand specific client groups being served and manage outcomes in areas such as chronic disease management. Needed to support system planning/redesign and predict future system utilization (at the individual or system level). **BA5: Human Resource Management:** Use of business intelligence/analytics to manage key human resources indicators. Includes staff scheduling/proactive resource planning to avoid over/understaffing; human resource processes (recruitment, onboarding, tracking training compliance); and other functions such as managing entitlements/collective agreement compliance. **BA7: Performance Measurement and Quality Improvement Management:** Use of business intelligence/analytics to identify, monitor, and evaluate the impact of specific quality improvement initiatives and to manage key high-level performance indicators/variances. The ability to manage and widely share results through use of visual formats and dashboards. Ability to link key data from multiple data sets and sources for use by executives to monitor performance to the strategic and operating plan. **BA2: Referral Management:** Use of business intelligence/analytics to manage status, volumes, or appropriateness of referrals to specialist and/or other providers between and within organizations in a consistent way.
Neutral Relevance (median >=4 and <7)	**BA10: Incident and Risk Management:** Use of business intelligence/analytics to monitor and manage critical incidents and other risk related organizational indicators such as privacy.
Non-Consensus Concepts (IQR >2)	
Neutral Relevance (median >=4 and <7)	**BA8: Supply Chain and Materials Management:** Use of business intelligence/analytics to manage supplies and materials such as biomedical equipment (utilization and expiration). Managing throughout supply chain including supplier/vendor contracts from purchase to centralized distribution to local unit storage to use/destruction. **BA9: Documentation Standards Management:** Use of business intelligence/analytics systems to review documentation (clinical and other business document) quality, consistency, and completeness across multiple departments or units. **BA11: Office/Clinic Management:** Use of business intelligence/analytics to report on clinic office management including scheduling, and access to care initiatives (such as advanced access, online scheduling).

additional concepts were ranked at a neutral/medium relevance level but with no consensus (IQR >2; range: 3 to 4) (see Appendix M).

Business strategies. Panelists achieved consensus on 10 of the 11 concepts (90.9%) identified for the construct of business strategies resulting in this construct having the highest rate of consensus (see Table 11). These were a mix of organizational objectives and

Table 11

Business Strategies Concepts with Description Statements

High Consensus Concepts (IQR <=2)	
Highly Relevant (median >=7)	**BS2: Data Driven Decision Making:** Use of business intelligence/analytics to establish and reinforce an organizational culture of informed, timely and transparent decision making based on fact and evidence. **BS3: Increased Budget Awareness (Explainable Variances):** Use of business intelligence/analytics to ensure organizational awareness of budget variations and to ensure cost centre managers understand and can explain budget variances in order to better manage them. **BS4: Strategic Planning and Prioritization:** Use of business intelligence/analytics to support strategic planning and prioritization to identify opportunities and manage status/risks in strategic initiatives. **BS1: Improve Care Coordination:** Use of business intelligence/analytics to manage care and improve transparency and communication between settings. Includes monitoring to ensure transition protocols/processes are followed to support continuity of care, ensuring that care is delivered in most appropriate setting for each client/patient. The objectives are well organized workflows, access processes are understood and communicated and wait times are transparent to both the client and other providers.
Neutral Relevance (median >=4 and <7)	**BS6: Improve Organizational Processes/Performance:** Use of business intelligence/analytics for key organizational indicators to identify, improve, and manage operational processes to increase efficiency and effectiveness of services provided and reduce waste. **BS5: Improve Client/Customer Experience:** Use of business intelligence/analytics to identify and exceed client/patient expectations. Use of key indicators of client feedback to manage performance, identify organizational strengths and weaknesses, monitor efforts to reduce occurrence of known concerns, and see the impact of change initiatives **BS7: Innovative/Agile Organization:** Use of business intelligence/analytics to identify areas for innovation and support organizational innovation with dynamic decision making and informed change management strategies. **BS11: Provincial Councils and Regional Committees:** Use of business intelligence/analytics to support meetings of various programs to coordinate care and service planning. Provincial committees that include regional and provincial representation to address specific program planning and collaboration **BS10: Adoption of Virtual Healthcare Solutions:** Use of business intelligence/analytics to manage adoption and optimization of virtual healthcare solutions. Support the sharing of information that can be shared across the province to grow similar programs in other areas. Enhance time for meetings and provide a means to meet that is almost as good as face to face. **BS8: Improve Patient Engagement:** Patient access to self-scheduling and their diagnostic results.
Non-Consensus Concepts (IQR >2)	
Neutral Relevance (median >=4 and <7)	**BS9: Improving Accountability and Transparency:** Use of business intelligence/analytics to improve visibility of performance across programs and services. Standardizing our work and expectations and reporting on the same – internally and externally

approaches. Concepts were ranked for relevance using a 9-point Likert Scale from *1=not at all relevant, not a strategy in our organization* to *9=very relevant, most relevant measure, direct relationship to organizational strategies* (see Appendix H for survey format). Four of the consensus concepts (IQR <=2) were identified as highly relevant and six were identified as medium/neutral relevance (see Appendix N). One remaining concept was ranked at a neutral relevance level but with no consensus (IQR= 3). Again, in this construct there was a mix of

clinical and universal business strategies (see Appendix and N). This construct had the largest number of concepts that achieved consensus at the neutral/medium level (n=6) suggesting greater variation in applicability of these concepts. This construct also included some concepts that may be less directly attributed to BI solutions, such as *BS11:Provincial Councils and Regional Committees* or *BS10:Adoption of Virtual Healthcare Solutions* which may have contributed to the neutral responses.

Concepts Representative of Organizational Performance

The next research question explored the measures representative of the construct of Organizational Performance as an expected outcome of BI System implementation in the health sector. *Organizational Performance* is the ultimate objective of BI implementation as this construct represents the business benefits that are being sought.

Panelists identified eight concepts to represent *Organizational Performance*. Panelists ranked these concepts for relevance in their organization using a 9-point Likert Scale from *1=not at all relevant, not a performance objective in our organization* to *9=very relevant, most relevant measure, direct relationship to organizational performance* (see Appendix H). Consensus was achieved on six of the eight concepts (75.0%) identified and again there was a mix of clinical and universal business concepts (see Appendix O). Four of these were identified as highly relevant and two were medium/neutral relevance. This was the only category where there were non-consensus items (n=2, IQR=3 and 4) that achieved a high relevance median (see Table 12).

Table 12

Organizational Performance Objective Concepts with Description Statements

High Consensus Concepts (IQR <=2)	
Highly Relevant (median >=7)	**OP5: Improved Wait Times:** Use of business intelligence/analytics to manage targets related to wait times for targeted services, settings and diagnostics. **OP2: Reduce Costs:** Use of business intelligence/analytics to identify and manage targeted operational cost drivers with a goal of reducing overall expenditures. **OP6: Improve Client/Patient Outcomes:** Use of business intelligence/analytics to measure and report on targeted improvements in client/patient outcomes at an individual or aggregate/cohort level. Can be measured from both the client and the system perspectives. **OP3: Maximize Revenues/Remuneration:** Use of business intelligence/analytics to manage revenue generation opportunities to maximize the dollars available through efficiencies, compensation strategies and targeted populations.
Neutral Relevance (median >=4 and <7)	**OP7: Accountable Organization/Compliance Reporting:** Use of business intelligence/analytics to support organizational accountability and transparency through compliance with policy, external reporting and other regulatory requirements such as accreditation to optimize funding and meet stakeholder/funder expectations. **OP8: Human Resource Objectives/Employee Engagement:** Use of business intelligence/analytics to manage key human resource related objectives in support of employee engagement and other key measures.
Non-Consensus Concepts (IQR >2)	
Highly Relevant (median >=7)	**OP4: Resource Optimization:** Use of business intelligence/analytics to manage strategies to optimize resource allocation (right resources/right place/right care level) and ensure resources working to full scope of practice. **OP1: Reduce Waste:** Use of business intelligence/analytics to monitor targeted reductions in waste throughout key processes and activities such as unnecessary diagnostic testing and supply management.

Overall Results

Consensus was achieved on 15 concepts (50.0%) across the constructs with median rankings at the highly relevant level and was achieved on nine concepts (30.0%) at the neutral/medium relevance level. There were no low priority items (median <4) identified for any concept in any round. An additional six concepts (20.0%) were identified but did not achieve consensus. Four of these were ranked as neutral/medium relevance and two achieved a median in the highly relevant category despite not achieving consensus (see Table 13).

Eleven of the concepts (36.7%) identified appear to be specific to health service delivery rather than generic business operations based on analysis of the descriptive term or summary comments. These include concepts such as *BA1:Patient/Client Flow Management*, *OP6:Improve Client/Patient Outcomes,* and *BS1:Improve Care Coordination* among others (see Table 13).

Table 13

Summary of Concepts by Relevance and Consensus

Consensus Concepts (IQR <=2)		
	Neutral Relevance (median >=4 and <7)	**Highly Relevant (median >=7)**
Business Activities and Processes	• BA10: Incident and Risk Management	• BA1: Patient/Client Flow Management* • BA4: Resource Utilization Management (Diagnostic and Pharmaceutical)* • BA3: Financial Management • BA6: Clinical Outcomes Management* • BA5: Human Resource Management • BA7: Performance Measurement and Quality Improvement Management • BA2: Referral Management*
Business Strategies	• BS6: Improve Organizational Processes/Performance • BS5: Improve Client/Customer Experience* • BS7: Innovative/Agile Organization • BS11: Provincial Councils and Regional Committees • BS10: Adoption of Virtual Healthcare Solutions* • BS8: Improve Patient Engagement*	• BS2: Data Driven Decision Making • BS3: Increased Budget Awareness (Explainable Variances) • BS4: Strategic Planning and Prioritization • BS1: Improve Care Coordination*
Performance Objectives	• OP7: Accountable Organization/Compliance Reporting • OP8: Human Resource Objectives/Employee Engagement	• OP5: Improved Wait Times* • OP2: Reduce Costs • OP6: Improve Client/Patient Outcomes* • OP3: Maximize Revenues/Remuneration
Non-consensus Concepts (IQR >2)		
	Neutral Relevance (median >=4 and <7)	**Highly Relevant (median >=7)**
Business Activities and Processes	• BA8: Supply Chain and Materials Management • BA9: Documentation Standards Management • BA11: Office/Clinic Management*	
Business Strategies	• BS9: Improving Accountability and Transparency	
Performance Objectives		• OP4: Resource Optimization • OP1: Reduce Waste
* = Clinical or health service delivery specific concepts		

Variation Between Rounds

The Delphi process was stopped after three rounds when a strong majority (80.0%) of the constructs (24 of 30) achieved the pre-established measure of group stability (<15% change in concept medians). In addition, almost half of the concept medians (14 of 30) were unchanged between the two Rounds (see Table 14). Consensus increased between the two Rounds from 16

Table 14

Concept Median and Percentage Change Between Rounds

Concepts	Round 1 (n=20) % Identified	Round 2 Median (IQR) (n=21)	Round3 Median (IQR) (n=16)	% Change (Round 2 to Round 3)
Business Processes and Activities				
BA1: Patient/Client Flow Management	45%	8 (2)	8 (1)	0.0%
BA4: Resource Utilization Management (Diagnostic and Pharmaceutical)	25%	7.5 (2)	8 (1)	-6.7%
BA3: Financial Management	50%	8 (2)	8 (1)	0.0%
BA6: Clinical Outcomes Management	30%	8 (2)	7.5 (1)	6.3%
BA5: Human Resource Management	60%	7.5 (3)	7.5 (1)	0.0%
BA7: Performance Measurement and Quality Improvement Management	45%	8 (3)	7 (1)	12.5%
BA2: Referral Management	30%	8 (1)	7 (2)	12.5%
BA10: Incident and Risk Management	15%	6 (3)	6 (2)	0.0%
BA8: Supply Chain and Materials Management	55%	7 (3)	6.5 (3)	7.1%
BA9: Documentation Standards Management	40%	7 (2)	6 (3)	14.3%
BA11: Office/Clinic Management	5%	5 (6)	6 (4)	-20.0%
Business Strategies				
BS2: Data Driven Decision Making	60%	8 (2)	8 (1)	0.0%
BS3: Increased Budget Awareness (Explainable Variances)	45%	7 (3)	7 (1)	0.0%
BS4: Strategic Planning and Prioritization	15%	6 (2)	7 (1)	-16.7%
BS1: Improve Care Coordination	55%	7 (1)	7 (2)	0.0%
BS6: Improve Organizational Processes/Performance	20%	7 (4)	6.5 (2)	7.1%
BS5: Improve Client/Customer Experience	65%	7.5 (1)	6 (2)	20.0%
BS7: Innovative/Agile Organization	20%	6 (3)	6 (1)	0.0%
BS11: Provincial Councils and Regional Committees	5%	5 (2)	6 (2)	-20.0%
BS10: Adoption of Virtual Healthcare Solutions	10%	6 (3)	5.5 (1)	8.3%
BS8: Improve Patient Engagement	5%	5 (4)	5 (2)	0.0%
BS9: Improving Accountability and Transparency	10%	5.5 (3)	6 (3)	-9.1%
Organizational Performance				
OP5: Improved Wait Times	60%	8 (2)	8 (2)	0.0%
OP2: Reduce Costs	70%	8 (2)	8 (1)	0.0%
OP6: Improve Client/Patient Outcomes	65%	8 (2)	8 (2)	0.0%
OP3: Maximize Revenues/Remuneration	20%	6 (3)	7 (2)	-16.7%
OP7: Accountable Organization/Compliance Reporting	80%	7 (3)	6.5 (2)	7.1%
OP8: Human Resource Objectives/Employee Engagement	20%	6 (2)	5 (2)	16.7%
OP4: Resource Optimization	25%	7.5 (2)	7.5 (3)	0.0%
OP1: Reduce Waste	55%	7 (2)	7 (4)	0.0%

concepts (53.3%) in **Round 2** to 24 concepts (80.0%) in **Round 3**. All of these factors were indicative that consensus was unlikely to change notably with an additional round of data collection so the data collection was stopped at **Round 3**. The decrease in the participation rate from 84% in **Round 2** to 64% in **Round 3** was also a consideration in the decision not to pursue

a fourth round. The median ranking for 24 of the 30 concepts either stayed the same or increased between **Round 2** and **Round 3** with the remaining 6 decreasing. Ten of the concepts identified as highly relevant (with consensus) in **Round 2** sustained this to **Round 3** and five of the concepts shifted from high or medium relevance with no consensus to high relevance with consensus in **Round 3**. Four concepts shifted from high relevance with consensus in **Round 2** to no consensus in **Round 3**. These were *BA9:Documentation Standards, BS5: Improve Client/Customer Experiences, OP1:Reduce Waste,* and *OP4:Resource Optimization* (see Table 14). This is likely related to differences between panelists as three of these (all except *OP1:Reduce Waste*) demonstrated significant variation at the sub-group level as discussed in the following section. A high or low rate of identification in **Round 1** did not appear to correspond to the resulting median or level of consensus by **Round 3** suggesting panelists benefited from the broader group context and actively considered new items presented by the broader group.

Open-ended Responses

In addition to concept specific responses, panelists were provided with the opportunity to provide general comments. Across the three Rounds, only six respondents provided additional feedback. Four of these were not construct related but rather to the functionality needed for successful BI systems. Comments included: the need to drill down from organizational level data; having a linkage between various data sources (clinical, human resource, financial); being able to see an overall big picture of the organization as well as seasonal trending; and being able to identify linkages and data between service sectors to plan and measure items such as care transition, patient flow, and handoffs. More than one panelist identified organizational factors that need to be addressed, indicating they saw BI as a key enabler, “It will (eventually) create a culture of

analytics and evidence-based decision making. The organizational culture needs to be trained to accept this move to analytics."

Throughout the open-ended and concept specific responses, there were several responses indicating that the ability to act on data may be moderated by overarching political factors limiting the benefits of BI. This is reflected in two of the comments provided under *BS2:Data Driven Decision Making*, "It is unfortunate that decisions are not more data-driven. Generally, that is because data is not available. In the absence of that many decisions are made along political lines which often is not in the best interest of the patient or the taxpayer"; and "Politics and Community Pressure highly influence the ability to accomplish this measure". Political pressure was also reflected under *Strategic Planning and Prioritization* with one panelist noting, "[There is] Limited ability to accomplish some of this related to community pressure and political environment bowing to community pressure."

One panelist indicated that the responses appear to be acute care focused and emphasized the need to consider community and long-term care indicators also. This observation is consistent with the panelist profiles as only two respondents (8%) indicated a primary care or community based services focus versus 36% indicating a hospital setting and 48% indicating an Regional Health Authority or Local Health Integration Network employment setting which include a mix of both service delivery settings (see Appendix K). One respondent noted their opinion that all of the concepts identified were important so they focused their scoring on those that had the most immediate and urgent priority for them.

Sub-Group Comparisons

The study also considered variations among sub-groups of respondents to examine variation in rankings between panelist leadership levels and panelists with and without a direct

Table 15

Harvey Ball Summary of Round 3 Results

Business Processes and Activities	All (n=16)	NP (n-6)	NonNP (n=10)	TMT (n=10)	OM (n=6)
BA1: Patient/Client Flow Management	●	●	●	●	●
BA4: Resource Utilization Management (Diagnostic and Rx)	●	●	●	●	●
BA3: Financial Management	●	●	○	●	●
BA6: Clinical Outcomes Management	●	●	●	●	●
BA5: Human Resource Management	●	●	○	○	●
BA7: Performance Measurement and QI Management	●	●	●	●	●
BA2: Referral Management	●	●	◐	●	◐
BA10: Incident and Risk Management	◐	◐	◐	◐	◐
BA8: Supply Chain and Materials Management	◐	●	◐	◐	○
BA9: Documentation Standards Management	◐	◐	◐	◐	◐
BA11: Office/Clinic Management	◐	◐	◐	◐	○
Business Strategies					
BS2: Data Driven Decision Making	●	●	●	●	●
BS3: Increased Budget Awareness (Explainable Variances)	●	●	●	●	●
BS4: Strategic Planning and Prioritization	●	◐	●	◐	○
BS1: Improve Care Coordination	●	●	◐	●	○
BS6: Improve Organizational Processes/Performance	◐	●	◐	◐	○
BS5: Improve Client/Customer Experience	◐	◐	◐	◐	◐
BS7: Innovative/Agile Organization	◐	◐	◐	◐	◐
BS11: Provincial Councils and Regional Committees	◐	◐	◐	◐	◐
BS10: Adoption of Virtual Healthcare Solutions	◐	◐	◐	◐	◐
BS8: Improve Patient Engagement	◐	◐	◐	◐	◐
BS9: Improving Accountability and Transparency	◐	◐	○	◐	○
Organizational Performance					
OP5: Improved Wait Times	●	●	●	●	●
OP2: Reduce Costs	●	●	●	●	●
OP6: Improve Client/Patient Outcomes	●	●	●	●	●
OP3: Maximize Revenues/Remuneration	●	◐	●	●	○
OP7: Accountable Organization/Compliance Reporting	◐	◐	◐	◐	○
OP8: Human Resource Objectives/Employee Engagement	◐	◐	◐	◐	◐
OP4: Resource Optimization	○	●	●	●	●
OP1: Reduce Waste	○	◐	○	◐	●

Legend: ● = high perceived value (median 7-9); high consensus (IQR<=2)
◐ = medium perceived value (median 4-<7); high consensus (IQR<=2)
○ = high perceived value (median 7 - 9); no consensus (IQR>2)
◐ = medium perceived value (median 4 - <7); no consensus (IQR>2)

nursing related portfolio. Responses were summarized according to these overarching sub-groups in **Round 3** (see Table 15) and also compared statistically for significant variation at **Round 1** and **Round 3**.

Sub-group participation rate. A total of 20 panelists participated in **Round 1** divided equally between each of the subgroups. In **Round 2** there were 21 participants with 10 participants in each of the nonNP and OM groupings and 11 in each of the NP and TMT groupings. In **Round 3** there were 16 participants: six in nursing evenly divided between TMT and OM and 10 in the non-nursing portfolio group with a notably higher number in TMT versus OM, 7 and 3 respectively (see Appendix I).

Sub-group selection. To establish the sub-groups, panelists self identified their leadership role as Top/Senior Management Team (TMT) or Operational Manager (OM) and self identified whether they had responsibility for a nursing related portfolio (NP or NonNP) (see Appendix I). As a result, each panelist falls into one of each of the sub-groupings (leader type and nursing portfolio status). For those identifying their leadership role, an option to select Other was also provided and these were allocated to either the TMT or OM group by the Researcher based on title. Those with Director titles were grouped into TMT and those with manager or other titles were grouped into OM. Responses were compared at two points: at **Round 1** (the extent to which the panelists identified a measure independently through the open-ended questions) and in the final Round (**Round 3**). In **Round 1**, where panelists identified concepts using free text, differences in the rate of identifying these concepts were compared between sub-groups using Pearson's Chi-square test (denoted as X^2, with corresponding degrees of freedom and a p value of <=.05 considered significant) (see Appendices P, Q and R for detailed Round 1 results). In **Round 3**, ANOVA was used to compare the mean concept ranking between and

within the sub-groupings again using a p value of <=.05 as significant (see Appendices S, T and U for detailed Round 3 results). In both cases, there are limitations in the statistical approach taken given the small sample size, the use of self-report for groupings and the overlap between groups. Consequently, findings should be considered with these limitations in mind.

Nursing Portfolio Sub-Group Results

Research sub-question A (Q-A) explored the extent to which panel members with responsibility for a nursing portfolio differ from those without in their overall scoring of measures of BI Assimilation and Operational Performance.

Nursing portfolio variations - Round 1. Overall, there was a higher level of consensus among the NP versus the non-NP panelists. The NP group achieved consensus on 27 of 30 concepts where the nonNP group achieved consensus on only 16. Significant variations were seen between NP and NonNP panelists on 4 items in **Round 1** (see Table 16). In all cases, NP

Table 16

Concepts with Significant Variation by Nursing Portfolio (Round 1)

BA5: Human Resource Management				
	NP (n=10)	**NonNP (n=10)**	**Overall**	**Pearson's chi-square**
TMT (n=10)*	100%, n=4/4*	33.3%, n=2/6*	60%	* significant $X^2(1)>=4.444$, $p=.035$
OM (n=10)	66.7%, n= 4/6	50%, n=2/4	60%	
Overall	80%	40%	60%	
BS1: Improve Care Coordination				
	NP (n=10)	**NonNP (n=10)**	**Overall**	**Pearson's chi-square**
TMT (n=10)	75%, n=3/4	66.7%, n= 4/6	70%	* significant $X^2(1)>=4.444$, *p=.035*
OM (n=10)*	66.7%, n=4/6*	0%, n=0/4*	40%	
Overall	70%	40%	55%	
BS5: Improve Client/Customer Experience				
	NP (n=10)	**NonNP (n=10)**	**Overall**	**Pearson's chi-square**
TMT (n=10)*	100%, n=4/4*	33.3%, n=2/6*	60%	* significant $X^2(1)>=4.444$, *p=.035*
OM (n=10)	50%, n=3/6	100%, n=4/4	70%	
Overall	70%	60%	65%	
OP6: Improve Client/Patient Outcomes				
	NP (n=10)	**NonNP (n=10)**	**Overall**	**Pearson's chi-square**
TMT (n=10)	100%, n=4/4	50%, n=3/6	70%	* significant $X^2(1)>=5.495$, *p=.019*
OM (n=10)	83.3%, n=5/6	25%, n=1/4	60%	
Overall*	90%*	40%*	65%	

panelists were more likely to identify these concepts. One of these, *OP5:Improve Client/Patient Outcomes* was significantly different when the total panelist population were compared. Two of these *BA5:Human Resource Management* and *BS5:Improve Client/Customer Experience* demonstrated significant differences at the TMT panelist level only. The last of these *BS1:Improve Care*

Table 17

Concepts with Notable Variation by Nursing Portfolio (Round 1)

BA9: Documentation Standards Management				
	NP (n=10)	**NonNP (n=10)**	**Overall**	**Pearson's chi-square**
TMT (n=10)*	50%, n=2/4*	0%, n=0/6*	20%	* *non*-significant $X^2(1)>=3.750$, *p=.053*
OM (n=10)	50%, n=3/6	75%, n=3/4	60%	
Overall	50%	30%	40%	
BS6: Improve Organizational Processes/Performance				
	NP (n=10)	**NonNP (n=10)**	**Overall**	**Pearson's chi-square**
TMT (n=10)*	50%, n=2/4*	0%, n=0/6*	20%	* *non*-significant $X^2(1)>=3.750$, *p=.053*
OM (n=10)	16.7%, n=1/6	25%, n=1/4	20%	
Overall	30%	10%	20%	
OP3: Maximize Revenues/Remuneration				
	NP (n=10)	**NonNP (n=10)**	**Overall**	**Pearson's chi-square**
TMT (n=10)	25%, n=1/4	16.7%, n=1/6	20%	* *non*-significant $X^2(1)>=3.750$, *p=.053*
OM (n=10)*	0%, n=0/6*	50%, n=2/4*	20%	
Overall	10%	30%	20%	
OP4: Resource Optimization				
	NP (n=10)	**NonNP (n=10)**	**Overall**	**Pearson's chi-square**
TMT (n=10)	25%, n=1/4	33.3%, n=2/6	30%	* *non*-significant $X^2(1)>=3.750$, *p=.053*
OM (n=10)*	0%, n=0/6*	50%, n=2/4*	20%	
Overall	10%	40%	25%	

Coordination demonstrated significant difference between NP panelists at the OM level only. It is not surprising that three of the four concepts where significant differences seen were directly related to care delivery measures. Non-significant but notable variations were seen in four additional concepts none of which related to health care delivery concepts (See Table 17). Two of these, *Documentation Standards Management* and *Improve Organizational Processes/Performance* saw notable differences at the TMT level with only the Nursing Portfolio panelist respondents identifying that concept. Conversely, at the Operational Manager level none

of the Nursing Portfolio panelists identified the two concepts of *Maximize Revenues/Remuneration* and *Resource Optimization.*

Nursing portfolio variations - Round 3. By the third Round, only one concept demonstrated a notable but not significant variation between NP and NonNP panelists with no significant variations. This was seen among OM respondents with NP/OM panelists having a notably lower mean score than NonNP/OM on the concept of *BS8:Improve Patient Engagement* (see Table 18). This concept received a lower ranking overall with both the mean and median ranking of 5 on the Likert scale and overall group consensus. The NP group were the only sub-group to reach consensus. Open ended comments indicate limited group cohesion on the concept which was ultimately described at a separate solution (patient access to self-scheduling and diagnostic results) versus a business intelligence concept. The rationale provided by panelists suggested this was a lower priority among broader pressures to deliver care (see Appendix L).

Table 18

Concepts with Notable Variation by Nursing Portfolio (Round 3)

BS8: Improve Patient Engagement				
	NP (n=6)	**NonNP (n=10)**	**Overall mean**	**ANOVA**
TMT (n=10)	5.33	4.86	5.00	* *non*-significant $F_{1, 4} = 7.364$, $p = .053$
OM (n=6)*	4.33*	7.33*	5.83	
Overall mean	4.83	5.60	5.31	

Leadership Group Sub-Group Results

Research sub-question B (Q-B) explored the extent to which TMT and OM panel members differ from each other in their overall scoring of measures of BI Assimilation and Operational Performance.

Leadership group variations - Round 1. Significant variations were seen between TMT and OM panelists on 4 items in **Round 1**. In all cases, the variation was seen between the non-NP panelists which may again, be reflective of the higher level of role similarity among the NP

Table 19

Concepts with Significant Variation by Leadership Group (Round 1)

BA6: Clinical Outcomes Management				
	NP (n=10)	**NonNP (n=10)***	**Overall**	**Pearson's chi-square**
TMT (n=10)	25%, n=1/4	66.7%, n=4/6*	50%	* significant $X^2(1)>=4.444$, *p=.035*
OM (n=10)	16.7%, n=1/6	0%, n=0/4*	10%	
Overall	20%	40%	30%	
BA9: Documentation Standards Management				
	NP (n=10)	**NonNP (n=10)***	**Overall**	**Pearson's chi-square**
TMT (n=10)	50%, n=2/4	0%, n=0/6*	20%	* significant $X^2(1)>=6.429$, *p=.011*
OM (n=10)	50%, n=3/6	75%, n=3/4*	60%	
Overall	50%	30%	40%	
BS1: Improve Care Coordination				
	NP (n=10)	**NonNP (n=10)***	**Overall**	**Pearson's chi-square**
TMT (n=10)	75%, n=3/4	66.7%, n= 4/6*	70%	* significant $X^2(1)>=4.444$, *p=.035*
OM (n=10)	66.7%, n=4/6	0%, n=0/4*	40%	
Overall	70%	40%	55%	
BS5: Improve Client/Customer Experience				
	NP (n=10)	**NonNP (n=10)***	**Overall**	**Pearson's chi-square**
TMT (n=10)	100%, n=4/4	33.3%, n=2/6*	60%	* significant $X^2(1)>=4.444$, *p=.035*
OM (n=10)	50%, n=3/6	100%, n=4/4*	70%	
Overall	70%	60%	65%	

group. In two of these, only the TMT panelists identified the concept at all, both of which related to direct patient care: *BA6:Clinical Outcomes Management* and *BS1:Improve Care Coordination* (which also saw significant differences between NP respondents at the OM level). The remaining two, *BA9:Documentation Standards Management* and *BS5:Improve Client Customer Experience* had significantly higher rates of concept identification at the OM level (see Table 19). Non-significant but notable variations were seen in three additional concepts two of which related to clinical care delivery. *BA6:Clinical Outcomes Management* and *BA2:Referral Management* saw notable differences at the full group level with the TMT respondents identifying these concepts more frequently than OM. As noted above, *BA6:Clinical Outcomes Management* had a significant variation at the Non-NP level. The remaining concept, *BS7:Innovative/Agile Organization* was more frequently identified by OM level respondents at the NonNP Sub-group level (see Table 20).

Table 20

Concepts with Notable Variation by Leadership Group (Round 1)

BA6: Clinical Outcomes Management				
	NP (n=10)	**NonNP (n=10)**	**Overall***	**Pearson's chi-square**
TMT (n=10)	25%, n=1/4	66.7%, n=4/6	50%*	* non-significant $X^2(1)>=3.810$, $p = .051$
OM (n=10)	16.7%, n=1/6	0%, n=0/4	10%*	
Overall	20%	40%	**30%**	

BA2: Referral Management				
	NP (n=10)	**NonNP (n=10)**	**Overall***	**Pearson's chi-square**
TMT (n=10)	50%, n=2/4	50%, n=3/6	50%*	* *non*-significant $X^2(1)>=3.810$, $p=.051$
OM (n=10)	16.7%, n=1/6	0%, n=0/4	10%*	
Overall	30%	30%	30%	

BS7: Innovative/Agile Organization				
	NP (n=10)*	**NonNP (n=10)**	**Overall**	**Pearson's chi-square**
TMT (n=10)	50%, n=2/4*	16.7%, n=1/6	30%	* *non*-significant $X^2(1)>=3.750$, *p=.053*
OM (n=10)	0%, n=0/6*	25%, n=1/4	10%	
Overall	20%	20%	20%	

Leadership group variations - Round 3. By the third Round, there were two concepts where notable variation was seen between TMT and OM panelists. A notable but non-significant variation was seen between the total grouping of TMT and OM panelists on the concept of *OP5:Improved Wait Times* with OM panelists raking this slightly higher than their TMT counterparts. Significant variations were seen on *OP4:Resource Optimization* at both the TMT

Table 21

Variation by Leadership Group (Round 3)

OP5: Improved Wait Times				
	NP (n=6)	**NonNP (n=10)**	**Overall mean**	**ANOVA**
TMT (n=10)	7.00	7.86	7.60*	* *non*-significant $F_{1, 14} = 4.295$, $p = .057$
OM (n=6)	8.67	8.33	8.50*	
Overall mean	7.83	8.00	7.94	

OP4: Resource Optimization				
	NP (n=6)	**NonNP (n=10)**	**Overall mean***	**ANOVA**
TMT (n=10)	7.33	7.29	7.30*	* significant $F_{1, 14} = 7.541$, $p = .016$
OM (n=6)	8.00	8.67	8.33*	
Overall mean	7.67	7.70	7.69	

OP4: Resource Optimization				
	NP (n=6)	**NonNP (n=10)***	**Overall mean**	**ANOVA**
TMT (n=10)	7.33	7.29*	7.30	** significant* $F_{1, 8} = 7.823$, $p = .023$
OM (n=6)	8.00	8.67*	8.33	
Overall mean	7.67	7.70	7.69	

and OM level overall and again at the NonNP level with OM ranking the concept higher than TMT respondents in both cases (see Table 21). Interestingly, *OP4:Resource Optimization* as a concept did not achieve consensus in the overall study results, although it did achieve high value and consensus within each of the individual subgroups. The open-ended comments for the concept expressed strong support but also reflected a broad range of measures which may have contributed to the sub-group variation (see Appendix L).

Conclusion

Panelists identified a total of 30 concepts to measure the three constructs, 11 in each of the BI Assimilation categories (business activities/processes and business strategies) and 8 in the organizational performance category. Of these, 15 concepts were ranked as a high priority and achieved high consensus. Seven of these were in *Business Processes and Activities* and four in each of *Business Strategies* and *Organizational Performance*. For all concepts except one, there was no significant difference between sub-group rankings at the end of the third consensus round. However, more differences were seen in the extent to which subgroups initially identified concepts in **Round 1** where 6 of the 30 concepts had significant differences between or within sub-groups and an additional 6 had notable although not significant differences.

Chapter 6 – Discussion

Research Limitations

Limitations associated with the Delphi technique were, for the most part, mitigated through the study design. While the panel members were, by virtue of their roles, experts as health system leaders and managers, they were not necessarily experts in the use of BI in their settings, which may have limited the breath of potential responses. Experts self selected into the study and, based on responses regarding BI systems in use, may not have been familiar with the full capacity of BI systems. Also of note, only four of the panelists indicated current roles directly related to business intelligence or health information management.

Controlled feedback, a common element in most Delphi studies, was applied allowing panelists to see the average response of the group and gauge their perspectives against this (von der Gracht, 2012). Due to this, there is a potential that the high ranking of the measures (with no concepts resulting in a low priority ranking overall) was the result of controlled feedback versus a true indicator of group priority. This may have impacted the scoring, particularly on concepts that were indirectly tied to BI measures. These include *BS10:Adoption of Virtual Healthcare Solutions* and *BS11:Provincial Councils and Regional Committees,* both of which received a wide range of scores but ultimately achieved a consensus level IQR. Panelists were asked to focus on their own work setting when ranking the measures. As a result, the limited support seen for some non-acute measures such as *BA11:Office/Clinic Management* may be reflective of work setting versus overall value to the health sector.

The Researcher undertook the work of summarizing and collating the content provided by the panelists for concept names, descriptions and rationale independently and there is an inherent level of subjectivity in this work. Concepts that were identified under more than one construct

area were grouped based on the proportion of respondents selecting that construct area and through analysis of the description statements. This may have resulted in the loss of subtle variations in panelist meaning. Potential subjectivity was minimized through the subsequent rounds where panelists could comment on the descriptions and identify lost intent. It was also mitigated through the use of the SME Reviewers who were provided with both the raw de-identified responses and the completed summary work. In addition, the summary work included visual cues (color coding variations in construct placement) and specific questions where the Researcher had made grouping decisions and wanted a second opinion.

In considering the sub-group results, the lower response rate in **Round 3** limited the overall ability to undertake meaningful statistical comparisons of group variation. In addition, the notably higher number of non-nursing portfolio TMT participants (n=7) in **Round 3** as compared with three participants in each of the other sub-groups may have skewed the analysis towards that sub-group perspective. Correspondingly, the **Round 1** results compared through Pearson's chi-square are based on a more balanced cohort with 10 panelists in each of the higher-level groupings but these concepts do not yet have the benefit of the consensus process as panelists worked independently at this stage.

Alignment to Conceptual Framework Constructs

As discussed earlier in this paper, the conceptual framework for this study closely reflects an existing Business Value of BI Model established by Elbashir et al. (2013) which has been validated through use in other sectors. To determine the extent to which this model would need modification prior to replication in the health sector, the concepts identified by the panelists were mapped to the underlying concept measures used in the existing model determined through correspondence with the primary author (M. Elbashir, personal communication, February 20,

2015). A visual mapping of these demonstrates that only a small portion of the high priority concepts, four of the 15 identified by the panelists, could be matched to concepts in the BI Assimilation and Organizational Performance Constructs in the Business Value of BI Model. Similarly, only nine of the 20 concepts in the Business Value of BI Model map to any concepts provided by the panelists (see Figure 3).

For *Business Processes and Activities*, only one of the Business Value of BI Model concepts (*Manufacturing and/or internal operations)* matched high priority, high consensus items identified in this study. However, this is through the descriptive statements only as the terminology used did not align and it reflects two distinct concepts identified by the panelists (*BA4: Resource Utilization Management* and *BA5: Human Resource Management).* Two additional concepts align to a concept proposed by the panelists. These were *Delivery of Products/Services* and *Supplier Management (inbound logistics)* both of which can be mapped to *BA8: Supply Chain and Materials Management*. One additional concept *Customer Services* matched but was grouped by the panelists under the construct of business strategies and is discussed in that section (see Figure 3).

For *Business Strategies*, none of the Business Value of BI measures matched the high priority, high consensus items and, when all concepts are considered, only three align to concepts proposed by the panelists. The concept of *BS5: Improve Client/Customer Experience* maps to two concepts in the Business Value of BI model, *Customer Services* and *Enhancing customer relations.* One additional concept, *Creating flexible manufacturing/operations processes* can be mapped to *BS7: Innovative/Agile Organization* (see Figure 3).

Organizational Performance in this study aligns to the construct of *BI Business Value* within the model. Within this construct, two high priority high consensus items mapped to three concepts in the original model. *Being low-cost producer/provider,* which was categorized as a

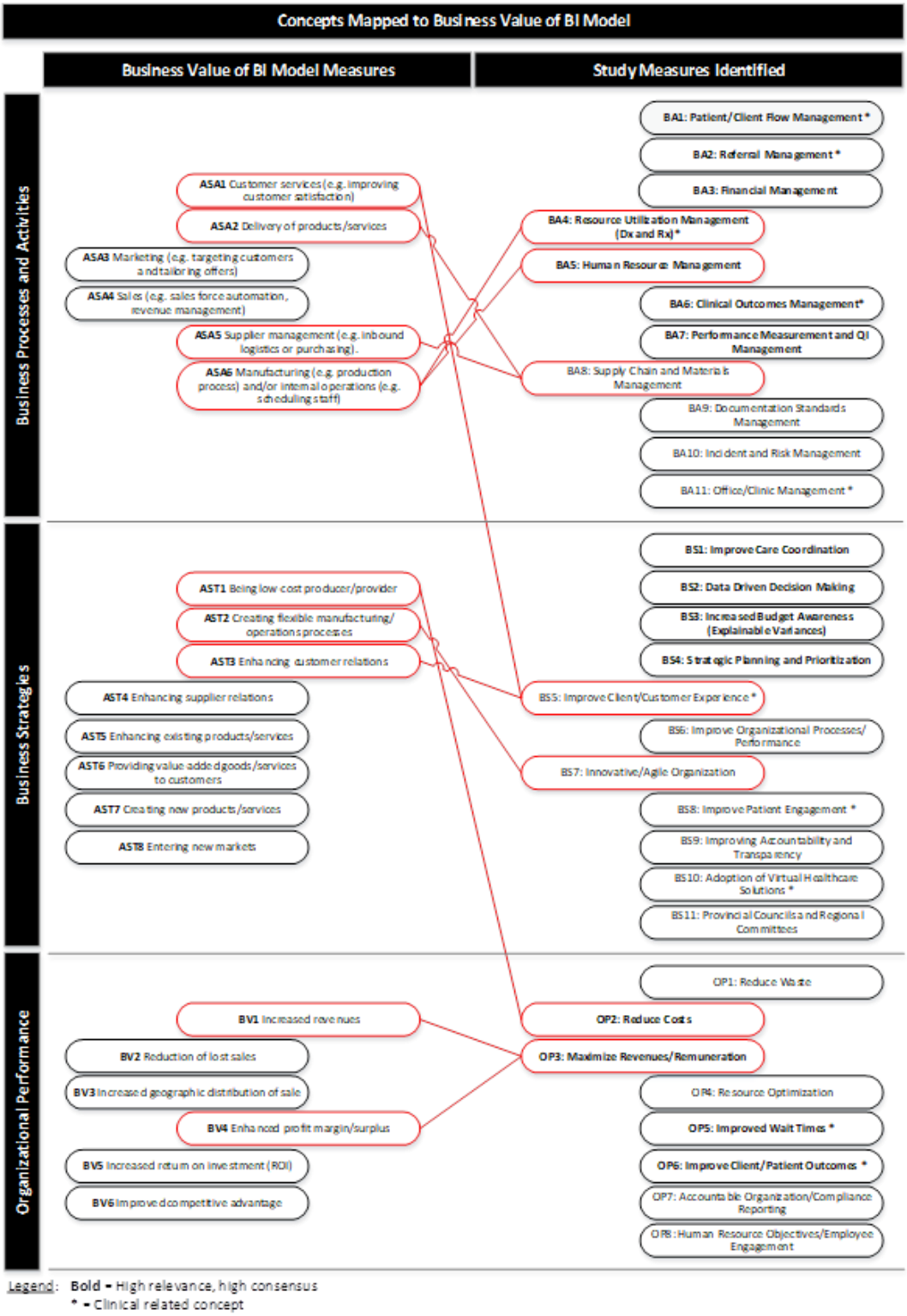


Figure 3. Study concepts mapped to "Business Value of BI" model.

business strategy concept under the BI Business Value Model, can be mapped indirectly to *OP2: Reduce costs. Increased revenues* and *Enhanced profit margin/surplus* mapped to the concept of framework in other sectors using the Business Value of BI model validating the need for health sector specific measures.

Implications for the Business Intelligence Benefits Model for Health. The study results confirm that models from other sectors do not adequately reflect health sector measures when expected organizational impacts are considered, limiting their transferability to health. The panelist responses demonstrated the need for health sector specific indicators in addition to more generic business operations indicators which were also required. Overall, the value and applicability of the constructs of BI Assimilation and Performance Outcomes in the framework were supported as the panelists identified multiple concepts to reflect each of these (see Figure 4).

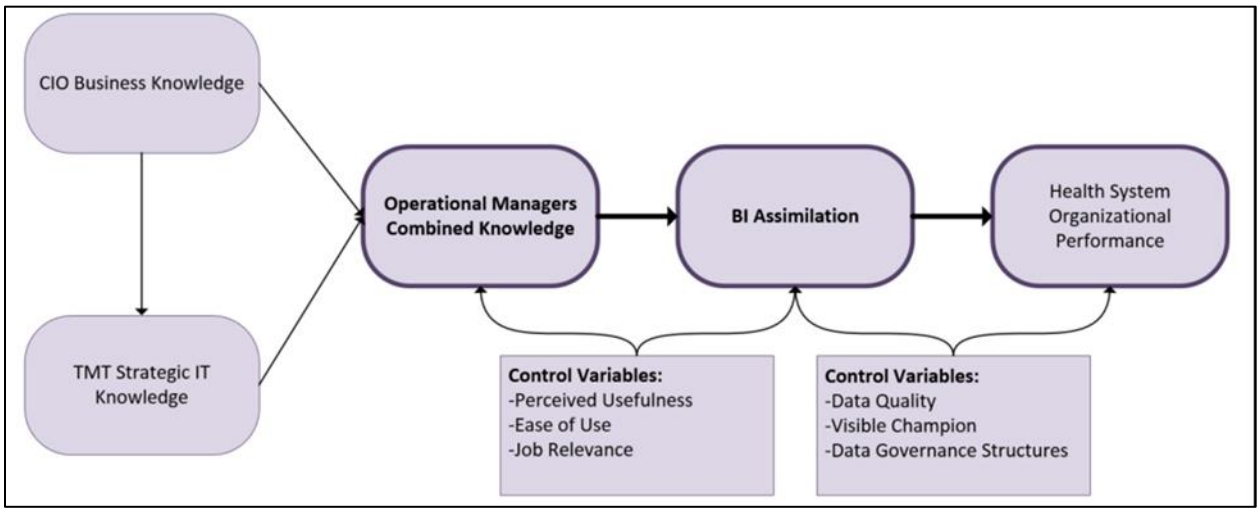


Figure 4. Business Intelligence Benefits Model for Health.

While not a focus for the study, the subtle subgroup variations seen support other elements within the model. The role of *CIO Business Knowledge, TMT Strategic IT Knowledge* and *Operational Managers Combined Knowledge* will be integral to realizing BI success in this setting given the priorities of the panelist sub-groups suggest each group may have a distinct

priority focus. In addition, the control variables established for this model were supported through the open-ended comments which reflected: expectations around perceived usefulness, ease of use, data quality risks, and the barriers posed by data governance structures, reflected in the comments regarding the political climate for decision making.

The constructs of *BI Assimilation* and *Health System Organizational Performance* were relevant to the panelists as all could identify multiple concepts under each. As previously discussed, *Organizational Performance* had the fewest concepts identified and also generated the fewest consensus items. Not surprisingly, most of the eight concepts identified under this construct related directly or indirectly to concepts identified under the *BI Assimilation* construct given processes and strategies intuitively should align to an expected performance objective. An example of this linkage can be seen with the process concepts of *BA1:Patient/Client Flow Management, BA3:Referral Management,* and *BA4:Resource Utilization Management (Diagnostic and Pharmaceutical)* all of which may contribute to realizing *OP5:Improved Wait Times*. The panelists were generally more specific and outcome focused in their description statements in this section which is reflective of the performance focus of this construct.

Implications for BI in the health Sector

Need for unique BI measures. Panelists identified measures specific to clinical or health service delivery within each of the three constructs in addition to more generic business-related applications of BI. Of the 30 concepts identified, 11 were unique to clinical or health service delivery based on the description statements with the remaining 19 relating to more universal business concepts. In all cases however, the rationale and performance indicators suggested were specific to the health delivery setting confirming the need for health sector specific measures of BI value. With only four of the 15 high relevance concepts matching to concepts in the Business

Value of BI model, it is clear there is a need for health sector specific measures in order to measure whether BI systems are meeting the needs of the health sector.

BI maturity in the health sector. The construct with the largest number of high priority concept measures supported through consensus was *Business Processes and Activities.* Most concepts in this construct had strong panelist engagement through the feedback and descriptor statements. This is not unexpected given the process focused nature of health service delivery. In addition, many of the underlying processes such as *BA1: Patient/Client Flow Management* are issues seen across most service delivery settings in Canada. The construct of *Business Strategies* had the highest rate of consensus although many of these measures were at the medium or neutral priority level. This may suggest these are not as immediate of a concern for those participating health system leaders or could be the result of increased variation in the priority of these across the distributed settings of the panelists. *Organizational Performance* had the fewest concepts identified and relatively fewer open ended comments. That pattern of response may be suggestive of overall maturity in each of the three construct focus areas.

A majority of the respondents (72%), indicated access to BI in their setting; however, use of these tools appears to be at an early stage of maturity based upon the descriptive statements provided. The concept measures and rational provided by the panelists were primarily related to descriptive retrospective or real-time indicators such as wait times, time to referral, or case costing. There were fewer examples of performance indicators that related to more advanced BI capabilities such as predictive or prescriptive analytics. There were some identified however, such as the ability to predict staffing needs or plan for seasonal trends. This may, in part, reflect a limitation of the BI systems in use by the respondents currently as many of the ones identified by the participants provide primarily historical data such as the Canadian Institute for Health

Information which reports on retrospective administrative data or point of service systems which typically have limited cross system/cross sector data for analysis.

Decision making context. Realizing full maturity in the use of BI systems for data driven decision making will also require supportive culture change within the Canadian health sector as has been seen in other settings. Several panelists provided unsolicited open-ended comments that reflected the tension between the political nature of health service delivery and data driven decision making at the leadership level. The comments suggest that the opportunity to make full use of BI may be constrained in this sector due to external factors, including the politically sensitive nature of health service delivery in the Canadian publicly funded system. An alternative perspective was provided by one of the SME Reviewers who, following one review, noted in response, that data may also be helpful in providing the evidence needed to move beyond decision making that can be swayed by political and other organizational factors. What is clear is that regardless of the external factors influencing the actions taken, it is unlikely the intended results will be realized without an informed and data driven basis for change.

Implications for nursing practice and leadership. For the most part, there was limited significant variation in concept identification and prioritization between sub-groups which indicates overall alignment between health system leadership groups on their expectations for BI use. Overall, there was a higher level of consensus among the NP versus the nonNP panelists reflecting, perhaps, the higher level of role similarity among the NP group overall. Significant variations were seen between TMT and OM panelists on 4 items in Round 1. In all cases, the variation was seen between the nonNP panelists which may again, be reflective of the greater diversity of roles among the NonNP group.

Despite the generally high alignment seen within the study, attention to sub-group variations will be still be an important consideration in setting specific BI implementations. Variations in information requirements may be exacerbated when considering underlying deficiencies in data within health information systems. These deficiencies may hinder the ability of each sub-sector to achieve meaningful and actionable data specific to their role and management focus. As already noted, there are known gaps in nursing information in many settings and this will limit use of BI for nursing leadership. The ability to reflect nursing information in BI systems is dependent on the inclusion of nursing requirements in underlying information systems. Addressing this will require increased nursing leadership competency related to informatics and attention to BI requirements throughout the information system lifecycle as well as strong advocacy for nursing data requirements (Kennedy & Moen, 2017). These may be best achieved through cross organizational approaches as identified by Sousa et al. (2017) who report success with a shared network of discipline specific sharing of information for nursing leaders, pooling access to data where nursing sensitive indicators are challenging to establish from most institutional health information systems.

BI system requirements. The study, through the identification of key concepts within the three construct areas, provides a foundation for considering BI requirements when planning system implementation. These considerations can be extended into underlying health information system implementations also as early identification of expected outputs can ensure the underlying data sources required for these information points are in place for future BI use. Understanding expected uses for BI is particularly important in light of recommendations from the literature to focus BI implementations on information products that deliver tactical value to executives quickly (Arnott, 2017; Ramakrishnan et al., 2012). The concepts identified in this

study can be utilized as a starting point for defining the high priority and high value data outputs for BI systems in order to align these with underlying data and realize early implementation benefits. In addition to considering data availability, awareness of future BI needs for data access can allow for early attention to issues such as data quality and consistency (Amster et al., 2015; Coleman et al., 2015) and establishment of data governance structures to support access to data across organizations (Hovenga & Grain, 2013).

Conclusion

The study results confirm there are many opportunities to utilize BI in the health sector given the breadth and specificity of the concepts identified. All the panelists identified multiple concepts representative of BI use that are applicable to their area of practice. Panelists were able to provide specific rationale and related performance indicators for all concepts. Many responses were detailed and lengthy suggesting panelists could visualize specific current or planned uses for this data. Many of the concepts identified further validate use identified anecdotally in the literature but not yet reflected in BI frameworks, further validating the findings in the study. These include: patient flow (Schaeffer et al., 2017); human resource management (Haque et al., 2014); documentation standards management (Ghosh & Scott, 2011); data driven decision making (Bonney, 2013; Ruland & Ravn, 2003); increased budget awareness (Foshay & Kuziemsky, 2014); improved care coordination (Wilbanks & Langford, 2014); improved client/customer experience (Barkley et al., 2014); human resource objectives (Rocha, Bernardino, Pedrosa, & Ferreira, 2017); improved accountability and transparency (Van De Graaff & Cameron, 2013); improved wait times (Ghosh & Scott, 2011); reduced cost (Ruland & Ravn, 2003); improved client/patient outcomes (Ferranti et al., 2010; Foshay & Kuziemsky,

2014; Ghosh & Scott, 2011; Schaeffer et al., 2017); and the ability to maximize revenues/remuneration (Barkley et al., 2014; Brooks et al., 2015; Ghosh & Scott, 2011).

Chapter 7 – Conclusions and Recommendations for Further Study

This dissertation is a first step towards ensuring that the effect of investments in BI systems can be measured in the context of the health service delivery organizations in which they are implemented. The research study demonstrates the need for health sector specific instruments when measuring BI value. It has also identified those concepts which are highest priority across a broad range of health system leaders including those in nursing leadership roles. Understanding the higher priority uses for BI will provide system implementers with direction on where to expect a more immediate return of value to health system leadership. Beyond BI implementation, use of these concepts can be a basis for planning health information system implementations generally to ensure the required data elements are available for BI systems in the future. The study also reflected the challenging cultural context for BI implementation in the health sector, recognizing the leadership challenge that data alone may not sway decisions in a broader political climate although without it, it is a certainty that decisions will not be evidence based.

The study proposes a new framework for BI through the *Business Intelligence Benefits Model for Health*, and contributes new knowledge by modifying established industry frameworks for use in the health sector. The model, while not directly tested through this study, has been shown to have face validity through the concepts identified which reflect both the objectives and the organizational culture of BI in health. Lastly, this study provides a basis for future empirical research as more work will be required to validate these concepts for use in measurement instruments and across more diverse health service settings. The study is well timed as the increasing adoption of health information systems poses new opportunities for the health sector in Canada to evolve to a data driven culture improving organizational sustainability and clinical care overall.

This study has contributed knowledge to a relatively unstudied area of research; the use of BI systems in health care settings and the distinct needs of leadership groups and nursing in particular. The findings of the study combined with the *Business Intelligence Benefits Model for Health* Framework provide a foundation that can now be expanded through future research. The findings demonstrate a high-level fit for the *Business Intelligence Benefits Model for Health* as a foundational framework for examining the organizational, strategic, human, technical and data factors that contribute to BI success in this sector. This was further validated by the 30 concept measures identified for the key constructs of *BI Assimilation* represented as *Business Processes and Activities* and as *Business Strategies* and the ultimate objective of BI system use, improved *Organizational Performance.*

The study demonstrated that the health sector has unique applications for BI and consequently requires specific concepts to for measuring BI success in the Canadian context. The variation between measures identified by the panelists and those used to measure these BI constructs in other sectors was notable. Only seven of the 30 concepts (23.3%) identified in the study can be mapped to nine of the 20 concepts (45.0%) in the *Business Value of BI Model.* Future research is now required to validate the foundational concepts established through the study to confirm applicability in a wider range of health delivery settings and within the broader conceptual model posed in this study. Terminology established for the concept names through the study will also require further research and testing to ensure both face and content validity for use in measurement instruments. With the concepts in place, the next step will be the application of the *Business Intelligence Benefits Model for Health* to validate the model and determine the extent to which the health sector results compare with other sectors where BI use is more embedded.

Further work is required in the community and primary care sectors to determine the extent to which these concepts are extendable to those settings as there was limited participation from this sector in the study. In addition, the study focused on the BI expectations of operational health system leaders. Further work is now needed to consider the analytics requirements of other Canadian health system stakeholders, particularly leadership perspectives at the policy or health system funder (government) level to determine the extent to which the needs of this cohort mirror those found here. This study included a limited number of panelists with existing analytics or health information management leadership roles and further validation with these groups specifically, given their in-depth understanding of the underlying data standards required for BI success would be beneficial

As quoted in the opening of this dissertation, “The accumulation of data has outpaced our capacity to use it to improve operating efficiency, clinical quality and financial effectiveness” (Ferranti et al., 2010, p. 136). The time is now for the health sector to take steps to ensure that the wealth of data available is harnessed to improve health service delivery and achieve objectives related to sustainability, safety, and improved patient care. Once optimized, BI can play a central role supporting improved health sector management and improving the quality and cost of health service delivery overall, aligning with the priorities identified by the Canadian Deputy Ministers of Health (Canadian Institute for Health Information, 2013). This is dependent however on attention to the broader organizational context to ensure data meets necessary standards for extraction and is aligned with organizational strategic directions.

References

Agnoletti, V., Buccioli, M., Padovani, E., Corso, R. M., Perger, P., Piraccini, E., . . . Gambale, G. (2013). Operating room data management: improving efficiency and safety in a surgical block. *BMC Surgery, 13*, 7-7. doi:10.1186/1471-2482-13-7

AlHazme, R. H., Rana, A. M., & De Lucca, M. (2014). Development and implementation of a clinical and business intelligence system for the Florida health data warehouse. *Online Journal Of Public Health Informatics, 6*(2), e182-e182. doi:10.5210/ojphi.v6i2.5249

Amster, A., Jentzsch, J., Pasupuleti, H., & Subramanian, K. G. (2015). Completeness, accuracy, and computability of National Quality Forum-specified eMeasures. *Journal Of The American Medical Informatics Association: JAMIA, 22*(2), 409-416. doi:10.1136/amiajnl-2014-002865

Ariyachandra, T. R., & Frolick, M. N. (2008). Critical success factors in business performance management—Striving for success. *Information systems management, 25*(2), 113-120.

Armstrong, C. P., & Sambamurthy, V. (1999). Information technology assimilation in firms: The influence of senior leadership and IT infrastructures. *Information systems research, 10*(4), 304-327.

Arnott, D. (2017). Patterns of business intelligence systems use in organizations. *Decision support systems and electronic commerce, 97*, 58-68. doi:10.1016/j.dss.2017.03.005

Assele Kama, A., Choquet, R., Mels, G., Daniel, C., Charlet, J., & Jaulent, M.-C. (2013). An ontological approach for the exploitation of clinical data. *Studies In Health Technology And Informatics, 192*, 142-146.

Assunção, M. D., Calheiros, R. N., Bianchi, S., Netto, M. A., & Buyya, R. (2015). Big Data computing and clouds: Trends and future directions. *Journal of Parallel and Distributed Computing, 79*, 3-15.

Bardsley, M. (2016). *Understanding analytical capability in health care*. Retrieved from London, UK: http://www.health.org.uk/publication/understanding-analytical-capability-health-care

Barkley, R., Greenapple, R., & Whang, J. (2014). Actionable data analytics in oncology: are we there yet? *Journal Of Oncology Practice / American Society Of Clinical Oncology, 10*(2), 93-96. doi:10.1200/JOP.2013.001344

Barton, A. J. (1994). Data needs for decision support of chief nurse executives. *Journal of Nursing Administration, 24*(4S), 19-25.

Bassellier, G., & Benbasat, I. (2004). Business competence of information technology professionals: conceptual development and influence on IT-business partnerships. *MIS Quarterly*, 673-694.

Behnam, S. A., & Badreddin, O. (2013). *Toward a Care Process Metamodel.* Paper presented at the ICSE Workshop on Software Engineering in Health Care.

Bhatnagar, A. (2009). Web analytics for business intelligence: Beyond hits and sessions. *Online, 33*(6), 32-35.

Bloor, M., Sampson, H., Baker, S., & Dahlgren, K. (2015). Useful but no Oracle: reflections on the use of a Delphi Group in a multi-methods policy research study. *Qualitative Research, 15*(1), 57-70. doi:10.1177/1468794113504103

Bonney, W. (2013). Applicability of Business Intelligence in Electronic Health Record. *Procedia - Social and Behavioral Sciences, 73*(0), 257-262. doi:http://dx.doi.org/10.1016/j.sbspro.2013.02.050

Brennan, P. F., & Bakken, S. (2015). Nursing Needs Big Data and Big Data Needs Nursing. *Journal of Nursing Scholarship, 47*(5), 477-484 478p. doi:10.1111/jnu.12159

Brooks, P., El-Gayar, O., & Sarnikar, S. (2015). A framework for developing a domain specific business intelligence maturity model: Application to healthcare. *International Journal of Information Management, 35*(3), 337-345. doi:http://dx.doi.org/10.1016/j.ijinfomgt.2015.01.011

Buntin, M. B., Burke, M. F., Hoaglin, M. C., & Blumenthal, D. (2011). The benefits of health information technology: a review of the recent literature shows predominantly positive results. *Health Affairs, 30*(3), 464-471.

Byrnes, J. (2012). Driving value: solving the issue of data overload with an executive dashboard. *Healthcare financial management : journal of the Healthcare Financial Management Association, 66*(10), 116, 118.

Campbell, S. M., Hann, M., Roland, M. O., Quayle, J. A., & Shekelle, P. G. (1999). The effect of panel membership and feedback on ratings in a two-round Delphi survey: results of a randomized controlled trial. *Medical Care, 37*(9), 964-968.

Canadian Institute for Health Information. (2013). *Better Information for Improved Health: A vision for Health System Use of Data in Canada - Summary and Recommendations*. Retrieved from Ottawa, ON: https://www.cihi.ca/en/hsu_vision_report_en.pdf

Cantrill, J., Sibbald, B., & Buetow, S. (1996). The Delphi and nominal group techniques in health services research. *International Journal of Pharmacy Practice, 4*(2), 67-74.

Cao, L., Zhang, H., Zhao, Y., Luo, D., & Zhang, C. (2011). Combined mining: discovering informative knowledge in complex data. *IEEE Transactions On Systems, Man, And Cybernetics. Part B, Cybernetics: A Publication Of The IEEE Systems, Man, And Cybernetics Society, 41*(3), 699-712. doi:10.1109/TSMCB.2010.2086060

Caro, J. J., & Moller, J. (2014). Decision-Analytic Models: Current Methodological Challenges. *Pharmacoeconomics, 32*(10), 943-950. doi:10.1007/s40273-014-0183-5

Carroll, L. N., Au, A. P., Detwiler, L. T., Fu, T.-C., Painter, I. S., & Abernethy, N. F. (2014). Visualization and analytics tools for infectious disease epidemiology: a systematic review. *Journal Of Biomedical Informatics, 51*, 287-298. doi:10.1016/j.jbi.2014.04.006

Carter, M., & Cox, R. (2000). Nurse managers' use of a computer decision support system. Differences in nursing labor costs per patient day. *Nursing Leadership Forum, 5*(2), 57-64.

Caspers, B. A., & Pickard, B. (2013). Value-based resource management: a model for best value nursing care. *Nursing Administration Quarterly, 37*(2), 95-104. doi:10.1097/NAQ.0b013e3182869e17

Chandler, N. (2014). Agenda Overview for Analytics, Business Intelligence and Performance Management, 2014. from Gartner Research Database

Chandler, N., Hostmann, B., Rayner, N., & Herschel, G. (2011). Gartner's business analytics framework. *Gartner Report, 219420*.

Chang, R., Kauffman, R., & Kwon, Y. (2014). Understanding the paradigm shift to computational social science in the presence of big data. *Decision Support Systems, 63*(0), 67-80. doi:http://dx.doi.org/10.1016/j.dss.2013.08.008

Chang, Y., Hsu, P., & Wu, Z. (2015). Exploring managers' intention to use business intelligence: the role of motivations. *Behaviour & Information Technology, 34*(3), 273-285. doi:10.1080/0144929X.2014.968208

Chaudhuri, S., Dayal, U., & Narasayya, V. (2011). An overview of business intelligence technology. *Commun. ACM, 54*(8), 88-98. doi:10.1145/1978542.1978562

Chen, H., Chiang, R. H., & Storey, V. C. (2012). Business Intelligence and Analytics: From Big Data to Big Impact. *MIS Quarterly, 36*(4), 1165-1188.

Chismar, W. G., & Wiley-Patton, S. (2002). Test of the technology acceptance model for the internet in pediatrics. *Proceedings / AMIA ...Annual Symposium.AMIA Symposium*, 155-159.

Chute, C. G., Beck, S. A., Fisk, T. B., & Mohr, D. N. (2010). The Enterprise Data Trust at Mayo Clinic: a semantically integrated warehouse of biomedical data. *Journal Of The American Medical Informatics Association: JAMIA, 17*(2), 131-135. doi:10.1136/jamia.2009.002691

Coleman, N., Halas, G., Peeler, W., Casaclang, N., Williamson, T., & Katz, A. (2015). From patient care to research: a validation study examining the factors contributing to data quality in a primary care electronic medical record database. *Bmc Family Practice, 16*(1), 11. doi:10.1186/s12875-015-0223-z

Côrte-Real, N., Oliveira, T., & Ruivo, P. (2014). *Understanding the hidden value of business intelligence and analytics (BI&A).* Paper presented at the Twentieth American Conference on Information Systems, Savannah.

Côrte-Real, N., Ruivo, P., & Oliveira, T. (2014). The Diffusion Stages of Business Intelligence & Analytics (BI&A): A Systematic Mapping Study. *Procedia Technology, 16*(0), 172-179. doi:http://dx.doi.org/10.1016/j.protcy.2014.10.080

Dalkey, N., & Helmer, O. (1963). An experimental application of the Delphi method to the use of experts. *Management science, 9*(3), 458-467.

Davenport, T. H. (2009). Make better decisions. *Harvard Business Review, 87*(11), 117.

Davenport, T. H., Harris, J. G., De Long, D. W., & Jacobson, A. L. (2001). Data to Knowledge to Results: Building an Analytic Capability. *California Management Review, 43*(2), 117-138. doi:10.2307/41166078

Davern, M. J., & Kauffman, R. J. (2000). Discovering potential and realizing value from information technology investments. *Journal of Management Information Systems*, 121-143.

Davidson, A. J. (2015). Creating value: unifying silos into public health business intelligence. *EGEMS (Washington, DC), 2*(4), 1172-1172. doi:10.13063/2327-9214.1172

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 319-340.

De Lusignan, S., Wells, S., Shaw, A., Rowlands, G., & Crilly, T. (2005). A knowledge audit of the managers of primary care organizations: top priority is how to use routinely collected clinical data for quality improvement. *Medical Informatics and the Internet in Medicine, 30*(1), 69-80. doi:10.1080/14639230400028455

de Meyrick, J. (2003). The Delphi method and health research. *Health education, 103*(1), 7-16.

Delone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: a ten-year update. *Journal of Management Information Systems, 19*(4), 9-30.

Demirkan, H., & Delen, D. (2013). Leveraging the capabilities of service-oriented decision support systems: Putting analytics and big data in cloud. *Decision Support Systems, 55*(1), 412-421. doi:http://dx.doi.org/10.1016/j.dss.2012.05.048

Durham, D. D., Rokoske, F. S., Hanson, L. C., Cagle, J. G., & Schenck, A. P. (2011). Quality improvement in hospice: adding a big job to an already big job? *American Journal Of Medical Quality: The Official Journal Of The American College Of Medical Quality, 26*(2), 103-109. doi:10.1177/1062860610379631

Elbashir, M. Z., Collier, P. A., & Davern, M. J. (2008). Measuring the effects of business intelligence systems: The relationship between business process and organizational performance. *International Journal of Accounting Information Systems, 9*(3), 135-153. doi:http://dx.doi.org/10.1016/j.accinf.2008.03.001

Elbashir, M. Z., Collier, P. A., & Sutton, S. G. (2011). The Role of Organizational Absorptive Capacity in Strategic Use of Business Intelligence to Support Integrated Management Control Systems. *Accounting Review, 86*(1), 155-184. doi:10.2308/accr.00000010

Elbashir, M. Z., Collier, P. A., Sutton, S. G., Davern, M. J., & Leech, S. A. (2013). Enhancing the Business Value of Business Intelligence: The Role of Shared Knowledge and Assimilation. *Journal of Information Systems, 27*(2), 87-105. doi:10.2308/isys-50563

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal Of Advanced Nursing, 62*(1), 107-115.

Ferrand, D., Amyot, D., & Corrales, C. V. (2010). Towards A Business Intelligence Framework For Healthcare Safety. *Journal of Internet Banking & Commerce, 15*(3), 1-9.

Ferranti, J. M., Langman, M. K., Tanaka, D., McCall, J., & Ahmad, A. (2010). Bridging the gap: leveraging business intelligence tools in support of patient safety and financial effectiveness. *Journal Of The American Medical Informatics Association: JAMIA, 17*(2), 136-143. doi:10.1136/jamia.2009.002220

Foshay, N., & Kuziemsky, C. (2014). Towards an implementation framework for business intelligence in healthcare. *International Journal of Information Management, 34*(1), 20-27. doi:10.1016/j.ijinfomgt.2013.09.003

Foshay, N., Mukherjee, A., & Taylor, A. (2007). Does data warehouse end-user metadata add value? *Communications of the ACM, 50*(11), 70-77.

Foshay, N., Taylor, A., & Mukherjee, A. (2014). Winning the hearts and minds of business intelligence users: the role of metadata. *Information systems management, 31*(2), 167-180. doi:10.1080/10580530.2014.890444

Fosso Wamba, S., Akter, S., Edwards, A., Chopin, G., & Gnanzou, D. (2015). How 'big data' can make big impact: Findings from a systematic review and a longitudinal case study. *International Journal of Production Economics, 165*(0), 234-246. doi:http://dx.doi.org/10.1016/j.ijpe.2014.12.031

Garay, J., Cartagena, R., Esensoy, A. V., Handa, K., Kane, E., Kaw, N., & Sadat, S. (2015). Strategic analytics: towards fully embedding evidence in healthcare decision-making. *Healthcare Quarterly (Toronto, Ont.), 17 Spec No*, 23-27.

Gárdai, P. (2013). *Business Intelligence Competency Centers, a way to improve Business Intelligence performance.* Faculty of Science Supervised by: Prof. TM van Engers, University of Amsterdam SA.

Ghosh, B., & Scott, J. E. (2011). Antecedents and Catalysts for Developing a Healthcare Analytic Capability. *Communications of the Association for Information Systems, 29*, 395-410.

Glaser, J., & Stone, J. (2008). Effective use of business intelligence. *Healthcare Financial Management: Journal Of The Healthcare Financial Management Association, 62*(2), 68-72.

Graf, T., Erskine, A., & Steele, G. D., Jr. (2014). Leveraging data to systematically improve care: coronary artery disease management at Geisinger. *The Journal Of Ambulatory Care Management, 37*(3), 199-205. doi:10.1097/JAC.0000000000000038

Gray, E. A., & Thorpe, J. H. (2015). Comparative effectiveness research and big data: balancing potential with legal and ethical considerations. *Journal Of Comparative Effectiveness Research, 4*(1), 61-74. doi:10.2217/cer.14.51

Grigoroudis, E., Orfanoudaki, E., & Zopounidis, C. (2012). Strategic performance measurement in a healthcare organisation: A multiple criteria approach based on balanced scorecard. *Omega-International Journal of Management Science, 40*(1), 104-119. doi:10.1016/j.omega.2011.04.001

Hadavandi, E., Shavandi, H., Ghanbari, A., & Abbasian-Naghneh, S. (2012). Developing a hybrid artificial intelligence model for outpatient visits forecasting in hospitals. *Applied Soft Computing, 12*(2), 700-711. doi:10.1016/j.asoc.2011.09.018

Han, H., Yonggang, W., Tat-Seng, C., & Xuelong, L. (2014). Toward Scalable Systems for Big Data Analytics: A Technology Tutorial. *Access, IEEE, 2*, 652-687. doi:10.1109/ACCESS.2014.2332453

Han, J., Rabinovich, M., Abraham, P., Satyanarayana, P., Liao, T. V., Udoji, T. N., . . . Martin, G. S. (2016). Effect of Electronic Health Record Implementation in Critical Care on Survival and Medication Errors. *The American journal of the medical sciences, 351*(6), 576-581.

Haque, W., Urquhart, B., Berg, E., & Dhanoa, R. (2014). Using business intelligence to analyze and share health system infrastructure data in a rural health authority. *JMIR Medical Informatics, 2*(2), e16-e16. doi:10.2196/medinform.3590

Health Canada. (2017). *A common statement of principles on shared health priorities*. Ottawa, ON: Government of Canada Retrieved from https://www.canada.ca/en/health-canada/corporate/transparency/health-agreements/principles-shared-health-priorities.html.

Helm-Murtagh, S. C. (2014). Use of big data by Blue Cross and Blue Shield of North Carolina. *North Carolina Medical Journal, 75*(3), 195-197.

HIMSS, N. I. C.-B. D. P. W. (2015). CNO-CNIO Vendor Roundtable Guiding Principles for Big Data in Nursing Using Big Data to Improve the Quality of Care and Outcomes: HIMSS.

Hočevar, B., & Jaklič, J. (2008). Assessing benefits of business intelligence systems–a case study. *Management: Journal of Contemporary Management Issues, 13*(2 (Special issue)), 87-119.

Holden, R. J., & Karsh, B.-T. (2010). The Technology Acceptance Model: Its past and its future in health care. *Journal Of Biomedical Informatics, 43*(1), 159-172. doi:10.1016/j.jbi.2009.07.002

Holsapple, C., Lee-Post, A., & Pakath, R. (2014). A unified foundation for business analytics. *Decision Support Systems, 64*(0), 130-141. doi:http://dx.doi.org/10.1016/j.dss.2014.05.013

Horvath, M. M., Cozart, H., Ahmad, A., Langman, M. K., & Ferranti, J. (2009). Sharing adverse drug event data using business intelligence technology. *Journal Of Patient Safety, 5*(1), 35-41. doi:10.1097/PTS.0b013e31819aa951

Horvath, M. M., Winfield, S., Evans, S., Slopek, S., Shang, H., & Ferranti, J. (2011). The DEDUCE Guided Query tool: Providing simplified access to clinical data for research

and quality improvement. *Journal Of Biomedical Informatics, 44*(2), 266-276. doi:10.1016/j.jbi.2010.11.008

Hovenga, E. J. S., & Grain, H. (2013). Health data and data governance. *Studies In Health Technology And Informatics, 193*, 67-92.

Hsu, C.-C., & Sandford, B. A. (2007). The Delphi technique: making sense of consensus. *Practical assessment, research & evaluation, 12*(10), 1-8.

Hubner-Bloder, G., & Ammenwerth, E. (2009). Key performance indicators to benchmark hospital information systems—a Delphi study. *Methods Of Information In Medicine, 48*(6), 508-518.

Ingemansson, M., Bastholm-Rahmner, P., & Kiessling, A. (2014). Practice guidelines in the context of primary care, learning and usability in the physicians' decision-making process--a qualitative study. *Bmc Family Practice, 15*, 141. doi:10.1186/1471-2296-15-141

Institute of Medicine. (2011). *The future of nursing: Leading change, advancing health*: National Academies Press Washington, DC.

Işık, Ö., Jones, M. C., & Sidorova, A. (2013). Business intelligence success: The roles of BI capabilities and decision environments. *Information & Management, 50*(1), 13-23. doi:http://dx.doi.org/10.1016/j.im.2012.12.001

Isken, M. W., & Rajagopalan, B. (2002). Data mining to support simulation modeling of patient flow in hospitals. *Journal Of Medical Systems, 26*(2), 179-197.

Jeffs, L., Nincic, V., White, P., Hayes, L., & Lo, J. (2015). Leveraging Data to Transform Nursing Care: Insights From Nurse Leaders. *Journal Of Nursing Care Quality, 30*(3), 269-274.

Jennings, H. (2013). *How To Present Performance Data to Decision Makers in Healthcare.* (Dissertation/Thesis). Retrieved from http://uvic.summon.serialssolutions.com/2.0.0/link/0/eLvHCXMwY2AwNtIz0EUrE4xAp3gnJlmCJtUsjA1NkiwMk9NS0iyNUpMs0hKNElF3kzHALnNDO20A2Ba20DcxNQcWuczAhjcw9eqFuSAd1wmtFdwEGXhckGazhRiYUvNEGBw88ssVQvIVAiD7ehQCECvzFVwSSxIVSvIVXKAX2yj4JmYDm18KmXkKHvB1WKIM5m6uIc4euiD74lOAOT45NR50PDOUCR13iQdLJyfGg5wbD3KusRgDC7AznyrBoJCUmJZsZGkC7LaYJ4GmzCzMU4zNgEJGJinGiebmxpIMBqSaLkW6FmkGLiPwtQ6goQQZBpaSotJUWUg4AgCbv4Rm

Jin, T., & Ju, B. (2014). The corporate information agency: Do competitive intelligence practitioners utilize It? *Journal of the Association for Information Science & Technology, 65*(3), 589-608. doi:10.1002/asi.22993

Jourdan, Z., Rainer, R. K., & Marshall, T. E. (2008). Business intelligence: An analysis of the literature 1. *Information systems management, 25*(2), 121-131.

Kable, A. K., Pich, J., & Maslin-Prothero, S. E. (2012). A structured approach to documenting a search strategy for publication: A 12 step guideline for authors. *Nurse Education Today, 32*(8), 878-886.

Kandel, S., Paepcke, A., Hellerstein, J. M., & Heer, J. (2012). Enterprise Data Analysis and Visualization: An Interview Study. *IEEE Transactions On Visualization And Computer Graphics, 18*(12), 2917-2926.

Kandogan, E., Balakrishnan, A., Haber, E. M., & Pierce, J. S. (2014). From data to insight: work practices of analysts in the enterprise. *IEEE Computer Graphics And Applications, 34*(5), 42-50. doi:10.1109/MCG.2014.62

Kao, H.-Y., Yu, M.-C., Masud, M., Wu, W.-H., Chen, L.-J., & Wu, Y.-C. J. (2016). Design and evaluation of hospital-based business intelligence system (HBIS): A foundation for design science research methodology. *Computers in Human Behavior, 62*, 495-505. doi:http://dx.doi.org/10.1016/j.chb.2016.04.021

Karami, M., Fatehi, M., Torabi, M., Langarizadeh, M., Rahimi, A., & Safdari, R. (2013). Enhance hospital performance from intellectual capital to business intelligence. *Radiology Management, 35*(6), 30-35.

Karami, M., Safdari, R., & Rahimi, A. (2013). Effective radiology dashboards: key research findings. *Radiology Management, 35*(2), 42-45.

Kennedy, M. A., & Moen, A. (2017). Nurse Leadership and Informatics Competencies: Shaping Transformation of Professional Practice. *Studies In Health Technology And Informatics, 232*, 197-206.

Khan, M., & Khan, S. S. (2011). Data and information visualization methods, and interactive mechanisms: A survey. *International Journal of Computer Applications, 34*(1), 1-14.

King, W. R., & He, J. (2006). A meta-analysis of the technology acceptance model. *Information & Management, 43*(6), 740-755.

Krumholz, H. M. (2014). Big Data And New Knowledge In Medicine: The Thinking, Training, And Tools Needed For A Learning Health System. *Health Affairs, 33*(7), 1163-1170. doi:10.1377/hlthaff.2014.0053

Kuo, M.-H., Sahama, T., Kushniruk, A. W., Borycki, E. M., & Grunwell, D. K. (2014). Health big data analytics: current perspectives, challenges and potential solutions. *International Journal of Big Data Intelligence, 1*(1), 114-126.

Lee, J., Elbashir, M. Z., Mahama, H., & Sutton, S. G. (2014). Enablers of top management team support for integrated management control systems innovations. *International Journal of Accounting Information Systems, 15*(1), 1-25. doi:10.1016/j.accinf.2013.07.001

Leenaerts, M. (2015). *Evaluation of Health Data Warehousing: Development of a Framework and Assessment of Current Practices.* (Dissertation/Thesis). Retrieved from http://dspace.library.uvic.ca/bitstream/handle/1828/5959/Leenaerts_Marianne_PhD_2015.pdf?sequence=3&isAllowed=y

Leidner, D. E., Preston, D., & Chen, D. (2010). An examination of the antecedents and consequences of organizational IT innovation in hospitals. *The Journal of Strategic Information Systems, 19*(3), 154-170.

Lewis, W., Agarwal, R., & Sambamurthy, V. (2003). Sources of influence on beliefs about information technology use: An empirical study of knowledge workers. *MIS Quarterly*, 657-678.

Liaw, S.-T., Taggart, J., Yu, H., & de Lusignan, S. (2013). Data extraction from electronic health records - Existing tools may be unreliable and potentially unsafe. *Australian Family Physician, 42*(11), 820-823.

Loewen, L., & Roudsari, A. (2017a). Evidence for Busines Intelligence in Health Care: A Literature Review. *Studies In Health Technology And Informatics, 235*, 579.

Loewen, L., & Roudsari, A. (2017b). Evidence for Business Intelligence in Health Care: A Literature Review. In R. Randell, R. Cornet, C. McCowan, N. Peek, & P. J. Scott (Eds.), *Informatics for Health: Connected citizen-led wellness and population health* (Vol. 235, pp. 579-583). Amsterdam: IOS Press.

Loewen, L., & Roudsari, A. (2017c, February, 2017). *Measuring Business Intelligence Success in Healthcare: A Conceptual Model [poster]*. Paper presented at the ITCH, Victoria, Canada.

London, K. S., Singal, B., Fowler, J., Prepejchal, R., Simmons, S., & Finefrock, D. (2015). A Delphi Method Analysis to Create an Emergency Medicine Educational Patient Satisfaction Survey. *Western Journal of Emergency Medicine, 16*(7), 1106.

Luhn, H. P. (1958). A business intelligence system. *IBM Journal of Research and Development, 2*(4), 314-319.

Manfreda, A., Kovacic, A., Stemberger, M. I., & Trkman, P. (2014). Absorptive Capacity as a Precondition for Business Process Improvement. *Journal of Computer Information Systems, 54*(2), 35-43.

Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Byers, A. H. (2011). Big data: The next frontier for innovation, competition, and productivity.

Marino, D. J. (2014). Using business intelligence to reduce the cost of care. *Healthcare Financial Management: Journal Of The Healthcare Financial Management Association, 68*(3), 42.

McAfee, A., & Brynjolfsson, E. (2012). Big data: the management revolution. *Harvard Business Review, 90*(10), 60.

McGrath, J. M., Brown, R. E., & Samra, H. A. (2012). Before you search the literature: how to prepare and get the most out of citation databases. *Newborn and Infant Nursing Reviews, 12*(3), 162-170.

McLaughlin, N., Afsar-Manesh, N., Ragland, V., Buxey, F., & Martin, N. A. (2014). Tracking and sustaining improvement initiatives: leveraging quality dashboards to lead change in a neurosurgical department. *Neurosurgery, 74*(3), 235-243. doi:10.1227/NEU.0000000000000265

McMillan, S. S., King, M., & Tully, M. P. (2016). How to use the nominal group and Delphi techniques. *International Journal of Clinical Pharmacy*, 1-8.

Meijering, J. V. (2016). The effect of controlled opinion feedback on Delphi features: Mixed messages from a real-world Delphi experiment. *Technological forecasting & social change, 103*, 166-173. doi:10.1016/j.techfore.2015.11.008

Miller, G. J., Bräutigam, D., & Gerlach, S. V. (2006). *Business intelligence competency centers: a team approach to maximizing competitive advantage* (Vol. 8): John Wiley & Sons.

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *Annals of Internal Medicine, 151*(4), 264-269.

Moore, K. D., Eyestone, K., & Coddington, D. C. (2012). How business intelligence can improve value. *Healthcare Financial Management: Journal Of The Healthcare Financial Management Association, 66*(10), 112-114.

Murphy, M. K. (1998). Consensus development methods, and their use in clinical guideline development. *Health Technology Assessment (Winchester, England), 2*(3), i.

Naghdipour, N. N. (2014). New Trends in Business Intelligence: A case study on the impact of organizational demands of information and new technologies on BI.

Nagle, L. M., & White, P. (2015). *Towards a Pan-Canadian Strategy for Nursing Data Standards - White Paper*. Paper. Toronto, ON.

Nagy, P. G., Warnock, M. J., Daly, M., Toland, C., Meenan, C. D., & Mezrich, R. S. (2009). Informatics in radiology: automated Web-based graphical dashboard for radiology

operational business intelligence. *Radiographics: A Review Publication Of The Radiological Society Of North America, Inc, 29*(7), 1897-1906. doi:10.1148/rg.297095701

Nakatsu, R. T., & Iacovou, C. L. (2009). A comparative study of important risk factors involved in offshore and domestic outsourcing of software development projects: A two-panel Delphi study. *Information & Management, 46*(1), 57-68.

Negash, S. (2004). Business intelligence. *The Communications of the Association for Information Systems, 13*(1), 54.

Nelson, K. M., & Cooprider, J. G. (1996). The Contribution of Shared Knowledge to IS Group Performance. *MIS Quarterly, 20*(4), 409-432.

Nickel, N., Finlayson, G., Fransoo, R., Dragan, R., Burchill, C., Ekuma, O., . . . Burchill, S. (2017). *Variations in resource use and costs of hospital care in Manitoba.* Retrieved from Winnipeg, MB:

Niu, L., Lu, J., Zhang, G., & Wu, D. (2013). FACETS: A cognitive business intelligence system. *Information Systems, 38*(6), 835-862. doi:http://dx.doi.org/10.1016/j.is.2013.02.002

Nouraei, S. A. R., Hudovsky, A., Frampton, A. E., Mufti, U., White, N. B., Wathen, C. G., . . . Darzi, A. (2015). A Study of Clinical Coding Accuracy in Surgery: Implications for the Use of Administrative Big Data for Outcomes Management. *Annals Of Surgery*.

Nouraei, S. A. R., Virk, J. S., Hudovsky, A., Wathen, C., Darzi, A., & Parsons, D. (2015). Accuracy of clinician-clinical coder information handover following acute medical admissions: implication for using administrative datasets in clinical outcomes management. *Journal Of Public Health (Oxford, England)*.

Nysenbaum, J. B. (2014). Availability and usability of behavioral health organization encounter data in MAX 2009. *Medicare & medicaid research review, 4*(2). doi:pmid:

Okoli, C. (2004). The Delphi method as a research tool: an example, design considerations and applications. *Information & Management, 42*(1), 15-29. doi:10.1016/j.im.2003.11.002

Paré, G. (2014). Barriers to organizational adoption of EMR systems in family physician practices: A mixed-methods study in Canada. *International journal of medical informatics (Shannon, Ireland), 83*(8), 548-558. doi:10.1016/j.ijmedinf.2014.06.003

Popovič, A., Hackney, R., Coelho, P. S., & Jaklič, J. (2012). Towards business intelligence systems success: Effects of maturity and culture on analytical decision making. *Decision Support Systems, 54*(1), 729-739.

Popovic, J. R. (2017). Distributed data networks: a blueprint for Big Data sharing and healthcare analytics. *Annals Of The New York Academy Of Sciences, 1387*(1), 105-111. doi:10.1111/nyas.13287

Powell, C. (2003). The Delphi technique: myths and realities. *Journal Of Advanced Nursing, 41*(4), 376-382.

Preston, D. S., & Karahanna, E. (2009). Antecedents of IS strategic alignment: a nomological network. *Information systems research, 20*(2), 159-179.

Prevedello, L. M., Andriole, K. P., Hanson, R., Kelly, P., & Khorasani, R. (2010). Business intelligence tools for radiology: creating a prototype model using open-source tools. *Journal Of Digital Imaging, 23*(2), 133-141. doi:10.1007/s10278-008-9167-3

Pruinelli, L., Delaney, C. W., Garciannie, A., Caspers, B., & Westra, B. L. (2016). Nursing Management Minimum Data Set: Cost-Effective Tool To Demonstrate the Value of Nurse Staffing in the Big Data Science Era. *Nursing Economic$, 34*(2), 66.

Raghupathi, W., & Raghupathi, V. (2014). Big data analytics in healthcare: promise and potential. *Health Information Science And Systems, 2*, 3-3. doi:10.1186/2047-2501-2-3

Ramakrishnan, T., Jones, M. C., & Sidorova, A. (2012). Factors influencing business intelligence (BI) data collection strategies: An empirical investigation. *Decision Support Systems, 52*(2), 486-496. doi:http://dx.doi.org/10.1016/j.dss.2011.10.009

Reader, T. W., Gillespie, A., & Roberts, J. (2014). Patient complaints in healthcare systems: a systematic review and coding taxonomy. *BMJ Quality & Safety, 23*(8), 678-689. doi:10.1136/bmjqs-2013-002437

Render, M. L., Freyberg, R. W., Hasselbeck, R., Hofer, T. P., Sales, A. E., Deddens, J., . . . Almenoff, P. L. (2011). Infrastructure for quality transformation: measurement and reporting in veterans administration intensive care units. *BMJ Quality & Safety, 20*(6), 498-507. doi:10.1136/bmjqs.2009.037218

Risling, T. (2017). Educating the nurses of 2025: Technology trends of the next decade. *Nurse Education In Practice, 22*, 89-92. doi:10.1016/j.nepr.2016.12.007

Rocha, S., Bernardino, J., Pedrosa, I., & Ferreira, I. (2017). Dashboards and Indicators for a BI Healthcare System. In Á. Rocha, A. M. Correia, H. Adeli, L. P. Reis, & S. Costanzo (Eds.), *Recent Advances in Information Systems and Technologies: Volume 1* (pp. 81-90). Cham: Springer International Publishing.

Ruland, C. M., & Ravn, I. H. (2003). Usefulness and effects on costs and staff management of a nursing resource management information system. *Journal Of Nursing Management, 11*(3), 208-215.

Safran, C., Bloomrosen, M., Hammond, W. E., Labkoff, S., Markel-Fox, S., Tang, P. C., & Detmer, D. E. (2007). Toward a National Framework for the Secondary Use of Health Data: An American Medical Informatics Association White Paper. *Journal of the American Medical Informatics Association, 14*(1), 1-9. doi:10.1197/jamia.M2273

Salmond, S. W., & Echevarria, M. (2017). Healthcare Transformation and Changing Roles for Nursing. *Orthopedic Nursing, 36*(1), 12-25. doi:10.1097/NOR.0000000000000308

Schaeffer, C. (2016). Big Data Management in US Hospitals Benefits and Barriers. *The Health Care Manager*, 1. doi:10.1097/HCM.0000000000000139

Schaeffer, C., Booton, L., Halleck, J., Studeny, J., & Coustasse, A. (2017). Big Data Management in US Hospitals: Benefits and Barriers. *The Health Care Manager, 36*(1), 87-95. doi:10.1097/HCM.0000000000000139

Scheibe, M., Skutsch, M., & Schofer, J. (2002). IV. C. Experiments in Delphi Methodology. *The Delphi method: Techniques and applications*, 257-281.

Sen, A., Ramamurthy, K., & Sinha, A. P. (2012). A Model of Data Warehousing Process Maturity. *IEEE Transactions on Software Engineering, 38*(2), 336-353. doi:10.1109/TSE.2011.2

Sensmeier, J. (2015). BIG DATA and the future of nursing knowledge. *Nursing Management, 46*(4), 22-27. doi:10.1097/01.NUMA.0000462365.53035.7d

Seuring, S., & Gold, S. (2012). Conducting content-analysis based literature reviews in supply chain management. *Supply Chain Management: An International Journal, 17*(5), 544-555.

Shneiderman, B., & Plaisant, C. (2015). Sharpening analytic focus to cope with big data volume and variety. *IEEE Computer Graphics And Applications, 35*(3), 10-14. doi:10.1109/MCG.2015.64

Shollo, A. (2015). Towards an understanding of the role of business intelligence systems in organisational knowing The role of BI systems in organisational knowing. *Information systems journal (Oxford, England), 26*(4), 339-367. doi:10.1111/isj.12071

Siemieniuch, C. E., & Sinclair, M. A. (2004). A framework for organisational readiness for knowledge management. *International Journal of Operations & Production Management, 24*(1), 79-98. doi:10.1108/01443570410511004

Simpao, A. F., Ahumada, L. M., Gálvez, J. A., & Rehman, M. A. (2014). A review of analytics and clinical informatics in health care. *Journal Of Medical Systems, 38*(4), 45-45. doi:10.1007/s10916-014-0045-x

Skinner, R., Nelson, R. R., Chin, W. W., & Land, L. (2015). The Delphi Method Research Strategy in Studies of Information Systems. *Communications of the Association for Information Systems, 37*(1), 2.

Smaltz, D. H., Sambamurthy, V., & Agarwal, R. (2006). The antecedents of CIO role effectiveness in Organizations:An empirical study in the healthcare sector. *Engineering Management, IEEE Transactions on, 53*(2), 207-222. doi:10.1109/TEM.2006.872248

Sousa, K. H., Reeder, B., Bondy, J., Ozkaynak, M., & Weiss, J. (2017). The Colorado Collaborative for Nursing Research: Providing Trended Nurse-Sensitive Patient Outcome Data Across Entities. *Journal of Nursing Administration, 47*(6), 345-349.

Spitzer, A., Ellsbury, D., & Clark, R. H. (2015). The Pediatrix BabySteps® Data Warehouse--a unique national resource for improving outcomes for neonates. *Indian Journal Of Pediatrics, 82*(1), 71-79. doi:10.1007/s12098-014-1585-2

Spitzer, R., & Miranda, E. (2017). Enhancing Professional Role Competency Through Data Analytics and Evidence-Based Education. *Nurse Leader, 15*(3), 189-192.

Spruit, M. (2014). Towards healthcare business intelligence in long-term care. *Computers in Human Behavior, 30*, 698-707. doi:10.1016/j.chb.2013.07.038

Srinivas, T. R., Taber, D. J., Su, Z., Zhang, J., Mour, G., Northrup, D., . . . Mauldin, P. D. (2017). Big Data, Predictive Analytics, and Quality Improvement in Kidney Transplantation: A Proof of Concept. *American Journal Of Transplantation: Official Journal Of The American Society Of Transplantation And The American Society Of Transplant Surgeons, 17*(3), 671-681. doi:10.1111/ajt.14099

Sukumar, S. R., Natarajan, R., & Ferrell, R. K. (2015). Quality of Big Data in health care. *Int J Health Care Qual Assur, 28*(6), 621-634. doi:10.1108/ijhcqa-07-2014-0080

Thatcher, M. E., & Clemons, E. K. (2000). Managing the costs of informational privacy: Pure bundling as a strategy in the individual health insurance market. *Journal of Management Information Systems, 17*(2), 29-57.

Tomić, B., & Milić, T. (2013). Automated interpretation of key performance indicator values and its application in education. *Knowledge-Based Systems, 37*(0), 250-260. doi:http://dx.doi.org/10.1016/j.knosys.2012.08.006

Tremblay, M. C., Hevner, A. R., & Berndt, D. J. (2012). Design of an information volatility measure for health care decision making. *Decision Support Systems, 52*(2), 331-341. doi:10.1016/j.dss.2011.08.009

Van De Graaff, J., & Cameron, A. (2013). Quest for business intelligence in health care. *Healthcare Financial Management: Journal Of The Healthcare Financial Management Association, 67*(2), 44.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science, 46*(2), 186-204.

von der Gracht, H. A. (2012). Consensus measurement in Delphi studies. *Technological forecasting & social change, 79*(8), 1525-1536. doi:10.1016/j.techfore.2012.04.013

Wagner, H.-T., Beimborn, D., & Weitzel, T. (2014). How Social Capital Among Information Technology and Business Units Drives Operational Alignment and IT Business Value. *Journal of Management Information Systems, 31*(1), 241-272. doi:10.2753/MIS0742-1222310110

Wang, H. (2014). Distinguishing the adoption of business intelligence systems from their implementation: the role of managers' personality profiles. *Behaviour & Information Technology, 33*(10), 1082-1092. doi:10.1080/0144929X.2013.869260

Wang, M. (2013). Predefined three tier business intelligence architecture in healthcare enterprise. *Journal Of Medical Systems, 37*(2), 9928-9928. doi:10.1007/s10916-013-9928-5

Wang, Y., & Byrd, T. A. (2017). Business analytics-enabled decision making effectiveness through knowledge absorptive capacity in health care. *Journal of Knowledge Management, 21*(3).

Ward, C., Morella, L., Ashburner, J., & Atlas, S. (2014). An interactive, all-payer, multidomain primary care performance dashboard. *The Journal Of Ambulatory Care Management, 37*(4), 339-348. doi:10.1097/JAC.0000000000000044

Ward, M. J., Marsolo, K. A., & Froehle, C. M. (2014). Applications of business analytics in healthcare. *Business Horizons, 57*(5), 571-582. doi:http://dx.doi.org/10.1016/j.bushor.2014.06.003

Wells, R., Alexander, J. A., Piotrowski, M. M., Banaszak-Holl, J., Adams-Watson, J. G., Davis, J., & Valentine, N. M. (1999). How other members of the top management team see the nurse executive. *Nursing Administration Quarterly, 23*(3), 38-51.

Welton, J. M. (2014). Business intelligence and nursing administration. *The Journal Of Nursing Administration, 44*(5), 245-246. doi:10.1097/NNA.0000000000000060

Welton, J. M., & Harper, E. M. (2015). Nursing Care Value-Based Financial Models. *Nursing Economics, 33*(1), 14-+.

Westra, B. L., Latimer, G. E., Matney, S. A., Park, J. I., Sensmeier, J., Simpson, R. L., . . . Delaney, C. W. (2015). A national action plan for sharable and comparable nursing data to support practice and translational research for transforming health care. *Journal Of The American Medical Informatics Association: JAMIA, 22*(3), 600-607. doi:10.1093/jamia/ocu011

Whitt, M. R., Burns, S. D., & Gittens, S. A. (2015). Personal health information - The patient's electronic file. *Electronic Healthcare Law Review, 5*(2), 13-20.

Wilbanks, B. A., & Langford, P. A. (2014). A review of dashboards for data analytics in nursing. *Computers Informatics Nursing, 32*(11), 545-549.

Wixom, B., Ariyachandra, T., Goul, M., Gray, P., Kulkarni, U., & Phillips-Wren, G. (2011). The current state of business intelligence in academia. *Communications of the Association for Information System, 29*(16), 299-312.

Wixom, B., & Watson, H. (2001). An Empirical Investigation of the Factors Affecting Data Warehousing Success. *MIS Quarterly, 25*(1), 17-41. doi:10.2307/3250957

Wixom, B., & Watson, H. (2012). The BI-based organization. *Organizational Applications of Business Intelligence Management: Emerging Trends, IGI Global, Hershey*, 193-208.

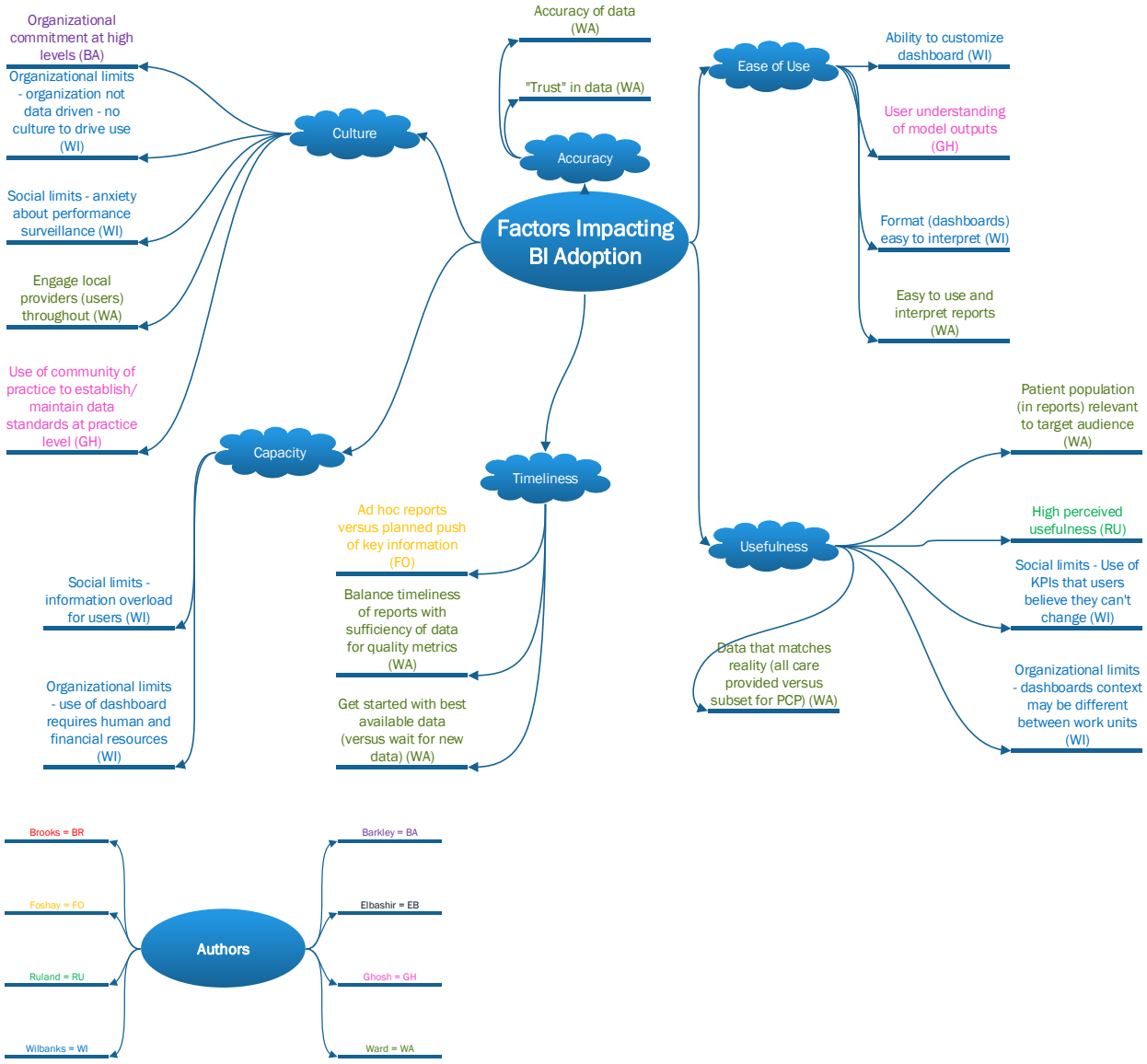
Wixom, B., Watson, H., & Werner, T. (2011). Developing an enterprise business intelligence capability: The Norfolk Southern journey. *MIS Quarterly Executive, 10*(2), 61-71.

Wool, C. (2015). Instrument development: Parental satisfaction and quality indicators of perinatal palliative care. *Journal of Hospice & Palliative Nursing, 17*(4), 301-308.

Yeoh, W., & Koronios, A. (2010). Critical success factors for business intelligence systems. *Journal of Computer Information Systems, 50*(3), 23-32.

Zechmeister-Koss, I., Schnell-Inderst, P., & Zauner, G. (2014). Appropriate evidence sources for populating decision analytic models within health technology assessment (HTA): a systematic review of HTA manuals and health economic guidelines. *Medical decision making : an international journal of the Society for Medical Decision Making, 34*(3), 288-299. doi:10.1177/0272989X13509406

Appendix A – Sample Visual Representation of Thematic Analysis



Appendix B – Certificate of Ethics Approval

University of Victoria
Office of Research Services | Human Research Ethics Board
Administrative Services Building Rm B202 PO Box 1700 STN CSC Victoria BC V8W 2Y2 Canada
T 250-472-4545 | F 250-721-8960 | uvic.ca/research | ethics@uvic.ca

Certificate of Approval

PRINCIPAL INVESTIGATOR:	**Liz Loewen**	**ETHICS PROTOCOL NUMBER** Minimal Risk Review - Delegated	**16-451**
UVic STATUS:	**Ph.D. Student**	ORIGINAL APPROVAL DATE:	27-Jan-17
UVic DEPARTMENT:	**HEIS**	APPROVED ON:	27-Jan-17
SUPERVISOR:	**Dr. Abdul Roudsari**	APPROVAL EXPIRY DATE:	26-Jan-18

PROJECT TITLE: **Establishing a Business Intelligence Measurement Framework for Healthcare**

RESEARCH TEAM MEMBER Dr. Karen Courtney (UVic), Dr. Kathryn Hannah (UVic)

DECLARED PROJECT FUNDING: **None**

CONDITIONS OF APPROVAL

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Modifications
To make any changes to the approved research procedures in your study, please submit a "Request for Modification" form. You must receive ethics approval before proceeding with your modified protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Participants.

Signature removed for publication

Dr. Rachael Scarth
Associate Vice-President Research Operations

Certificate Issued On: 03-Feb-17

16-451 Loewen, Liz

Appendix C – Snowball Recruiter Invitation

University of Victoria

Recruiter Invitation

Project Title: **Establishing a Business Intelligence Measurement Framework for Healthcare**

Dear Colleague,

I am seeking your assistance in identifying possible participants for my PhD study looking at Business Intelligence (BI) in Healthcare.

The objective of this research is to establish health sector specific measures for foundational constructs of Business Intelligence (BI) success. BI is the use of specialized tools to collect, analyze, and present organizational data to operational managers and leaders in user friendly format(s) to support decision making in alignment with organizational objectives. As BI success results from organizational factors in addition to underlying information systems, the concepts being studied are *BI Assimilation* (the use of BI to manage operational processes) and *Organizational Performance* (the use of BI to achieve organizational strategies).

You are being asked to assist me by reaching out to 5-10 individuals in your network of colleagues to make them aware of the opportunity to participate in this study by sharing the attached information.

Please forward the attached study description and invitation to individuals in your professional network who fit the following criteria:
Participants must be:

- Currently employed in a leadership role (Top Management/Leadership Team or Operational Manager) within a health service delivery organization. Sample titles may include: CEO, COO, CMO, CNO, Director, Medical Director, Manager.
- Working within a publicly funded health service delivery organization in Canada. Sample organizations include: local health integration networks, hospitals, primary care clinics, regional health authorities.
- Participants should have an interest in BI solutions for their setting but are not required to have an existing BI solution in use.

The following types of roles are NOT included in the study. Please do NOT include individuals who fall into these roles:

- Individuals from organizations or in roles whose main focus is not direct health service delivery. Sample organizations include: government health policy or oversight departments; consulting organizations.
- Individuals from organizations located outside of Canada.
- Individuals without leadership or management responsibilities.

If you have any questions about the criteria or the study, please don't hesitate to contact myself or my Dissertation Supervisor (contact information below).

Do not feel any pressure to assist with this research study. As the researcher, I will be blinded to the identity of the participants and also will not know which participants, if any, have been invited into the study by you. You will receive up to two reminders from me if the initial recruitment doesn't result in sufficient study numbers unless you ask that I not contact you again regarding this study.

As you have participated in recruitment, I ask that you not participate in the study yourself even if you receive a subsequent invitation from another of the recruiters.

Thank you for considering this request and for any assistance you can provide.

Regards,

Liz Loewen, MN, PhD(c)

Researcher:
LIZ LOEWEN, PhD STUDENT,
School of Health Information Sciences, Faculty of Human and Social Development, University of Victoria
PHONE: 204-926-9171, EMAIL: lloewen@uvic.ca

Dissertation Supervisor:
Dr. ABDUL ROUDSARI, PROFESSOR,
School of Health Information Sciences, Faculty of Human and Social Development, University of Victoria
PHONE: 250-721-8578, EMAIL: Abdul@uvic.ca

Attachments: Participant Study Information and Invitation (Appendix D)

Appendix D – Potential Participant Information and Study Invitation

University of Victoria

Participant Information and Study Invitation

This information is being sent to you by a colleague who has identified you as a leader within a health service delivery organization in Canada and who may be willing to contribute your expertise to a study looking at how business intelligence (the use of the use of specialized tools to collect, analyze, and present organizational data to operational managers and leaders in user friendly format(s) to support decision making in alignment with organizational objectives) is being used or can be used in the health sector.

You are being contacted to see if you would be willing to participate in this study which involves completing four to five surveys over a four to seven-month period. These are expected to take no more than four hours in total during this time. Please review the detailed project information below and, if you are interested in participating, contact [Name], Research Assistant at [email] and she will email you a link to the study consent form.

Please respond within the next seven days. Your assistance is very much appreciated.

Project information

Project Title: **Establishing a Business Intelligence Measurement Framework for Healthcare**

Researcher: **LIZ LOEWEN**, PhD STUDENT, School of Health Information Sciences, Faculty of Human and Social Development, University of Victoria
PHONE: 204-926-9171, EMAIL: lloewen@uvic.ca

Supervisor: Dr. ABDUL ROUDSARI, PROFESSOR, School of Health Information Sciences, Faculty of Human and Social Development, University of Victoria
PHONE: 250-721-8578, EMAIL: Abdul@uvic.ca

Research Assistant: **[NAME]**, [Affiliation]
EMAIL: [email]

Purpose and Objective of the Research:
The objective of this research is to establish health sector specific measures for foundational constructs of Business Intelligence (BI) success. BI is the use of specialized tools to collect, analyze, and present organizational data to operational managers and leaders in user friendly format(s) to support decision making in alignment with organizational objectives. As BI success results from organizational factors in addition to underlying information systems, the concepts being studied are *BI Assimilation* (the use of BI to manage business strategies and operational processes) and *Organizational Performance* (the use of BI to achieve organizational strategies).

This research is important because:
Information systems are now increasingly used to support operational processes in most healthcare settings across Canada. These systems, such as electronic medical records, have been shown to improve direct care delivery through clearer and legible documentation, the ability to share information

automatically between care settings, and tools to alert users to possible concerns such as drug interactions. The use of information systems has also resulted in increased access to data that can be used to improve decision making at the health system level. Access to real-time information can enable front line managers and health system leaders make informed decisions to drive improvements in resource allocation, quality management, and client/patient access. This concept, also referred to as Business Intelligence (BI), is a routine management practice in sectors such as finance and manufacturing and an expected outcome of information system implementations.

The benefits of BI have not been fully realized in the health sector where limited access to BI systems and factors such as data quality, complexity, and access to data have been identified as barriers. This research will build on theoretical frameworks used in other sectors to establish health specific measures for constructs to measure use of BI. This will allow for further study to understand how increased access to and use of this valuable information asset can be achieved in healthcare settings.

Participation:

You are being invited to participate because you have been identified by the colleague who sent you this invitation as a manager or senior leader within a health service delivery organization. Participation in this project is entirely voluntary. Whether you choose to participate or not will have no effect on your position or how you will be treated. Neither the researcher nor the individual who forwarded this invitation to you will know whether or not you have participated.

This study is recruiting health system leaders from organizations across Canada using a blinded snowball technique where the researcher will not know which organizations the participants belong to. Therefore, it is not logistically feasible to apply for ethics clearance at all potential settings/institutions. If you have concerns about this as a potential participant you should carefully consider your participation. If your institution's ethics board has concerns about your participation, they should contact the researcher (myself) or the University of Victoria Research Ethics Board at (250) 472-4545 ethics@uvic.ca.

Duration:

You will be contacted approximately once a month during the research study over a four to seven-month period. The first survey will take approximately 60 minutes to complete. The demographic survey and subsequent surveys should take less than 30 minutes each for a total of no more than 4 hours over the duration of the research study.

Procedures:

Your participation is most appreciated! If you are interested in participating, please contact the research assistant by email ([Name] at [email]) who will respond to you with a unique project identifier and a link to complete a consent form online and a demographic questionnaire. The researcher (Liz Loewen) will not know your identity, only your identifier number. You will receive links from the research assistant for three to four research surveys asking your opinion on the study measures over approximately four to seven months. All surveys will be completed online using a secure web-based survey (FluidSurvey) with all servers hosted in Canada. You will only use your ID# when completing the survey.

The demographic survey will collect information about you and your role as a manager or senior leader within a health delivery organization in order to confirm your eligibility for the study and describe the respondents as a group. In the study, results will also be compared between types of participants (senior leadership team compared to operational managers; and, nursing leaders compared to non-nursing leaders).

This study is using a Delphi process to achieve consensus between the study participants. This is an anonymous process where group opinions are collected and presented back to the group members over a sequence of feedback surveys to achieve consensus. The first survey will collect your opinions and recommendations about measures to describe how you would or do use BI to manage operational processes and where BI is being/can be used to achieve organizational strategies. In the second survey,

you will receive a summary of all responses and be asked to rate them based on which you feel are most representative of these concepts. You can also suggest changes to the concepts. There will be 2-3 additional surveys to rate the concepts. The number of follow up surveys will depend on how quickly the group comes to a consensus.

Location:
You will be contacted by email with a survey link and can complete all forms from any location where you have online access. You will be given a 2-week period for completion of each survey. They can be completed on line at any time that is convenient to you during that period.

Inconvenience:
The primary inconvenience to you will be the time involved and intellectual energy to consider the items.

Compensation:
You will not be compensated for participating in this study. At your request, a summary of the study results will be sent to you once the study is complete whether or not you decide to participate. You can request this by contacting the Research Assistant.

Benefits:
This study, once executed will contribute to a previously unstudied area of health systems research. Information gathered through this study may be used to inform organizational priorities about business intelligence implementations and improve the return value to healthcare organizations. Business intelligence, once optimized in the health sector, has significant potential to result in improvements in both health service delivery and health system sustainability.

Risks:
There are no known or anticipated risks to you by participating in this research.

Researcher's Relationship with Participants:
The researcher may be known to you as a colleague. To help prevent this relationship from influencing your decision to participate, the following steps have been taken:

- You are being invited into the study by a third party who is not part of the study and who does not need to know whether you choose to participate or not.
- You will only be identified by name and contact information to the project research assistant who will maintain this information in a separate file for the purposes of assigning a participant number and communicating with you during the study.
- You will only be identified to the researcher by your participant number and the researcher will be blinded throughout the study (and after the study) as to who has participated in or withdrawn from the study.

Withdrawal of Participation:
You may withdraw at any time without explanation or consequence. You can do this by contacting the research assistant directly using the contact provided. Should you withdraw, your data will be maintained up to the point of your withdrawal (as it will have been included in the summary statistics presented to participants at each step of the process) and, after this, you will no longer be contacted to participate in subsequent surveys

Continued or On-going Consent:
As there will be four to five contacts during the study period, it is assumed you have consented to the full study unless you ask to withdraw at any point. Participants who miss one of the response cycles due to

workload or vacation will not be considered a withdrawal and will be still be included in the study and could participate again in the next cycle

Research Results May be Used/Disseminated in the Following Ways:
Results will be published in a dissertation and may also be disseminated through presentations, scholarly meetings and published articles.

Disposal of Data
Data from this study will be downloaded from the secure website once the final analysis is complete and maintained on a password protected file. It will be destroyed securely after a period of three years by being overwritten and then destroyed using secure processes.

Questions or Concerns:
If you have questions or concerns you may contact the researcher or supervisor using the information at the top of page 1 at any time. You may also contact the Human Research Ethics Office, University of Victoria, (250) 472-4545 ethics@uvic.ca.

Thank you for considering participation in this study.

Appendix E – Online Study Consent Form

<<FORMATTED FOR ONLINE SURVEY>>

University of Victoria

Participant Consent Form

Project Title: **Establishing a Business Intelligence Measurement Framework for Healthcare**

Researcher:

LIZ LOEWEN, PhD STUDENT,
School of Health Information Sciences, Faculty of Human and Social Development, University of Victoria
PHONE: 204-926-9171, EMAIL: lloewen@uvic.ca

Supervisor:

Dr. ABDUL ROUDSARI, PROFESSOR,
School of Health Information Sciences, Faculty of Human and Social Development, University of Victoria
PHONE: 250-721-8578, EMAIL: Abdul@uvic.ca

Research Assistant:

NAME, Affiliation
EMAIL:

Participation:

You have been invited to participate by a colleague who identified you as a manager or senior leader within a health service delivery organization. Participation in this project is entirely voluntary. Whether you choose to participate or not will have no effect on your position or how you will be treated. Neither the researcher nor the individual who forwarded this invitation to you will know whether or not you have participated.

Purpose and Objective of the Research:

The objective of this research is to establish health sector specific measures for foundational constructs of Business Intelligence (BI) success. BI is the use of specialized tools to collect, analyze, and present organizational data to operational managers and leaders in user friendly format(s) to support decision making in alignment with organizational objectives. As BI success results from organizational factors in addition to underlying information systems, the concepts being studied are *BI Assimilation* (the use of BI to manage business strategies and operational processes) and *Organizational Performance* (the use of BI to achieve organizational strategies).

This research is important because:

Information systems are now increasingly used to support operational processes in most healthcare settings across Canada. These systems, such as electronic medical records, have been shown to improve direct care delivery through clearer and legible documentation, the ability to share information automatically between care settings, and tools to alert users to possible concerns such as drug interactions. The use of information systems has also resulted in increased access to data that can be used to improve

decision making at the health system level. Access to real-time information can enable front line managers and health system leaders make informed decisions to drive improvements in resource allocation, quality management, and client/patient access. This concept, also referred to as Business Intelligence (BI), is a routine management practice in sectors such as finance and manufacturing and an expected outcome of information system implementations.

The benefits of BI have not been fully realized in the health sector where limited access to BI systems and factors such as data quality, complexity, and access to data have been identified as barriers. This research will build on theoretical frameworks used in other sectors to establish health specific measures for constructs to measure use of BI. This will allow for further study to understand how increased access to and use of this valuable information asset can be achieved in healthcare settings.

Procedures:
Once you have indicated your consent to participate through this online form, you will be linked to a demographic questionnaire. The demographic survey will collect information about you and your role as a manager or senior leader within a health delivery organization in order to confirm your eligibility for the study and describe the respondents as a group. The researcher (Liz Loewen) will not know your identity, only your identifier number. Following this, you will receive links from the research assistant for three to four research surveys asking your opinion on the study measures over approximately four to seven months. All surveys will be completed online using a secure web-based survey (FluidSurvey) with all servers hosted in Canada. You will only use your ID# when completing the survey.

This study is recruiting health system leaders from organizations across Canada using a blinded snowball technique where the researcher will not know which organizations the participants belong to. Therefore, it is not logistically feasible to apply for ethics clearance at all potential settings/institutions. If you have concerns about this as a potential participant you should carefully consider your participation. If your institution's ethics board has concerns about your participation, they should contact the researcher (myself) or the University of Victoria Research Ethics Board at (250) 472-4545 ethics@uvic.ca.

This study is using a Delphi process to achieve consensus between the study participants. This is an anonymous process where group opinions are collected and presented back to the group members over a sequence of feedback surveys to achieve consensus. The first survey will collect your opinions and recommendations about measures to describe how you would or do use BI to manage operational processes and where BI is being/can be used to achieve organizational strategies. In the second survey, you will receive a summary of all responses and be asked to rate them based on which you feel are most representative of these concepts. You can also suggest changes. There will be 2-3 additional surveys to rate the concepts. The number of follow up surveys will depend on how quickly the group comes to a consensus. In the study, results will also be compared between types of participants (senior leadership team compared to operational managers; and, nursing leaders compared to non-nursing leaders).

Duration:
You will be contacted approximately once a month during the research study over a four to seven-month period. It is expected the initial project survey will take approximately 60 minutes to complete. The demographic survey and subsequent surveys should take less than 30 minutes each for a total of no more than 4 hours over the duration of the research study.

Location:
You will be contacted approximately once a month during the research study by email with a survey link and can complete all forms from any location where you have online access. You will be given a 2-week period for completion of each survey. They can be completed on line at any time that is convenient to you during that period.

Inconvenience:
The primary inconvenience to you will be the time involved and intellectual energy to consider the items.

Compensation:
You will not be compensated for participating in this study. At your request, a summary of the study results will be sent to you once the study is complete whether or not you decide to participate in the study to completion. You can request this by contacting the Research Assistant.

Benefits:
This study, once executed will contribute to a previously unstudied area of health systems research. Information gathered through this study may be used to inform organizational priorities about business intelligence implementations and improve the return value to healthcare organizations. Business intelligence, once optimized in the health sector, has significant potential to result in improvements in both health service delivery and health system sustainability.

Risks:
There are no known or anticipated risks to you by participating in this research.

Researcher's Relationship with Participants:
The researcher may be known to you as a colleague. To help prevent this relationship from influencing your decision to participate, the following steps to prevent coercion have been taken:

- You are being invited into the study by a third party who is not part of the study and who does not need to know whether you choose to participate or not.
- You will only be identified by name and contact information to the project research assistant who will maintain this information in a separate file for the purposes of assigning a participant number and communicating with you during the study.
- You will only be identified to the researcher by your participant number and the researcher will be blinded throughout the study (and after the study) as to who has participated in or withdrawn from the study.

Withdrawal of Participation:
You may withdraw at any time without explanation or consequence. You can do this by contacting the research assistant directly using the contact provided. Should you withdraw, your data will be maintained up to the point of your withdrawal (as it will have been included in the summary statistics presented to participants at each step of the process) and, after this, you will no longer be contacted to participate in subsequent surveys.

Continued or On-going Consent:
As there will be four to five contacts during the study period, it is assumed you have consented to the full study unless you ask to withdraw at any point. Participants who miss one of the response cycles due to workload or vacation will not be considered a withdrawal and will be still be included in the study and have the opportunity to participate again in the next cycle

Anonymity and Confidentiality:
To help ensure your anonymity and confidentiality, the following steps have been taken:

- You are being invited into the study by a third party who does not need to know whether you choose to participate or not.
- You will only be identified by name and contact information to the project research assistant who will maintain this information in a separate file for the purposes of assigning a participant number and communicating with you during the study.

- You will only be identified to the researcher by your participant number and the researcher will be blinded throughout the study (and after the study) as to who has participated in or withdrawn from the study.
- If needed, in order to clarify your comments, the researcher may contact you through the research assistant to confirm/clarify but you will not be individually identified to the researcher through this process to maintain your confidentiality and avoid unintended bias by the researcher.
- All results will be presented in aggregate groupings throughout the study process and in subsequent publications. Neither you nor your organization will be directly identified as a participant nor linked directly to any of your responses.
- Security settings will be used in the online survey to protect the data from unintended access and data will be downloaded and removed from the survey site following the study.
- The removed survey data will only be linked to the participant number and will be stored securely (using a password protected file) for a period of three years following the study.

Research Results May be Used/Disseminated in the Following Ways:
Results will be published in a dissertation and may also be disseminated through presentations, scholarly meetings and published articles.

Disposal of Data
Data from this study will be downloaded from the secure website once the final analysis is complete and maintained on a password protected file. It will be destroyed securely after a period of three years by being overwritten and then destroyed using secure processes.

Questions or Concerns:
If you have questions or concerns you may contact the researcher or supervisor using the information at the top of page 1 at any time. You may also contact the Human Research Ethics Office, University of Victoria, (250) 472-4545 ethics@uvic.ca.

Consent
By completing and submitting this online consent form and the subsequent questionnaires, **YOUR FREE AND INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers, and that you consent to participate in this research project.

Please enter your unique study identification number _____

Please confirm your consent to participate in this study [selection box] <Yes, I agree to participate in this study>

Once you submit, you will be forwarded to the Participant Profile Survey to confirm your eligibility and collect descriptive information about you. Thank you for participating in this study.

[submit button]

Appendix F – Participant Profile Survey

<<FORMATTED FOR ONLINE SURVEY>>

University of Victoria

Participant Profile Survey

Project Title: Establishing a Business Intelligence Measurement Framework for Healthcare

Thank you for your interest in participating in this study!

The purpose of this questionnaire is to gather information to confirm your eligibility for participation in the study and to describe the study participants as a group.

Please complete the following information. If there are any items that you would prefer not to enter, you may leave these blank.

Please enter your participant ID# (provided to you by the Research Assistant)	<free text, mandatory>
Please enter your professional title (e.g. Chief Nursing Officer, Manager Human Resources). Please remove any specific organizational identifiers	<free text>
What province or territory is your organization (or work place) located in?	<free text>
What type of organization are you employed in? (select one)	☐ Regional Health Authority/Local Health Integration Network ☐ Hospital ☐ Community Health Clinic ☐ Primary Care Clinic/Physician Office ☐ Community Services/Home Care ☐ Other (describe) _____
How would you describe your leadership role? I am a member of (select one):	☐ Top Management Team (Executive Level) ☐ Operational Manager ☐ Other (describe) _____
What is your primary area of responsibility? (select one)	☐ Executive Leadership ☐ Clinical Service Delivery Leadership ☐ Business Operations (describe) _____ ☐ Other (describe) _____
Do you have a professional designation or certification related to your position (e.g. MD, RN, OT, CPA)? If yes, please indicate:	☐ Yes. If yes, specify _____ ☐ No
Are you a nurse or responsible for a nursing related portfolio?	☐ Yes ☐ No

Do you have direct access to Business Intelligence (BI) systems in your current role?* *This study defines BI as, the use of specialized tools to collect, analyze, and present organizational data to operational leaders in user-friendly format(s) to support organizational objectives.	☐ Yes. If yes, indicate the system name if known _____ ☐ No
Please list the electronic information systems in use in your work setting (select all that apply).	☐ Clinical Documentation Systems ☐ Financial Management Systems ☐ Logistics Management Systems ☐ Human Resources Systems ☐ Others (describe) _____
Number of years you have worked in your current role:	<free text>
Please indicate the approximate number of staff who report up to you	☐ Number of direct reports (those who report directly to you) _____ ☐ Number of indirect reports (those who report to someone who reports to you either directly or indirectly) _____
What is the dollar value of the annual budget you are responsible for?	☐ Less than $1 Million ☐ $1,000,000 – $50,000,000 ☐ $50,000,001 – $100,000,000 ☐ $100,000,001 – $500,000,000 ☐ $500,000,001 – $1,000,000,000 ☐ Greater than $1 Billion

Thank you for completing this survey. The Research Assistant will contact you when the next survey (Round 1) is open for responses.

For assistance, please contact [name], Research Assistant at [email].

Appendix G - Round 1 Survey

<<FORMATTED FOR ONLINE SURVEY>>

Please enter your participant ID #: _____

Establishing a Business Intelligence Measurement Framework for Healthcare
The purpose of this questionnaire is to gather your input on relevant measures for two constructs that demonstrate Business Intelligence (BI) success in the Canadian Health Sector. These constructs are BI Assimilation and Organizational Performance.

This study defines BI as, *the use of specialized tools to collect, analyze, and present organizational data to operational leaders in user-friendly format(s) to support organizational objectives*.

In this context,

- *BI Assimilation* is the extent to which BI Systems are being used to support business strategies and business activities within the organization.
- *Organizational Performance* measures are the indicators of the business benefits that are being achieved.

When considering your responses, you may draw from your direct experience with BI systems or your expectations of what BI systems will provide for your organization. Everyone's responses will be summarized, collated and shared back with the group. Your individual responses will not be identified.

Concept 1 - Business Activities or Processes
What business activities or processes do I most expect BI Systems to support in my organization?
Examples of activities or processes include:

- Supplier management (e.g. inbound logistics or purchasing)
- Documentation improvements
- Referral management
- Increased economic awareness for managers
- Internal operations (e.g. scheduling staff)
- Patient throughput/flow

Please identify five to ten business activities or processes BI does or would support in your organization. You may use any of the examples identified or you may generate your own. For each, provide a one-line description and give a brief rationale.

Item 1 (repeats up to 10 times)
Business activities or processes (be as specific as possible):
Description (what this means to you):
Rationale (why this is important:

Concept 2 - Business Strategies
What business strategies do I most expect my organization to achieve through implementation of BI Systems?
Example business strategies include:

- Customer services (e.g. improving customer satisfaction)
- Enhancing supplier relations
- Improved Care Coordination
- Data driven decision making
- Improved timeliness of decision making

- Explainable budget variances
- Creating flexible operational processes
- Reducing costs

Please identify five to ten business strategies you expect BI does or would support in your organization. You may use any of the examples identified or you may generate your own. For each, provide a one-line description and give a brief rationale.

Item 1 (repeats up to 10 times)

Business strategies (be as specific as possible):

Description (what this means to you):

Rationale (why this is important:

Concept 3 - Organizational Performance Objectives

What organizational performance objectives do I expect will be most enabled as a result of implementation of BI Systems?

Examples of organizational performance objectives include:

- Maximize remuneration
- Reduced costs for specific targets (e.g. overtime, imaging, drug, resource utilization, patient cost share)
- Improve specific patient outcomes (e.g. mortality, length of stay, readmission rates, adverse events, rate of high users in emergency)
- Improve specific process outcomes (access to care, wait times, lab throughput)
- Compliance with external reporting obligations (e.g. government, funding bodies, accreditation)
- Reduce waste
- Increase occupancy rates

Please identify five to ten performance objectives you expect BI does or would support in your organization. You may use any of the examples identified or you may generate your own. For each, provide a one-line description and give a brief rationale.

Item 1 (repeats up to 10 times)

Organizational performance objectives (be as specific as possible):

Description (what this means to you):

Rationale (why this is important:

Additional Comments

Please use this space to provide additional feedback on the survey process or describe any assumptions you made in responding to the questions.

Thank you for your contributions to this Survey. Survey #2 will be sent to participants in 3-6 weeks and will be an opportunity to rank a summary of all responses combined.

For assistance, please contact <name>, Research Assistant at <email>.

Appendix H – Round 2 and 3 Survey Format

<<EXAMPLE - FORMATTED FOR ONLINE SURVEY>>

Introduction Round 2
Thank you for your responses to the Round 1 Survey. The purpose of this Round 2 Survey is to share everyone's input and begin to come to consensus on measures for the constructs that demonstrate use of Business Intelligence (BI). These constructs are grouped as business processes/activities, business strategies and organizational performance measures.

Everyone's feedback has been collated and summarized. You will be given a proposed name, definition and rationale for each measure based on the responses collected in Round 1. You have also been provided with the percentage of respondents who identified this concept. Once you have reviewed these, you are asked to rate each measure using the sliding scale below it to indicate your score. You may also use the comments area to make any suggestions for changes to the measure, definition or rationale.

When considering your responses, you may draw from your direct experience with BI systems or your expectations of what BI systems will provide for your organization. Following this round, the overall scores will be calculated and shared back with the group for validation. The comments will also be summarized. Any new measures will be added in also.

Introduction Round 3
Thank you for your responses to the Round 2 Survey. The purpose of this Round 3 Survey is to share everyone's input from the last round and finalize our level of consensus on measures for the constructs that demonstrate use of Business Intelligence (BI). **As a reminder, this study defines BI as*, the use of specialized tools to collect, analyze, and present organizational data to operational leaders in user-friendly format(s) to support organizational objectives*.** These constructs are grouped as business processes/activities, business strategies and organizational performance measures.

In addition to any new feedback (highlighted in red), you have also been provided with the group median and interquartile range for each concept. The median is the middle value for the group rating and the interquartile range is a measure of variation - the closer it is to 1 the higher the level of consensus in the responses in the last round.

When considering your responses, you may draw from your direct experience with BI systems or your expectations of what BI systems will provide for your organization. Your individual responses will not be identified.

All
Please enter your participant number below and enter next to proceed.
Please enter your participant ID #

Business Activities or Processes
The measures on the next two pages relate to business activities or processes identified by respondents as those most expected to be supported with business intelligence/analytics solutions in health organizations. Page 1 of 2.

BA1: Patient/Client Flow Management *<<Example shows one construct only>>*

Summarized description: Use of business intelligence/analytics to monitor and manage patient/client flow and transitions within and between settings/departments.

Measures suggested by respondents: length of stay; emergency department wait time; bed utilization.

Other terms used by respondents: patient throughput; bed management; hospital flow.

Rationale provided by respondents: Analytical tools are needed to respond to data trends and in real time to show bottlenecks, to adjust capacity in target departments, to manage volume surge/overcrowding, to link to workload/staffing needs, and provide timely/appropriate care. Allows organizations to realize better efficiencies, achieve related outcomes and can impact funding formulas/budget.

Percentage of Panelists who identified this measure: 45% <<replaced with median and interquartile range for each measure in Round 3>>

To what extent does this activity or process align to expected outcomes of BI system use in your organization and work setting?

Your response:

Not at all Not an activity or process in our organization		**Somewhat** Insignificant process/activity in our organization		**Neutral** Relevant but not a process or activity of focus		**Relevant** Relevant, significant relationship to organizational activities	**Very Relevant** Most relevant measure, direct relationship to organizational activities	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Please add any comments you may have on this measure name, description or rationale.

Please use the space below to add any additional business activities or processes you feel are missing and should be included.

Business strategies (be as specific as possible):
Description (what this means to you):
Rationale (why this is important:

<<***end of section***>>

<u>Business Strategies</u>

The measures on the next two pages relate to <u>business strategies</u> identified by respondents as those most expected to be supported with business intelligence/analytics solutions in health organizations. Page 1 of 2.

<u>BS1: Improve Care Coordination</u><<*Example shows one construct only*>>

Summarized description: Use of business intelligence/analytics to manage care and improve transparency and communication between settings. Includes monitoring to ensure transition protocols/processes are followed to support continuity of care, ensuring that care is delivered in most appropriate setting for each client/patient. The objectives are well organized workflows, access processes are understood and communicated and wait times are transparent to both the client and other providers.

Measures suggested by respondents: adherence to established processes; appropriate referrals; timely discharge and follow up; bed utilization.

Other terms used by respondents: manage care coordination and flow; transition between care sectors; improved length of stay; improved cooperation; improved access.

Rationale provided by respondents: Improve patient and family experience and satisfaction. Improve staff satisfaction. Eliminate fragmentation for patients as they navigate the system. It is a challenge to ensure timely communication between programs. Reduce waste and improve patient experience. Uncoordinated care can be unsafe, poor quality and inefficient. Supports accountability by providers and transparency for the public.

Percentage of Panelists who identified this measure: 55% <<replaced with median and interquartile range for each measure in Round 3>>

To what extent does this strategy align to expected outcomes of BI system use in your organization and work setting?

Your response:

Not at all Not a strategy in our organization		**Somewhat** Insignificant strategy in our organization		**Neutral** Relevant but not a strategic focus		**Relevant** Relevant, significant relationship to organizational strategies	**Very Relevant** Most relevant measure, direct relationship to organizational strategies	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Please add any comments you may have on this measure name, description or rationale.

Please use the space below to add any additional business activities or processes you feel are missing and should be included.

Business strategies (be as specific as possible):
Description (what this means to you):
Rationale (why this is important:

<<end of section>>

Organizational Performance Measures

The measures on the next two pages relate to organizational performance measures identified by respondents as those most expected to be supported with business intelligence/analytics solutions in health organizations. Page 1 of 2.

OP1: Reduce Waste *<<Example shows one construct only>>*

Summarized description: Use of business intelligence/analytics to monitor targeted reductions in waste throughout key processes and activities such as unnecessary diagnostic testing and supply management.

Measures suggested by respondents: alerts to identify over-ordering of time limited products; budget variances; triggers for low supplies/supplies nearing expiration.
Other terms used by respondents: decrease in wastage and supplies, lean processes (pull versus push).

Rationale provided by respondents: Waste poses a significant cost to the system, pulling information

collectively will improve how work is done. Reduced waste results in increased efficiency of services and more time available for higher value aspects of care. Over ordering of time limited products leads to waste. Reduced unnecessary diagnostic testing can improve quality and safety of care.

Percentage of Panelists who identified this measure: 55% *<<replaced with median and interquartile range for each measure in Round 3>>*

To what extent does this performance outcome measure align to expected outcomes of BI system use in your organization and work setting?

Your response:

Not at all Not a performance objective in our organization		**Somewhat** Insignificant performance objective in our organization		**Neutral** Relevant but not a focus		**Relevant** Relevant, significant relationship to organizational performance	**Very Relevant** Most relevant measure, direct relationship to organizational performance	
1	2	3	4	5	6	7	8	9

Please add any comments you may have on this measure name, description or rationale.

Please use the space below to add any additional organizational performance objectives you feel are missing and should be included.

Organizational performance objectives (be as specific as possible):
Description (what this means to you):
Rationale (why this is important:

<<end of section>>

Thank you for your participation.

Please use this space for any additional comments you may have regarding the process or your responses.

For assistance, please contact <name>, Research Assistant at <email>.

<<end of survey>>

Appendix I – Participation Rate by Data Collection Round

Data Collection Cycle				
Total Participants (responded to at least one round)		**Nursing**	**Non-Nursing**	**Total (n)**
	TMT	5	8	**13**
	OM	6	6	**12**
	Total (n)	**11**	**14**	**25**
Round 1 Participants		**Nursing**	**Non-Nursing**	**Total (n)**
	TMT	4	6	**10**
	OM	6	4	**10**
80.0% participation	**Total (n)**	**10**	**10**	**20**
Round 2 Participants		**Nursing**	**Non-Nursing**	**Total (n)**
	TMT	5	6	**11**
	OM	6	4	**10**
84.0% participation	**Total (n)**	**11**	**10**	**21**
Round 3 Participants		**Nursing**	**Non-Nursing**	**Total (n)**
	TMT	3	7	**10**
	OM	3	3	**6**
64.0% participation	**Total (n)**	**6**	**10**	**16**
Participated in Every Round		**Nursing**	**Non-Nursing**	**Total (n)**
	TMT	3	4	**7**
	OM	3	1	**4**
44.0% participation	**Total (n)**	**6**	**5**	**11**

Appendix J – Participant Work Titles

Title type	Details	All		TMT	OM	NP	Non
		n=25*	%	n=13	n=12	n=11	n=14
Chief xx Officer	Nursing, Executive, Operating, Medical, Information	6	24.0%	6	0	3	3
Vice President/Executive Vice President	Provincial Programs, Integrated Health Services	3	12.0%	3	0	1	2
Director/Executive Director	Clinical Programs, Clinical Informatics, Technology Assisted Programs, Decision Support, Business Intelligence, Information Services, Professional Practice Knowledge, Strategy, Operations, Primary Health Care and Chronic Disease, Information and Communication Technology, Emergency	7	28.0%	6	1	3	4
Manager/Regional Manager	Nursing Initiatives, Operations, Medical Imaging Systems, Planning & Innovation, Team	8	32.0%	0	8	5	3
Other	Privacy and Access Officer, Chair Surgery Executive/Standards; Lead Clinical Innovation	3	12.0%	0	3	0	3

* Panelists with dual titles counted separately

Appendix K – Participant Characteristics by Sub-group

Work Settings - Province:

	All		TMT		OM		NP		NonNP	
Province	**n=25**	**%**	**n=13**	**%**	**n=12**	**%**	**n=11**	**%**	**n=14**	**%**
MB	13	52.0%	6	46.2%	7	58.3%	5	45.5%	8	57.1%
ON	8	32.0%	5	38.5%	3	25.0%	3	27.3%	5	35.7%
SK	1	4.0%	0	0.0%	1	8.3%	0	0.0%	1	7.1%
NS	2	8.0%	1	7.7%	1	8.3%	2	18.2%	0	0.0%
Other (National)	1	4.0%	1	7.7%	0	0.0%	1	9.1%	0	0.0%

Work Settings – Location Type:

	All		TMT		OM		NP		NonNP	
	n=25	**%**	**n=13**	**%**	**n=12**	**%**	**n=11**	**%**	**n=14**	**%**
RHA/LHIN	12	48.0%	5	38.5%	7	58.3%	4	36.4%	8	57.1%
Hospital	9	36.0%	6	46.2%	3	25.0%	5	45.5%	4	28.6%
Primary Care/ Physician Office	1	4.0%	0	0.0%	1	8.3%	1	9.1%	0	0.0%
Community Services/ Home Care	1	4.0%	1	7.7%	0	0.0%	1	9.1%	0	0.0%
Other	2	8.0%	1	7.7%	1	8.3%	0	0.0%	2	14.3%

Work Settings – Primary Area of Responsibility:

	All		TMT		OM		NP		NonNP	
	n=25	**%**	**n=13**	**%**	**n=12**	**%**	**n=11**	**%**	**n=14**	**%**
Executive Leadership	7	28.0%	7	53.8%	0	0.0%	3	27.3%	4	28.6%
Clinical Service Delivery	7	28.0%	2	15.4%	5	41.7%	5	45.5%	2	14.3%
Business Operations	7	28.0%	3	23.1%	4	33.3%	2	18.2%	5	35.7%
Other	4	16.0%	1	7.7%	3	25.0%	1	9.1%	3	21.4%

Professional Profile – Work Titles:

See Appendix J

Professional Profile - Professional Designation:

	All		TMT		OM		NP		NonNP	
Designation Type*	**n=25**	**%**	**n=13**	**%**	**n=12**	**%**	**n=11**	**%**	**n=14**	**%**
Nursing Related	10	40.0%	4	30.8%	6	50.0%	8	72.7%	2	14.3%
Rehabilitation Related	2	8.0%	2	15.4%	0	0.0%	0	0.0%	2	14.3%
Medical Related	2	8.0%	1	7.7%	1	8.3%	1	9.1%	1	7.1%
Health Information Management Related	3	12.0%	1	7.7%	2	16.7%	0	0.0%	3	21.4%
Health Administration Related	4	16.0%	4	30.8%	0	0.0%	1	9.1%	3	21.4%
Other (Academic) Related	2	8.0%	2	15.4%	0	0.0%	0	0.0%	2	14.3%

* Respondents could identify more than one

Professional Profile - Years of Experience:

	All		TMT		OM		NP		NonNP	
Years	**n=25**	**%**	**n=13**	**%**	**n=12**	**%**	**n=11**	**%**	**n=14**	**%**
<1-5	12	48.0%	5	38.5%	7	58.3%	7	63.6%	5	35.7%
6-10 years	4	16.0%	2	15.4%	2	16.7%	0	0.0%	4	28.6%
11-15 years	6	24.0%	4	30.8%	2	16.7%	3	27.3%	3	21.4%
16-20 years	1	4.0%	1	7.7%	0	0.0%	0	0.0%	1	7.1%
>20	1	4.0%	0	0.0%	1	8.3%	0	0.0%	1	7.1%
Missing	1	4.0%	1	7.7%	0	0.0%	1	9.1%	0	0.0%

Span of Responsibility – Budget Size:

	All		TMT		OM		NP		NonNP	
	n=25	**%**	**n=13**	**%**	**n=12**	**%**	**n=11**	**%**	**n=14**	**%**
<$1M	7	28.0%	0	0.0%	7	58.3%	3	27.3%	4	28.6%
$1M-$50M	11	44.0%	7	53.8%	4	33.3%	5	45.5%	6	42.9%
$51M-$100M	1	4.0%	1	7.7%	0	0.0%	1	9.1%	0	0.0%
$101M - $500M	3	12.0%	3	23.1%	0	0.0%	1	9.1%	2	14.3%
$500M - $1B	1	4.0%	1	7.7%	0	0.0%	1	9.1%	0	0.0%
Missing	2	8.0%	1	7.7%	1	8.3%	0	0.0%	2	14.3%

Span of Responsibility – Number of Direct Reports:

	All		TMT		OM		NP		NonNP	
# staff	**n=25**	**%**	**n=13**	**%**	**n=12**	**%**	**n=11**	**%**	**n=14**	**%**
<5 staff	8	32.0%	4	30.8%	4	33.3%	2	18.2%	6	42.9%
6-10	7	28.0%	5	38.5%	2	16.7%	3	27.3%	4	28.6%
11-15	3	12.0%	2	15.4%	1	8.3%	1	9.1%	2	14.3%
16-20	1	4.0%	0	0.0%	1	8.3%	1	9.1%	0	0.0%
21-15	1	4.0%	1	7.7%	0	0.0%	1	9.1%	0	0.0%
>25	2	8.0%	0	0.0%	2	16.7%	2	18.2%	0	0.0%
Missing	3	12.0%	1	7.7%	2	16.7%	1	9.1%	2	14.3%

Span of Responsibility – Number of Indirect Reports:

	All		TMT		OM		NP		NonNP	
# staff	**n=25**	**%**	**n=13**	**%**	**n=12**	**%**	**n=11**	**%**	**n=14**	**%**
<50	7	28.0%	3	23.1%	4	33.3%	3	27.3%	4	28.6%
51-100	1	4.0%	0	0.0%	1	8.3%	0	0.0%	1	7.1%
101-500	6	24.0%	5	38.5%	1	8.3%	3	27.3%	3	21.4%
501-1,000	1	4.0%	1	7.7%	0	0.0%	0	0.0%	1	7.1%
>1,000	3	12.0%	3	23.1%	0	0.0%	2	18.2%	1	7.1%
Missing	7	28.0%	1	7.7%	6	50.0%	3	27.3%	4	28.6%

IT System Access – Direct Access to BI:

	All		TMT		OM		NP		NonNP	
	n=25	**%**	**n=13**	**%**	**n=12**	**%**	**n=11**	**%**	**n=14**	**%**
Yes	18	72.0%	9	69.2%	9	75.0%	8	72.7%	10	71.4%
No	7	28.0%	4	30.8%	3	25.0%	3	27.3%	4	28.6%
Missing	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%

Appendix L – Detailed Concept Descriptions

Business Processes/Activities

BA1: Patient/Client Flow Management

Summarized Description: Use of business intelligence/analytics to monitor and manage patient/client flow and transitions within and between settings/departments.

Measures suggested by respondents: length of stay (LOS); emergency department wait time; bed utilization; ALOS for admitted patients; estimated LOS on admission; LOS by inpatient unit, LOS in community service.

Other terms used by respondents: patient throughput; bed management; hospital flow.

Rationale provided by respondents: Analytical tools are needed to respond to data trends and to show bottlenecks, to adjust capacity in target departments, to manage volume surge/overcrowding, to link to workload/staffing needs, and provide timely/appropriate care. Allows organizations to realize better efficiencies, achieve related outcomes and can impact funding formulas/budget. This is a major focus for some settings. Prior data needed to identify seasonal, weekly, daily trends in utilization and plan for predictable events such as flu outbreaks. Concerns noted measures identified are acute care focused, similar flow management needed for other sectors such as home care where length of stay, patient throughput also relevant – as written not relevant for these sectors. Not all respondents were convinced real-time access to this data was reasonable to achieve.

BA2: Referral Management

Summarized Description: Use of business intelligence/analytics to manage status, volumes, or appropriateness of referrals to specialist and/or other providers between and within organizations in a consistent way.

Measures suggested by respondents: wait list volume; geographic referral patterns; time from referral to visit; referral acceptance rates; missed visits; and referral response rates.

Other terms used by respondents: managing the queue; central intake; patient appointment booking; service.

Rationale provided by respondents: Data to put improvements in place to better manage referral wait times, understand how services are organized, improve quality, increase patient safety. Able to identify areas for partnerships and capacity building. Lack of consistent referral processes create risk and inefficiency. Most important factor related to patient wait times. Current processes in most institutions are inefficient and can result in morbidity due to poor triage, lost referrals, lack of tracking etc. Referral concept needs to be defined (specificity and location) to be measured. Not in place in many settings.

BA3: Financial Management

Summarized Description: Use of business intelligence/analytics to manage key financial data to increase awareness of economic drivers, associate costs to activities, and support managers to manage to budget.

Measures suggested by respondents: financial statements or cost analysis by… *(encounter, procedure, treatment, patient, service, case, physician);* impacted by many factors such as, staffing levels, volumes, seasonal census variations; financial benchmarks/indicators (provincial, national); case costing linked to clinical data sets; linked to activity and performance deliverables; analytics for bundle funding by population (such as COPD client management across hospital, community, primary care, homecare)

Other terms used by respondents: cost management; financial statements; increased economic awareness for managers; increased financial awareness.

Rationale provided by respondents: Needed for accountability, ability to show value for money, financial stewardship and benchmarking. Budgets are very tight and require monitoring to ensure fiscal health and sustainability. Needed to link expenditures to outcomes and to evaluate practice changes (such as inter-professional practice). Leadership need to understand budget lines and variances, awareness of cost drivers, plan and forecast staffing and supplies requirements. Should be accompanied by training for managers to understand how these should be used. Consider also value judgements in weighing cost and benefit (expensive interventions in terminally ill example). Case costing was questioned as a priority by some respondents as it does not align to current funding models.

BA4: Resource Utilization Management (Diagnostic and Pharmaceutical)

Summarized Description: Use of business intelligence/analytics to manage diagnostic (lab, imaging) and pharmaceutical resource utilization and status to manage demand, ensure appropriate use and improve client/patient safety through reconciliation processes.

Measures suggested by respondents: monitor utilization; determine which tests add value; efficiency and effectiveness reviews (choosing wisely) for lab, pharmacy, DI.

Business Processes/Activities

Other terms used by respondents: choosing wisely; requisition management; results management; understand and improve utilization of DI, pharmacy, and lab.

Rationale provided by respondents: Allows for monitoring to ensure use is consistent with evidence based pathways (choosing wisely) to improve efficiency, clinical value and manage expenditures. Overuse of diagnostics results in unnecessary expenditures. Tracking requisitions through to results received to support patient safety and continuity of care. Very relevant, not in place in all settings but this is essential. Measures need to be linked to appropriateness and outcomes. Need data to support local evidence for appropriateness and effectiveness.

BA5: Human Resource Management

Summarized Description: Use of business intelligence/analytics to manage key human resources indicators. Includes staff scheduling/proactive resource planning to avoid over/understaffing; human resource processes (recruitment, onboarding, tracking training compliance); and other functions such as managing entitlements/collective agreement compliance.

Measures suggested by respondents: workforce planning; scheduling within collective agreement terms; employee data (payroll, vacation used, banked time, sick time, maintenance of mandatory/legislated competency/training); ability to see gaps (overstaffing) in real-time; staffing allocation aligned to patient volumes (day, week, month, year); predict staffing needs based on prospective data (planned retirements, parental leaves); occupational health and safety measures; labour productivity; talent management; compensation studies.

Other terms used by respondents: staff scheduling; internal operations; human resource information; manager knowledge; human resource management system; individual performance metrics; demand/capacity planning; staff recruitment system; ongoing education opportunities.

Rationale provided by respondents: Human resources are the largest cost driver in healthcare. Current staffing models reflect what occurs the majority of the time and do not account for variations in demand such as seasonality resulting in under and overstaffing. Savings from being overstaffed are not captured and significant costs are incurred through overtime when demand exceeds capacity. Need to ensure staffing meets patient demand and to determine best staff allocation/reallocation and staffing is flexible to maximize productivity. Cost efficient staff management must reflect contract terms also. Needed to ensure staff receive time away per time earned and positions are correct. Data would support improvements in recruitment strategies and processes. Ability to measure individual performance, efficiency and outputs and ensure staff meet minimum training requirements. Predictive staffing would avoid responding only after a lack of staffing is identified leaving units short staffed. Needs to be aligned with service models and outcomes/care intensity measures. BI may have limited added value in complex environments with multiple bargaining units and collective agreements unless these are addressed first.

BA6: Clinical Outcomes Management

Summarized Description: Use of business intelligence/analytics to better understand specific client groups being served and manage outcomes in areas such as chronic disease management. Needed to support system planning/redesign and predict future system utilization (at the individual or system level).

Measures suggested by respondents: average length of stay; emergency department wait times; inpatient/outpatient activities; client/program/branch specific outcomes; linking primary care data to homecare to identify early warnings of instability (to allow for early intervention to prevent emergency visits); volumes by service area/unit; most responsible diagnosis/related interventions; case costing.

Other terms used by respondents: increased clinical awareness; key clinical strategic initiatives; EMR data; chronic disease registry; patient utilization data and predictive analytics; clinical operational activities.

Rationale provided by respondents: Understanding the complexity of patients and the care they are receiving and impact on outcomes is an organizational priority. These impact efficiency and cost savings. Ensure the work we do meets the needs of the population. To drive clinical program quality improvement (outcomes are critical for changing practice – shifting from doing things the way we have always done them). Need to consider value judgements in weighing cost and benefit (expensive interventions in terminally ill example). Very relevant for patient outcomes and hospital care, need to also consider community care and primary care data. The underlying systems aren't in place in all settings but very relevant.

BA7: Performance Measurement and Quality Improvement Management

Summarized Description: Use of business intelligence/analytics to identify, monitor, and evaluate the impact of specific quality improvement initiatives and to manage key high-level performance indicators/variances. The ability

Business Processes/Activities

to manage and widely share results through use of visual formats and dashboards. Ability to link key data from multiple data sets and sources for use by executives to monitor performance to the strategic and operating plan.
Measures suggested by respondents: design care pathway for high volume/high variability patients; readmission rates; average length of stay; Ministry key performance indicators; infection control measures; medication usage and error; timelines to meet medical and surgical targets; adverse events; track variation at corporate, program, unit levels; key performance indicators.
Other terms used by respondents: target/evaluate impact of quality improvement initiatives (standardized care pathways); quality improvement plan/quality based funding; Lean Six Sigma projects; safety and quality monitoring; see data in new ways; monitor data in real-time; dashboards; corporate performance dashboard; business analysis; self-service; support development of impactful reports; linking various seemingly independent systems.
Rationale provided by respondents: Data is key to understanding problems and evaluating the impacts of quality improvements. Needed for data driven decision making and to ensure time spent on quality improvement is wisely invested. Needed for risk assessment (severity and probability). Data informs selection/effectiveness/sustainability of quality initiatives. Accountability and quality adherence reporting requirements for quality enhancement projects. Do no harm principle, patient care and safety are number one. Identifying variation triggers additional investigation and action. Supports performance measurement for internal and external uses. Ability to visualize and analyze data more quickly and efficiently with current information. Will be better able to answer questions in daily work. Enables accurate planning and assumptions. Supports credibility with partners. Using too much data or data from only one data source may not reflect issues accurately. Needed to meet demand for performance and outcomes from ministry funders. Our folks are not business analysis experts, a system that includes decision support would allow them to be more effective and potentially save costs (e.g. duplication or unnecessary ordering). Needed to inform standards committees to improve their work and to avoid responding based on anecdotal data. Measures identified are acute care focused but needed also in primary care, physician offices. This is increasingly important as the system moves towards value for money performance measures.

BA8: Supply Chain and Materials Management

Summarized Description: Use of business intelligence/analytics to manage supplies and materials such as biomedical equipment (utilization and expiration). Managing throughout supply chain including supplier/vendor contracts from purchase to centralized distribution to local unit storage to use/destruction.
Measures suggested by respondents: tracking expiration dates on supplies; prompts for equipment availability and maintenance dates; indicators of contract compliance (alerts when not followed); alerts for contract expiry/duplicate contracts; time from order to delivery.
Other terms used by respondents: logistics – purchasing and obtaining items; enhancing supplier relations; supplier management; point of care materials management systems; manage inflow and outflow of supplies; monitor and track biomedical equipment; contract management.
Rationale provided by respondents: Need to utilize resources efficiently to meet fiscal responsibilities and accountabilities. Lack of vendor/contract management increases cost to the system – want to get best price for products. Need to ensure suppliers do not promote non-contract items as this can be very costly to the system. There is a lack of information once materials leave a centralized distribution centre and are on the unit. Do not know if material is being properly rotated. Often materials (formula, procedural supplies) expire. Managers have little information on what is being ordered or how frequently. Equipment often misses routine maintenance, would reduce risk of malfunctioning equipment. Proactive information would help managers plan for large capital purchases. Devices could be enabled with bar coding or RFID tagging for ease of tracking. Generally well established in existing supply chain systems to support daily monitoring, may not benefit from reproduction in business intelligence systems. Measures in current systems may be limited to individual sites versus provincial focus. Measures identified are acute care focused but needed also in primary care, physician offices.

BA9: Documentation Standards Management

Summarized Description: Use of business intelligence/analytics systems to review documentation (clinical and other business document) quality, consistency, and completeness across multiple departments or units.
Measures suggested by respondents: Ensuring documentation design supports metrics to allow for outcomes measurement (related to practice expectations).
Other terms used by respondents: electronic document systems; documentation standards; SharePoint site; documentation integrity; documentation practices; patient charting.

Business Processes/Activities

Rationale provided by respondents: Standardization of processes and documentation needed for analytics. Avoid duplication of effort and support quality improvement activities. Reduce risk due to inconsistent documentation standards or incomplete records. A centralized location to house documents and resources is important for document management. Documentation standards need to be monitored regularly to be sustained. This is dependent on electronic systems being in place. Need to also consider client/patient expectations and goals for documentation. Documentation standards need to be informed by patient care.

BA10: Incident and Risk Management

Summarized Description: Use of business intelligence/analytics to monitor and manage critical incidents and other risk related organizational indicators such as privacy.

Measures suggested by respondents: near misses and incidents; frequency and types of privacy breaches.

Other terms used by respondents: Sentinel events; Incident reporting; privacy and risk management.

Rationale provided by respondents: Important to document and monitor near misses and incidents to improve quality of services, address patient safety, adhere to "do no harm" strategy. Understanding the frequency and types of privacy breaches helps to ensure policies and processes are in place to enable the organization to meet public expectations as well as relevant legislative requirements. This is key for risk management and mitigation but easier said than done. Basic reporting in place from safety and risk management systems but not integrated with business intelligence solutions in all settings. Caution that increased reporting on risk should be balanced against concerns that privacy and risk management are becoming prioritized over patient needs. Data alone won't manage risk – must drive systemic and systematic reviews based on what information is really needed.

BA11: Office/Clinic Management

Summarized Description: Use of business intelligence/analytics to report on clinic office management including scheduling, and access to care initiatives (such as advanced access, online scheduling).

Measures suggested by respondents: advanced access measures (time to appointment), appropriate office management.

Other terms used by respondents: appointment scheduling/office management.

Rationale provided by respondents: Ensure appropriate office management to support advanced access. Need for timely service accessibility, right care in the right place. Very important as primary care is seen across Canada as the foundation of the health system. Without this focus, we cannot impact other areas such as non-urgent visits to emergency, patient flow etc.

Business Strategies

BS1: Improve Care Coordination

Summarized Description: Use of business intelligence/analytics to manage care and improve transparency and communication between settings. Includes monitoring to ensure transition protocols/processes are followed to support continuity of care, ensuring that care is delivered in most appropriate setting for each client/patient. The objectives are well organized workflows, access processes are understood and communicated and wait times are transparent to both the client and other providers.

Measures suggested by respondents: adherence to established processes; appropriate referrals; timely discharge and follow up; bed utilization; recidivism rates; measures of effectiveness of transition communication between acute and community services.

Other terms used by respondents: manage care coordination and flow; transition between care sectors; improved length of stay; improved cooperation; improved access.

Rationale provided by respondents: Improve patient and family experience and satisfaction. Improve staff satisfaction. Eliminate fragmentation for patients as they navigate the system. It is a challenge to ensure timely communication between programs. Reduce waste and improve patient experience. Uncoordinated care can be unsafe, poor quality and inefficient. Supports accountability by providers and transparency for the public. Siloed nature of current healthcare infrastructure (services, systems and communication tools) is a barrier to efficient patient flow. Priority should be on critical points of patient hand off.

BS2: Data Driven Decision Making

Summarized Description: Use of business intelligence/analytics to establish and reinforce an organizational culture of informed, timely and transparent decision making based on fact and evidence.

Measures suggested by respondents: staffing; facility stability; budget variances; usage data; track care processes.

Business Strategies

Other terms used by respondents: data driven decision making; improved timeliness of decision making.
Rationale provided by respondents: Having quantifiable evidence to make decisions will improve patient and operational outcomes. Empowering direct care staff with data to make real-time decisions. Anecdotal information is insufficient – need data to make decisions and to evaluate outcome of changes. Remove emotion, bias and anecdote from decision making. Decision making is easier when everyone is working off the same information. Without timely decision making, there are additional costs to the system. Manual data collection takes time and delays process improvements. Provides agility to address issues. Needed to prepare business cases and drive improvements. Decisions currently often not data-driven as data is not available when needed. Political and community pressures highly influence the ability to fully accomplish this measure. Data often only available locally, need provincial level information to frame decisions

BS3: Increased Budget Awareness (Explainable Variances)

Summarized Description: Use of business intelligence/analytics to ensure organizational awareness of budget variations and to ensure cost centre managers understand and can explain budget variances in order to better manage them.
Measures suggested by respondents: cost analysis linked directly to patient care; variance reports; productivity and efficiency measures for each care approach.
Other terms used by respondents: accurate cost analysis; explainable budget variances; accurate cost analysis; improve financial health; fiscal stability.
Rationale provided by respondents: Healthcare budgets are complex and tools are needed to make budget information easier to understand. Budgets are tight and this will assist with managing them and reducing costs. Important to be accountable and fiscally responsible. Budgets lines may be unknown when budget set, ability to identify variances early allows for corrective actions and budget adjustments. Need to know where dollars go and for what to ensure financial health and coordination across the organization. Very important in current environment of fiscal restraint/value for money. Value in identifying when budgets get off track however should also be wider consultation with providers to determine appropriate budgets and set priorities for budget allocations.

BS4: Strategic Planning and Prioritization

Summarized Description: Use of business intelligence/analytics to support strategic planning and prioritization to identify opportunities and manage status/risks in strategic initiatives.
Measures suggested by respondents: status and risk tracking for key corporate priorities; market share analysis.
Other terms used by respondents: corporate prioritization; strategy and planning that supports partnerships.
Rationale provided by respondents: Provide evidence/data analysis to support strategic planning (market share analysis, partnership/collaboration opportunities). BI/analytics tools can ensure everyone in the hospital understand how they contribute to corporate priorities; ensure alignment across the organization. Important at an executive level but limited effect on patient care if not pushed down appropriately to end provider in multi-layer organizations such as health. Strategic priorities need to be established before measures determined. The ability to accomplish this may be limited due to community and political pressure. Need provincial level planning and strategic priorities based on data – allow for evidence informed decision making at a provincial level.

BS5: Improve Client/Customer Experience

Summarized Description: Use of business intelligence/analytics to identify and exceed client/patient expectations. Use of key indicators of client feedback to manage performance, identify organizational strengths and weaknesses, monitor efforts to reduce occurrence of known concerns, and see the impact of change initiatives.
Measures suggested by respondents: patient satisfaction; incident reports; patient complaints; patient suggestions; impact of access to other solutions such as eBooking, email access to providers on customer experience.
Other terms used by respondents: customer services; customer feedback and response; enhance customer care; improve patient satisfaction; customer/funder services; client relations program; improved productivity and client satisfaction; marketing via customer insight.
Rationale provided by respondents: Helps organization design and implement high quality customer focused services. Can use feedback to identify programs and services. Reflective of care providers delivering care in a respectful manner. Happy/satisfied clients have better outcomes and are more compliant with recommended treatments. Able to track and improve satisfaction with processes such as flow, quality care, communication. Difficult to manage if tracked with paper. Unable to meet client expectations if we don't know what they are.

Business Strategies

Support customer retention, build credibility. Needed to address concerns and reduce risk of recurrence of incidents/negative experiences. Support program that develops client engagement resources and assesses client experience. Help determine how to promote services/solutions; supports development of powerful creative materials. Need to solicit input cautiously to ensure not just hearing from those with "an axe to grind". Needs to be more than simple satisfaction/complaints. Challenging to align to unrealistic expectations. Important to move forward on measuring client/patient input. Needs to be much more than satisfaction, the public need to be actively engaged in meaningful ways.

BS6: Improve Organizational Processes/Performance

Summarized Description: Use of business intelligence/analytics for key organizational indicators to identify, improve, and manage operational processes to increase efficiency and effectiveness of services provided and reduce waste.

Measures suggested by respondents: flexible staffing models; initiating small tests of change/capacity to readily evaluate impact; length of stay; measurable outcomes (clinical/financial).

Other terms used by respondents: creating flexible operational processes; rapid assessment of process improvement; drive performance through data-driven decision making; efficiency and effectiveness of service provision; standardize best practices; enhance productivity; releasing time to care.

Rationale provided by respondents: Allows for rapid incremental improvements when results are positive and discontinuation of negative processes. Assign the right role to the right provider. Reduce time wasted unproductive initiatives. Ability to demonstrate efficiency and effectiveness of services provided to support growth. Proof of results will enhance uptake of process improvement practices. Allows for appropriate use of most expensive resources most productively. Improve client outcomes due to more time available for direct care. Caution that standardizing processes without flexibility/human context has associated risks. Ability to achieve this limited at times by collective agreements (can also inform collective bargaining).

BS7: Innovative/Agile Organization

Summarized Description: Use of business intelligence/analytics to identify areas for innovation and support organizational innovation with dynamic decision making and informed change management strategies.

Measures suggested by respondents: measures will vary, could be related to system re-design changes; bed mix; emergency room roles/functions; hours of operation.

Other terms used by respondents: support a more agile organization; innovation leadership; facilitate organizational change.

Rationale provided by respondents: Keep evolving as a healthcare organization to meet future needs. Flexible and dynamic staff can move more quickly to respond to opportunities. Ensure business intelligence processes are [not] seen as meaningless research. Things are changing quickly, the more we can support our staff through the changes the better. Innovation is the primary methodology by which healthcare will improve – need to support innovators in experimenting (particularly when challenged by entrenched interest groups). Desired but not a focus in all organizations.

BS8: Improve Patient Engagement

Summarized Description: Patient access to self-scheduling and their diagnostic results.

Measures suggested by respondents: Need to link to national patient survey questions; access to primary care.

Other terms used by respondents: none.

Rationale provided by respondents: Meaningful patient involvement. This is important but many patients don't have time or inclination to interact in this regard. Opportunities to engage more should not be a priority given difficulties experienced in getting good care cost effectively. Not prioritized due to limited information and costs to accomplish this. Extremely relevant in primary care particularly related to management of chronic disease, "patients first" strategies. Need meaningful engagement. Patient self-care portals needed to support patient management and provide analytics for this measure

BS9: Improving Accountability and Transparency

Summarized Description: Use of business intelligence/analytics to improve visibility of performance across programs and services. Standardizing our work and expectations and reporting on the same – internally and externally.

Measures suggested by respondents: link to performance deliverables and achievement of expected results.

Other terms used by respondents: increase transparency across large systems.

Rationale provided by respondents: Improved use of public funds, public and patient understanding and

Business Strategies

confidence in our system. Hold leaders accountable but recognize that they cannot be directly accountable for all things in massive organizations such as healthcare. Less relevant in primary care offices where not comparing to others. Data at the site/provider level can help ensure consistent practice and support accountability at the site and individual levels.

BS10: Adoption of Virtual Healthcare Solutions

Summarized Description: Use of business intelligence/analytics to manage adoption and optimization of virtual healthcare solutions. Support the sharing of information that can be shared across the province to grow similar programs in other areas. Enhance time for meetings and provide a means to meet that is almost as good as face to face.

Measures suggested by respondents: decreased travel time, patient satisfaction, clinical outcomes/appropriate use of resources, cost effectiveness.

Other terms used by respondents: electronic means for meetings.

Rationale provided by respondents: Grow and scale virtual care. Gain time efficiencies. Virtual solutions are part of future innovative approaches to care, need to understand practice impacts of not being able to see patients face-to-face. Need to think provincially and remotely.

BS11: Provincial Councils and Regional Committees

Summarized Description: Use of business intelligence/analytics to support meetings of various programs to coordinate care and service planning. Provincial committees that include regional and provincial representation to address specific program planning and collaboration.

Measures suggested by respondents: indicators of system integration; provincial outcomes; equity of service access; consistent adoption of service standards; effectiveness of provincial HR management strategies.

Other terms used by respondents: none.

Rationale provided by respondents: To ensure consistent practice across the health system. To reduce duplication and improve quality of care across the continuum. Virtual meeting platforms make this level of reporting more accessible. Supports coordinated, consistent care across jurisdictions.

Organizational Performance

OP1: Reduce Waste

Summarized Description: Use of business intelligence/analytics to monitor targeted reductions in waste throughout key processes and activities such as unnecessary diagnostic testing and supply management.

Measures suggested by respondents: alerts to identify over-ordering of time limited products; budget variances; triggers for low supplies/supplies nearing expiration.

Other terms used by respondents: decrease in wastage and supplies, lean processes (pull versus push).

Rationale provided by respondents: Waste poses a significant cost to the system, pulling information collectively will improve how work is done. Reduced waste results in increased efficiency of services and more time available for higher value aspects of care. Over ordering of time limited products leads to waste. Reduced unnecessary diagnostic testing can improve quality and safety of care. Getting staff buy in and sustainability in the process is key many staff are not buying in and revert to past practices of waste. Front line staff do not seem to acknowledge or recognize the importance of this.

OP2: Reduce Costs

Summarized Description: Use of business intelligence/analytics to identify and manage targeted operational cost drivers with a goal of reducing overall expenditures.

Measures suggested by respondents: drug/lab/imaging utilization; identify areas of waste; materials cost; overtime; agency staffing use; resource utilization; procedures; patient cost share; opportunity costs (reallocation opportunities); constant care; wasted/missed appointments.

Other terms used by respondents: reducing costs; improve financial health; reduced costs for specific targets; reduced waste and cost savings; technical efficiency.

Rationale provided by respondents: Needed for long term sustainability of the organization. Use for setting targets for managers to follow to help with system costs. Tracking appropriate use of staff/tests/procedures/drugs can reduce costs and improve safety. Revenues not covering expenses. Budgets are very tight. Need to steward funds appropriately. Access to a shared/single source of data to improve cost cutting decisions and avoid ordering decisions based on intuition. Need to have clinicians more engaged in ordering and providing care more wisely.

Organizational Performance

OP3: Maximize Revenues/Remuneration

Summarized Description: Use of business intelligence/analytics to manage revenue generation opportunities to maximize the dollars available through efficiencies, compensation strategies and targeted populations.

Measures suggested by respondents: outcomes tied to investments; maximizing revenue sources (third party billing, federal health (Indigenous, refugee) coverage).

Other terms used by respondents: maximize investments; increase market share.

Rationale provided by respondents: Understand the outcomes of where we invest dollars to inform future decision making. Ensuring the right person is doing the right job with appropriate compensation for role. Needs to be driven by business cases that also measure intangibles such as patient suffering, inconvenience, well-being – cannot be based on cost/revenue opportunity alone.

OP4: Resource Optimization

Summarized Description: Use of business intelligence/analytics to manage strategies to optimize resource allocation (right resources/right place/right care level) and ensure resources working to full scope of practice.

Measures suggested by respondents: resource allocation; measures of workflows, bottlenecks, wait times; productivity measures; staff satisfaction; quality of care measures; CTAS 4/5 visits in emergency.

Other terms used by respondents: allocative efficiency, right care/right place, access to services, improve throughput, reduce waste, effective use of resources, appropriate use of providers, optimize healthcare provider skills.

Rationale provided by respondents: Spending too much on acute care at the expense of other areas – using a more expensive service to address a need but not serving your patients well. Increase access with innovative service delivery models. Ensuring all positions are working to full scope and productivity. Support transparency to the public and patients regarding efficiency problems and appropriate care settings. Innovative service delivery models which break down silos are low hanging fruit in healthcare reform – analytics can make providers aware of what is happening in other spheres and avoid only optimizing from within. Very important measure.

OP5: Improved Wait Times

Summarized Description: Use of business intelligence/analytics to manage targets related to wait times for targeted services, settings and diagnostics.

Measures suggested by respondents: time to be seen after referral; time from emergency to the floor; time to provider initial assessment; time to disposition; length of stay; surgical/emergency/diagnostic wait times; average length of stay; patient experience; bed utilization; wait time on the phone to book appointments; appointment errors/staff time to book.

Other terms used by respondents: improve specific process outcomes/processes that impact patient care; reduce (emergency department) wait times; key clinical strategic initiatives; increased occupancy rates; improve patient access; reducing costs; improved flow; reduce non-value added inpatient length of stay; improve turnaround time on orders.

Rationale provided by respondents: Improvements to wait time processes can lower costs, increase efficiency, improve quality and improve satisfaction for patients and staff. Proactive management reduces the risk of overcrowding, improves overall access to care and patient outcomes and patient experience. Optimizing bed utilization increases occupancy and reduces wait time. Wait times are an important measure of efficiency in underlying processes – inputs can be very complex however so naïve to focus only on wait times (may lose factors such as cost and quality). Relevant also for primary care. Link also with community health measures (access, appropriate diagnostic resource use). Wait times are very complex and BI is currently too limited in predictions but improving.

OP6: Improve Client/Patient Outcomes

Summarized Description: Use of business intelligence/analytics to measure and report on targeted improvements in client/patient outcomes at an individual or aggregate/cohort level. Can be measured from both the client and the system perspectives.

Measures suggested by respondents: length of stay; wait time for inpatient bed; adverse events/incidents; hospital acquired condition rates; readmission rates in populations with preventable readmissions (asthma, surgical); identify cohorts with high resource utilization (frequent hospitalization, emergency visits; multiple services); morbidity and mortality.

Other terms used by respondents: improve specific patient outcomes (flow, length of stay, readmissions, satisfaction, mortality; high users in emergency); patient outcomes enhanced; reduce preventable readmissions;

Organizational Performance

identify high-resource patients.

Rationale provided by respondents: Improving health and well-being of patients is the foundation of healthcare. Organizational priority that patients leave facility as healthy as or healthier than expected when they leave care setting. Use of specific patient outcome indicators, if followed and addressed, can improve outcomes and the system. Supports better understanding of care needs and impacts of interventions. Can inform improvement initiatives (discharge phone calls, medication reconciliation). Addressing clinical situations earlier may reduce cost of care later.

OP7: Accountable Organization/Compliance Reporting

Summarized Description: Use of business intelligence/analytics to support organizational accountability and transparency through compliance with policy, external reporting and other regulatory requirements such as accreditation to optimize funding and meet stakeholder/funder expectations.

Measures suggested by respondents: patterns and volumes of use; external agency requirements (such as CIHI, Accreditation Canada); legislative or organizational requirements; rationing cost/service reductions; appropriate mix of service to population (including long term care/housing options).

Other terms used by respondents: compliance with external reporting; understanding meaningful use; compliance with government obligations; reporting obligations; increase compliance with hospital accreditation standards/accreditation required organizational practices (ROPs); service delivery levels; compliance and benchmarking.

Rationale provided by respondents: More accurate reporting on deliverables to funders and ability to track progress towards objectives for proactive management. Need to ensure we are receiving correct and appropriate funding to care for our population of patients. Improving the ability to meet preventative maintenance requirements and not using equipment past its lifetime. Tracking compliance measures reduce risk and improve client care outcomes. Provides transparency on reporting requirements across the organization and external accountability. Allows for comparisons across regions/provinces. Currently large amount of resourcing put into compliance reporting but wasted as little actually results in improved patient care. Data almost useless at a provider or standards level. easily done electronically but unclear value.

OP8: Human Resource Objectives/Employee Engagement

Summarized Description: Use of business intelligence/analytics to manage key human resource related objectives in support of employee engagement and other key measures.

Measures suggested by respondents: staff retention rates; employee career goals; staff engagement scores; performance management; overtime rates; predicted resource requirements; vacancies.

Other terms used by respondents: increased staff retention; staff career planning; staff engagement; reduced overtime; decreased vacancies/turnover of staff; optimize use of healthcare provider skills.

Rationale provided by respondents: Need tools to better manage human resources and understand the state of human resource capacity in the organization. Better management can increase retention (reduce costs associated with turnover; retain staff through career planning); manage staff accountability and performance rewards; and improve work life through appropriate and predictable staffing (with reduced costs for overtime). Exit interview results.

Appendix M - Round 3 Business Process and Activity Concepts (Median and IQR)

Consensus (IQR <=2) by Median Score (ranked by "All")

		All (n=16)		NP (n-6)		NonNP (n=10)		TMT (n=10)		OM (n=6)	
		Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
High (Median 7-9)	BA1: Patient/Client Flow Management	8	1	8	1	8	2	8	2	8	2
	BA4: Resource Utilization Management (Diagnostic and Pharmaceutical)	8	1	8	1	8	2	8	2	8	1
	BA3: Financial Management	8	1	8	1	7.5	3	7	2	8	0
	BA6: Clinical Outcomes Management	7.5	1	7.5	1	7.5	1	7	1	8	2
	BA5: Human Resource Management	7.5	1	7	1	8	3	7	3	8	2
	BA7: Performance Measurement and Quality Improvement Management	7	1	8	2	7	1	7	1	8	2
	BA2: Referral Management	7	2	7.5	2	6.5	3	7	2	6	3
Neutral (Median 4-6)	BA10: Incident and Risk Management	6	2	6	1	5	3	6	3	6	3

No Consensus (IQR >=3) by Median Score (ranked by "All")

		All (n=16) (n=16)		NP (n-6)		NonNP (n=10)		TMT (n=10)		OM (n=6)	
		Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
Neutral (Median 4-6)	BA8: Supply Chain and Materials Management	6.5	3	7	2	5.5	4	6	4	7	4
	BA9: Documentation Standards Management	6	3	6	3	6.5	3	6	2	6	4
	BA11: Office/Clinic Management	6	4	6.5	6	5.5	4	5	3	8	5

Appendix N - Round 3 Business Strategy Concepts (Median and IQR)

Consensus (IQR <=2) by Median Score (ranked by "All")

		All (n=16)		NP (n-6)		NonNP (n=10)		TMT (n=10)		OM (n=6)	
		Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
High (Median 7-9)	BS2: Data Driven Decision Making	8	1	8	1	8	1	8	2	8	2
	BS3: Increased Budget Awareness (Explainable Variances)	7	1	7	0	8	2	7	2	8	1
	BS4: Strategic Planning and Prioritization	7	1	6	2	7	1	6	1	7	3
	BS1: Improve Care Coordination	7	2	8	1	6	2	7	2	8	3
Neutral (Median 4-6)	BS6: Improve Organizational Processes/Performance	6.5	2	7.5	2	6	3	6	2	8	3
	BS5: Improve Client/Customer Experience	6	2	6	1	6	3	6	2	6	3
	BS7: Innovative/Agile Organization	6	1	6	2	6	1	5	1	6	1
	BS11: Provincial Councils and Regional Committees	6	2	6	3	5.5	2	6	2	6	3
	BS10: Adoption of Virtual Healthcare Solutions	5.5	1	5.5	1	5.5	2	5	2	6	2
	BS8: Improve Patient Engagement	5	2	5	2	5.5	4	5	3	6	5

No Consensus (IQR >=3) by Median Score (ranked by "All")

		All (n=16)		NP (n-6)		NonNP (n=10)		TMT (n=10)		OM (n=6)	
		Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
Neutral (Median 4-6)	BS9: Improving Accountability and Transparency	6	3	6	2	7	4	6	2	8	4

Appendix O - Round 3 Organizational Performance Concepts (Median and IQR)

Consensus (IQR <=2) by Median Score (ranked by "All")

		All (n=16)		NP (n-6)		NonNP (n=10)		TMT (n=10)		OM (n=6)	
		Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
High (Median 7-9)	OP5: Improved Wait Times	8	2	8	2	8	2	7	1	9	1
	OP2: Reduce Costs	8	1	8	1	8	2	7	2	8	1
	OP6: Improve Client/Patient Outcomes	8	2	8	2	7.5	2	7	2	9	2
	OP3: Maximize Revenues/ Remuneration	7	2	6	2	7	2	7	2	7	3
Neutral (Median 4-6)	OP7: Accountable Organization/ Compliance Reporting	6.5	2	6.5	2	6.5	4	6	3	7	3
	OP8: Human Resource Objectives/Employee Engagement	5	2	5	1	6	4	5	4	5	3

No Consensus (IQR >=3) by Median Score (ranked by "All")

Organizational Performance		All (n=16)		NP (n-6)		NonNP (n=10)		TMT (n=10)		OM (n=6)	
		Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
High (Median 7-9)	OP4: Resource Optimization	7.5	3	**7.5**	**1**	**7.5**	**1**	**7**	**1**	**8**	**2**
	OP1: Reduce Waste	7	4	6	1	7	3	6	2	**7**	**2**

Appendix P - Round 1 – Pearson's Chi-square Results Overall

	All (n=20)	NP/NonNP				*TMT/OM*			
		% Identifying the Concept		Pearson's Chi-square		% Identifying the Concept		Pearson's Chi-square	
	%	NP (n=10)	NonNP (n=10)	$X^2(1)>=$	*p*	TMT (n=10)	OM (n=10)	$X^2(1)>=$	*p*
Business Processes and Activities									
BA1: Patient/Client Flow Management	45	50	40	.202	.653	50	40	.202	.653
BA2: Referral Management	30	30	30	.000	1.000	50	10	3.810	.051
BA3: Financial Management	50	40	60	.800	.371	60	40	.8	.371
BA4: Resource Utilization Management (Diagnostic and Pharmaceutical)	25	20	30	.267	.606	40	10	2.400	.121
BA5: Human Resource Management	60	80	40	3.333	.068	60	60	.000	1.0
BA6: Clinical Outcomes Management	30	20	40	.952	.329	50	10	3.810	.051
BA7: Performance Measurement and Quality Improvement Management	45	30	60	1.818	.178	50	40	.202	.653
BA8: Supply Chain and Materials Management	55	60	50	.202	.653	40	70	1.818	.178
BA9: Documentation Standards Management	40	50	30	.833	.361	20	60	3.333	.068
BA10: Incident and Risk Management	15	20	10	.392	.531	10	20	.392	.531
BA11: Office/Clinic Management	5	0	10	1.053	.305	10	0	1.053	.305
Business Strategies									
BS1: Improve Care Coordination	55	70	40	1.818	.178	70	40	1.818	.178
BS2: Data Driven Decision Making	60	60	60	.000	1.000	70	50	.833	.361
BS3: Increased Budget Awareness (Explainable Variances)	45	40	50	.202	.653	50	40	.202	.653
BS4: Strategic Planning and Prioritization	15	0	30	3.529	.060	20	10	.392	.531
BS5: Improve Client/Customer Experience	65	70	60	.220	.639	60	70	.220	.639
BS6: Improve Organizational Processes/Performance	20	30	10	1.250	.264	20	20	.000	1.000
BS7: Innovative/Agile Organization	20	20	20	.000	1.000	30	10	1.250	.264
BS8: Improve Patient Engagement	5	0	10	1.053	.305	10	0	1.053	.305
BS9: Improving Accountability and Transparency	10	10	10	.000	1.000	10	10	.000	1.000
BS10: Adoption of Virtual Healthcare Solutions	10	10	10	.000	1.000	0	20	2.222	.136
BS11: Provincial Councils and Regional Committees	5	0	10	1.053	.305	0	10	1.053	.305
Organizational Performance									
OP1: Reduce Waste	55	60	50	.202	.653	50	60	.202	.653
OP2: Reduce Costs	70	70	70	.000	1.000	80	60	.952	.329
OP3: Maximize Revenues/Remuneration	20	10	30	1.250	.264	20	20	.000	1.000
OP4: Resource Optimization	25	10	40	2.400	.121	30	20	.267	.606
OP5: Improved Wait Times	60	80	40	3.333	.068	70	50	.833	.361
OP6: Improve Client/Patient Outcomes	65	90	40	5.495	.019	70	60	.220	.639
OP7: Accountable Organization/Compliance Reporting	80	80	80	.000	1.000	70	90	1.250	.264
OP8: Human Resource Objectives/Employee Engagement	20	30	10	1.250	.264	10	30	1.250	.264

* = significant at <=.05

Appendix Q - Round 1 - Pearson's Chi-square Results Detailed (by Leadership Role)

	TMT (n=10)					*OM (n=10)*				
	% Identifying the Concept			Pearson's Chi-square		% Identifying the Concept			Pearson's Chi-square	
	NP (n=4)	NonNP (n=6)	Total	$X^2(1)>=$	*p*	NP (n=6)	NonNP (n=4)	Total	$X^2(1)>=$	*p*
Business Processes and Activities										
BA1: Patient/Client Flow Management	75	33.3	50	1.667	.197	33.3	50	40	.278	.598
BA2: Referral Management	50	50	50	.000	1.00	16.7	0	10	.741	.389
BA3: Financial Management	50	66.7	40	1.667	.197	33.3	50	60	.278	.598
BA4: Resource Utilization Management (Diagnostic and Pharmaceutical)	25	50	40	.625	.429	16.7	0	10	.741	.389
BA5: Human Resource Management	100	33.3	60	4.444	.035*	66.7	50	60	.278	.598
BA6: Clinical Outcomes Management	25	66.7	50	1.667	.197	16.7	0	10	.741	.389
BA7: Performance Measurement and Quality Improvement Management	25	66.7	50	1.667	.197	33.3	50	40	.278	.598
BA8: Supply Chain and Materials Management	50	33.3	40	1.667	.197	66.7	75	70	.079	.778
BA9: Documentation Standards Management	50	0	20	3.750	.053	50	75	60	.625	.429
BA10: Incident and Risk Management	25	0	10	1.667	.197	16.7	25	20	.104	.747
BA11: Office/Clinic Management	0	16.7	10	.741	.389	0	0	0	ns	ns
Business Strategies										
BS1: Improve Care Coordination	75	66.7	70	.079	.778	66.7	0	40	4.444	.035*
BS2: Data Driven Decision Making	75	66.7	70	.079	.778	50	50	50	.000	1.000
BS3: Increased Budget Awareness (Explainable Variances)	50	50	50	.000	1.00	33.3	50	40	.278	.598
BS4: Strategic Planning and Prioritization	0	33.3	20	1.667	.197	0	25	10	1.667	.197
BS5: Improve Client/Customer Experience	100	33.3	60	4.444	.035*	50	100	70	2.857	.091
BS6: Improve Organizational Processes/Performance	50	0	20	3.750	.053	16.7	25	20	.104	.747
BS7: Innovative/Agile Organization	50	16.7	30	1.270	.260	0	25	10	1.667	.197
BS8: Improve Patient Engagement	0	16.7	10	.741	.389	0	0	0	ns	ns
BS9: Improving Accountability and Transparency	0	16.7	10	.741	.389	16.7	0	10	.741	.389
BS10: Adoption of Virtual Healthcare Solutions	0	0	0	ns	ns	16.7	25	20	.104	.747
BS11: Provincial Councils and Regional Committees	0	0	0	ns	ns	0	25	10	1.667	.197
Organizational Performance										
OP1: Reduce Waste	50	50	50	.000	1.00	66.7	50	60	.278	.598
OP2: Reduce Costs	75	83.3	80	.104	.747	66.7	50	60	.278	.598
OP3: Maximize Revenues/Remuneration	25	16.7	20	.104	.747	0	50	20	3.750	.053
OP4: Resource Optimization	25	33.3	30	.079	.778	0	50	20	3.750	.053
OP5: Improved Wait Times	100	50	70	2.857	.091	66.7	25	50	1.667	.197
OP6: Improve Client/Patient Outcomes	100	50	70	2.857	.091	83.3	25	60	3.403	.065
OP7: Accountable Organization/Compliance Reporting	75	66.7	70	.079	.778	83.3	100	90	.741	.389
OP8: Human Resource Objectives/Employee Engagement	25	0	10	1.667	.197	33.3	25	30	.079	.778

* = significant at <=.05

Appendix R - Round 1 - Pearson's Chi-square Results Overall (by Nursing Role)

	NP (n=10)					NonNP (n=10)				
	% Identifying the Concept			Pearson's Chi-square		% Identifying the Concept			Pearson's Chi-square	
	TMT (n=4)	OM (n=6)	Total	$X^2(1)>=$	*p*	TMT (n=6)	OM (n=4)	Total	$X^2(1)>=$	*p*
Business Processes and Activities										
BA1: Patient/Client Flow Management	75	33.3	50	1.667	.197	33.3	50	40	.278	.598
BA2: Referral Management	50	16.7	30	1.270	.260	50	0	30	2.857	.091
BA3: Financial Management	50	33.3	40	.278	.598	66.7	50	60	.278	.598
BA4: Resource Utilization Management (Diagnostic and Pharmaceutical)	25	16.7	20	.104	.747	50	0	30	2.857	.091
BA5: Human Resource Management	100	66.7	80	1.667	.197	33.3	50	40	.278	.598
BA6: Clinical Outcomes Management	25	16.7	20	.104	.747	66.7	0	40	4.444	.035*
BA7: Performance Measurement and Quality Improvement Management	25	33.3	30	.079	.778	66.7	50	60	.278	.598
BA8: Supply Chain and Materials Management	50	66.7	60	.278	.598	33.3	75	50	1.667	.197
BA9: Documentation Standards Management	50	50	50	.000	1.000	0	75	30	6.429	.011*
BA10: Incident and Risk Management	25	16.7	20	.104	.747	0	25	10	1.667	.197
BA11: Office/Clinic Management	0	0	0	ns	ns	16.7	0	10	.741	.389
Business Strategies										
BS1: Improve Care Coordination	75	66.7	70	.079	.778	66.7	0	40	4.444	.035*
BS2: Data Driven Decision Making	75	50	60	.625	.429	66.7	50	60	.278	.598
BS3: Increased Budget Awareness (Explainable Variances)	50	33.3	40	.278	.598	50	50	50	.000	1.000
BS4: Strategic Planning and Prioritization	0	0	0	ns	ns	33.3	25	30	.079	.778
BS5: Improve Client/Customer Experience	100	50	70	2.857	.091	33.3	100	60	4.444	.035*
BS6: Improve Organizational Processes/Performance	50	16.7	30	1.270	.260	0	25	10	1.667	.197
BS7: Innovative/Agile Organization	50	0	20	3.750	.053	16.7	25	20	.104	.747
BS8: Improve Patient Engagement	0	0	0	ns	ns	16.7	0	10	.741	.389
BS9: Improving Accountability and Transparency	0	16.7	10	.741	.389	16.7	0	10	.741	.389
BS10: Adoption of Virtual Healthcare Solutions	0	16.7	10	.741	.389	0	25	10	1.667	.197
BS11: Provincial Councils and Regional Committees	0	0	0	ns	ns	0	25	10	1.667	.197
Organizational Performance										
OP1: Reduce Waste	50	66.7	60	.278	.598	50	50	50	.000	1.000
OP2: Reduce Costs	75	66.7	70	.079	.778	83.3	50	70	1.270	.260
OP3: Maximize Revenues/Remuneration	25	0	10	1.667	.197	16.7	50	30	1.270	.260
OP4: Resource Optimization	25	0	10	1.667	.197	33.3	50	40	.278	.598
OP5: Improved Wait Times	100	66.7	80	1.667	.197	50	25	40	.625	.429
OP6: Improve Client/Patient Outcomes	100	83.3	90	.741	.389	50	25	40	.625	.429
OP7: Accountable Organization/Compliance Reporting	75	83.3	80	.104	.747	66.7	100	80	1.667	.197
OP8: Human Resource Objectives/Employee Engagement	25	33.3	30	.079	.778	0	25	10	1.667	.197

* = significant at <=.05

Appendix S - Round 3 – ANOVA Results Overall

	All (n=16) Mean	NP/NonNP			*TMT/OM*		
		Mean		ANOVA	Mean		ANOVA
		NP (n=6)	NonNP (n=10)		TMT (n=10)	OM (n=6)	
Business Processes and Activities							
BA1: Patient/Client Flow Management	8.00	8.00	8.00	$F_{1, 14}$ = .000, p =1.000	8.11	7.83	$F_{1, 13}$ = .230, p = .640
BA2: Referral Management	6.60	7.00	6.33	$F_{1, 14}$ = .416, p =.530	6.56	6.67	$F_{1, 13}$ = .011, p = .917
BA3: Financial Management	7.50	7.67	7.40	$F_{1, 14}$ = .237, p =.634	7.20	8.00	$F_{1, 14}$ =2.471 , p =.138
BA4: Resource Utilization Management (Dx and Rxal)	8.00	7.67	8.20	$F_{1, 14}$ = 2.154, p =.164	8.20	7.67	$F_{1, 14}$ = 2.154, p = .164
BA5: Human Resource Management	7.13	7.17	7.10	$F_{1, 14}$ = .005, p =.946	6.70	7.83	$F_{1, 14}$ = 1.501, p =.241
BA6: Clinical Outcomes Management	7.63	7.33	7.80	$F_{1, 14}$ = .884, p = .363	7.60	7.67	$F_{1, 14}$ = .017, p = .898
BA7: Performance Measurement and QI Management	7.50	7.50	7.50	$F_{1, 14}$ = .000, p =1.000	7.40	7.67	$F_{1, 14}$ = .318, p = .582
BA8: Supply Chain and Materials Management	6.00	6.33	5.80	$F_{1, 14}$ = .253, p = .623	5.60	6.67	$F_{1, 14}$ = 1.072, p = .318
BA9: Documentation Standards Management	6.31	6.17	6.40	$F_{1, 14}$ = .066, p = .801	6.40	6.17	$F_{1, 14}$ = .066 , p = .801
BA10: Incident and Risk Management	6.13	6.5	5.90	$F_{1, 14}$ = .549, p = .471	5.90	6.50	$F_{1, 14}$ = .549, p = .471
BA11: Office/Clinic Management	5.75	5.00	6.20	$F_{1, 14}$ = .808, p = .384	5.30	6.50	$F_{1, 14}$ = .808, p = .384
Business Strategies							
BS1: Improve Care Coordination	6.75	7.50	6.30	$F_{1, 14}$ = 2.554, p = .132	6.60	7.00	$F_{1, 14}$ = .244, p = .629
BS2: Data Driven Decision Making	7.94	8.17	7.80	$F_{1, 14}$ = .677, p = .425	8.00	7.83	$F_{1, 14}$ = .135, p = .719
BS3: Increased Budget Awareness (Explainable Variances)	7.19	7.17	7.20	$F_{1, 14}$ = .006, p = .941	7.00	7.50	$F_{1, 14}$ = 1.382, p =.259
BS4: Strategic Planning and Prioritization	6.81	6.33	7.10	$F_{1, 14}$ = 1.692, p = .214	6.60	7.17	$F_{1, 14}$ = .877, p =.365
BS5: Improve Client/Customer Experience	6.63	6.50	6.70	$F_{1, 14}$ = .066, p = .800	6.30	7.17	$F_{1, 14}$ = 1.363, p =.263
BS6: Improve Organizational Processes/Performance	7.25	7.33	7.20	$F_{1, 14}$ = .032, p = .860	6.90	7.83	$F_{1, 14}$ = 1.777, p =.204
BS7: Innovative/Agile Organization	6.19	6.17	6.20	$F_{1, 14}$ = .003, p = .958	6.00	6.50	$F_{1, 14}$ = .673, p =.426
BS8: Improve Patient Engagement	5.31	4.83	5.60	$F_{1, 14}$ = .504, p = .489	5.00	5.83	$F_{1, 14}$ = .599, p =.452
BS9: Improving Accountability and Transparency	6.63	5.83	7.10	$F_{1, 14}$ = 2.232, p = .157	6.40	7.00	$F_{1, 14}$ = .446, p =.515
BS10: Adoption of Virtual Healthcare Solutions	5.75	5.67	5.80	$F_{1, 14}$ = .035, p = .855	5.60	6.00	$F_{1, 14}$ = .318, p =.582
BS11: Provincial Councils and Regional Committees	5.88	5.67	6.00	$F_{1, 14}$ = .129, p = .725	5.80	6.00	$F_{1, 14}$ = .046, p =.833
Organizational Performance							
OP1: Reduce Waste	6.94	6.17	7.40	$F_{1, 14}$ = 4.152, p = .061	6.90	7.00	$F_{1, 14}$ = .021, p =.887
OP2: Reduce Costs	7.81	7.50	8.00	$F_{1, 14}$ = 1.382, p = .259	7.60	8.17	$F_{1, 14}$ = 1.826, p =.198
OP3: Maximize Revenues/Remuneration	6.73	6.17	7.11	$F_{1, 14}$ = 2.355, p = .149	6.70	6.80	$F_{1, 14}$ = .021, p =.888
OP4: Resource Optimization	7.69	7.67	7.70	$F_{1, 14}$ = .005, p = .944	7.30	8.33	$F_{1, 14}$ = 7.541, p = .016
OP5: Improved Wait Times	7.94	7.83	8.00	$F_{1, 14}$ = .114, p = .741	7.60	8.50	$F_{1, 14}$ = 4.295, p =.057
OP6: Improve Client/Patient Outcomes	7.81	7.83	7.80	$F_{1, 14}$ = .004, p = .953	7.50	8.33	$F_{1, 14}$ = 2.636, p =.127
OP7: Accountable Organization/Compliance Reporting	6.44	6.83	6.20	$F_{1, 14}$ = .387, p = .544	6.20	6.83	$F_{1, 14}$ = .387, p =.544
OP8: Human Resource Objectives/Employee Engagement	5.63	5.17	5.90	$F_{1, 14}$ = .646, p = .435	5.30	6.17	$F_{1, 14}$ = .918, p =.354

* = significant at <=.05

Appendix T - Round 3 – ANOVA Results (by Nursing Role)

	NP (n=6)				NonNP (n=10)			
	Mean			ANOVA	Mean			ANOVA
	TMT (n=3)	OM (n=3)	Total		TMT (n=7)	OM (n=3)	Total	
Business Processes and Activities								
BA1: Patient/Client Flow Management	7.67	8.33	8.00	$F_{1,4}$ =2.000, p = .230	8.33	7.33	8.00	$F_{1,7}$ =1.167, p =.316
BA2: Referral Management	7.00	7.00	7.00	$F_{1,4}$ =.000, p = 1.000	6.33	6.33	6.33	$F_{1,7}$ =.000, p =1.000
BA3: Financial Management	7.33	8.00	7.67	$F_{1,4}$ =4.000, p = .116	7.14	8.00	7.40	$F_{1,8}$ =.960, p =.356
BA4: Resource Utilization Management (Dx and Rx)	7.67	7.67	7.67	$F_{1,4}$ =.000, p = 1.000	8.43	7.67	8.20	$F_{1,8}$ =2.226, p =.174
BA5: Human Resource Management	7.00	7.33	7.17	$F_{1,4}$ =.250, p = .643	6.57	8.33	7.10	$F_{1,8}$ =1.292, p =.289
BA6: Clinical Outcomes Management	7.33	7.33	7.33	$F_{1,4}$ =.000, p = 1.000	7.71	8.00	7.80	$F_{1,8}$ =.145, p =.713
BA7: Performance Measurement and Quality Improvement Management	7.33	7.67	7.50	$F_{1,4}$ =.091, p = .778	7.43	7.67	7.50	$F_{1,8}$ =.217, p =.653
BA8: Supply Chain and Materials Management	6.67	6.00	6.33	$F_{1,4}$ =.182, p = .692	5.14	7.33	5.80	$F_{1,8}$ =2.405, p =.160
BA9: Documentation Standards Management	6.67	5.67	6.17	$F_{1,4}$ =.391, p = .566	6.29	6.67	6.40	$F_{1,8}$ =.093, p =.768
BA10: Incident and Risk Management	6.33	6.67	6.50	$F_{1,4}$ =.200, p = .678	5.71	6.33	5.90	$F_{1,8}$ =.214, p =.656
BA11: Office/Clinic Management	4.67	5.33	5.00	$F_{1,4}$ =.054, p = .828	5.57	7.67	6.20	$F_{1,8}$ =2.145, p =.181
Business Strategies								
BS1: Improve Care Coordination	7.67	7.33	7.50	$F_{1,4}$ =.200, p = .678	6.14	6.67	6.30	$F_{1,8}$ =.181, p =.682
BS2: Data Driven Decision Making	8.00	8.33	8.17	$F_{1,4}$ =.250, p = .643	8.00	7.33	7.80	$F_{1,8}$ =1.120, p =.321
BS3: Increased Budget Awareness (Explainable Variances)	7.00	7.33	7.17	$F_{1,4}$ =1.000, p = .374	7.00	7.67	7.20	$F_{1,8}$ =.862, p =.380
BS4: Strategic Planning and Prioritization	6.00	6.67	6.33	$F_{1,4}$ =.571, p = .492	6.86	7.67	7.10	$F_{1,8}$ =.955, p =.357
BS5: Improve Client/Customer Experience	6.33	6.67	6.50	$F_{1,4}$ =.200, p = .678	6.29	7.67	6.70	$F_{1,8}$ =1.330, p =.282
BS6: Improve Organizational Processes/Performance	6.67	8.00	7.33	$F_{1,4}$ =2.286, p = .205	7.00	7.67	7.20	$F_{1,8}$ =.361, p =.564
BS7: Innovative/Agile Organization	6.00	6.33	6.17	$F_{1,4}$ =.100, p = .768	6.00	6.67	6.20	$F_{1,8}$ =.589, p =.465
BS8: Improve Patient Engagement	5.33	4.33	4.83	$F_{1,4}$ =1.125, p = .349	4.86	7.33	5.60	$F_{1,8}$ =2.481, p =.154
BS9: Improving Accountability and Transparency	5.67	6.00	5.83	$F_{1,4}$ =.077, p = .795	6.71	8.00	7.10	$F_{1,8}$ =1.092, p =.327
BS10: Adoption of Virtual Healthcare Solutions	5.33	6.00	5.67	$F_{1,4}$ =1.000, p = .374	5.71	6.00	5.80	$F_{1,8}$ =.059, p =.815
BS11: Provincial Councils and Regional Committees	5.33	6.00	5.67	$F_{1,4}$ =.250, p = .643	6.00	6.00	6.00	$F_{1,8}$ =.000, p =1.000
Organizational Performance								
OP1: Reduce Waste	6.00	6.33	6.17	$F_{1,4}$ =.250, p = .643	7.29	7.67	7.40	$F_{1,8}$ =.151, p =.707
OP2: Reduce Costs	7.00	8.00	7.50	$F_{1,4}$ =3.000, p = .158	7.86	8.33	8.00	$F_{1,8}$ =.690, p =.430
OP3: Maximize Revenues/Remuneration	6.00	6.33	6.17	$F_{1,4}$ =.100, p = .768	7.00	7.50	7.11	$F_{1,7}$ =.259, p =.626
OP4: Resource Optimization	7.33	8.00	7.67	$F_{1,4}$ =1.000, p = .374	7.29	8.67	7.70	$F_{1,8}$ =7.823, p =.023*
OP5: Improved Wait Times	7.00	8.67	7.83	$F_{1,4}$ =6.250, p = .067	7.86	8.33	8.00	$F_{1,8}$ =.690, p =.430
OP6: Improve Client/Patient Outcomes	7.00	8.67	7.83	$F_{1,4}$ =6.250, p = .067	7.71	8.00	7.80	$F_{1,8}$ =.145, p =.713
OP7: Accountable Organization/Compliance Reporting	6.67	7.00	6.83	$F_{1,4}$ =.143, p = .725	6.00	6.67	6.20	$F_{1,8}$ =.153, p =.706
OP8: Human Resource Objectives/Employee Engagement	5.00	5.33	5.17	$F_{1,4}$ =.250, p = .643	5.43	7.00	5.90	$F_{1,8}$ =1.162, p =.313

* = significant at <=.05

Appendix U - Round 3 – ANOVA Results (Leadership Role)

	TMT (n=10)				OM (n=6)			
	Mean			ANOVA	Mean			ANOVA
	NP (n=3)	NonNP (n=7)	Total		NP (n=3)	NonNP (n=3)	Total	
Business Processes and Activities								
BA1: Patient/Client Flow Management	7.67	8.33	8.11	$F_{1,7}$ =1.556, p =.252	8.33	7.33	7.83	$F_{1,4}$ =.643, p =.468
BA2: Referral Management	7.00	6.33	6.56	$F_{1,7}$ =.158, p =.703	7.00	6.33	6.67	$F_{1,4}$ =.250, p =.643
BA3: Financial Management	7.33	7.14	7.20	$F_{1,8}$ =.045, p =.837	8.00	8.00	8.00	$F_{1,4}$ =.000, p =1.000
BA4: Resource Utilization Management (Diagnostic and Pharmaceutical)	7.67	8.43	8.20	$F_{1,8}$ =2.226, p =.174	7.67	7.67	7.67	$F_{1,4}$ =.000, p =1.000
BA5: Human Resource Management	7.00	6.57	6.70	$F_{1,8}$ =.074, p =.793	7.33	8.33	7.83	$F_{1,4}$ =4.500, p =.101
BA6: Clinical Outcomes Management	7.33	7.71	7.60	$F_{1,8}$ =.301, p =.589	7.33	8.00	7.67	$F_{1,4}$ =.571, p =.492
BA7: Performance Measurement and Quality Improvement Management	7.33	7.43	7.40	$F_{1,8}$ =.024, p =.881	7.67	7.67	7.67	$F_{1,4}$ =.000, p =1.000
BA8: Supply Chain and Materials Management	6.67	5.14	5.60	$F_{1,8}$ =1.237, p =.298	6.00	7.33	6.67	$F_{1,4}$ =.640, p =.469
BA9: Documentation Standards Management	6.67	6.29	6.40	$F_{1,8}$ =.101, p =.759	5.67	6.67	6.17	$F_{1,4}$ =.346, p =.588
BA10: Incident and Risk Management	6.33	5.71	5.90	$F_{1,8}$ =.247, p =.633	6.67	6.33	6.50	$F_{1,4}$ =.091, p =.778
BA11: Office/Clinic Management	4.67	5.57	5.30	$F_{1,8}$ =.273, p =.616	5.33	7.67	6.50	$F_{1,4}$ =.980, p =.378
Business Strategies								
BS1: Improve Care Coordination	7.67	6.14	6.60	$F_{1,8}$ =1.812, p =.215	7.33	6.67	7.00	$F_{1,4}$ =.364, p =.579
BS2: Data Driven Decision Making	8.00	8.00	8.00	$F_{1,8}$ =.000, p =1.000	8.33	7.33	7.83	$F_{1,4}$ =1.800, p =.251
BS3: Increased Budget Awareness (Explainable Variances)	7.00	7.00	7.00	$F_{1,8}$ =.000, p =1.000	7.33	7.67	7.50	$F_{1,4}$ =.500, p =.519
BS4: Strategic Planning and Prioritization	6.00	6.86	6.60	$F_{1,8}$ =1.394, p =.272	6.67	7.67	7.17	$F_{1,4}$ =.818, p =.417
BS5: Improve Client/Customer Experience	6.33	6.29	6.30	$F_{1,8}$ =.002, p =.966	6.67	7.67	7.17	$F_{1,4}$ =.818, p =.417
BS6: Improve Organizational Processes/Performance	6.67	7.00	6.90	$F_{1,8}$ =.100, p =.760	8.00	7.67	7.83	$F_{1,4}$ =.100, p =.768
BS7: Innovative/Agile Organization	6.00	6.00	6.00	$F_{1,8}$ =.000, p =1.000	6.33	6.67	6.50	$F_{1,4}$ =.500, p =.519
BS8: Improve Patient Engagement	5.33	4.86	5.00	$F_{1,8}$ =.096, p =.764	4.33	7.33	5.83	$F_{1,4}$ =7.364, p =.053
BS9: Improving Accountability and Transparency	5.67	6.71	6.40	$F_{1,8}$ =.765, p =.407	6.00	8.00	7.00	$F_{1,4}$ =2.400, p =.196
BS10: Adoption of Virtual Healthcare Solutions	5.33	5.71	5.60	$F_{1,8}$ =.110, p =.748	6.00	6.00	6.00	$F_{1,4}$ =.000, p =1.000
BS11: Provincial Councils and Regional Committees	5.33	6.00	5.80	$F_{1,8}$ =.215, p =.655	6.00	6.00	6.00	$F_{1,4}$ =.000, p =1.000
Organizational Performance								
OP1: Reduce Waste	6.00	7.29	6.90	$F_{1,8}$ =2.068, p =.188	6.33	7.67	7.00	$F_{1,4}$ =2.000, p =.230
OP2: Reduce Costs	7.00	7.86	7.60	$F_{1,8}$ =1.800, p =.217	8.00	8.33	8.17	$F_{1,4}$ =1.000, p =.374
OP3: Maximize Revenues/Remuneration	6.00	7.00	6.70	$F_{1,8}$ =1.400, p =.271	6.33	7.50	6.80	$F_{1,4}$ =.948, p =.402
OP4: Resource Optimization	7.33	7.29	7.30	$F_{1,8}$ =.009, p =.926	8.00	8.67	8.33	$F_{1,4}$ =1.000, p =.374
OP5: Improved Wait Times	7.00	7.86	7.60	$F_{1,8}$ =1.800, p =.217	8.67	8.33	8.50	$F_{1,4}$ =.500, p =.519
OP6: Improve Client/Patient Outcomes	7.00	7.71	7.50	$F_{1,8}$ =.909, p =.368	8.67	8.00	8.33	$F_{1,4}$ =1.000, p =.374

	TMT (n=10)				OM (n=6)			
	Mean			ANOVA	Mean			ANOVA
	NP (n=3)	NonNP (n=7)	Total		NP (n=3)	NonNP (n=3)	Total	
OP7: Accountable Organization/Compliance Reporting	6.67	6.00	6.20	$F_{1,8}$ =.175, p =.687	7.00	6.67	6.83	$F_{1,4}$ =.063, p =.815
OP8: Human Resource Objectives/Employee Engagement	5.00	5.43	5.30	$F_{1,8}$ =.104, p =.756	5.33	7.00	6.17	$F_{1,4}$ =1.923, p =.238

* = significant at <=.05