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Impact of Medical Device Integration on Real-Time Visibility of Electronic Medical Records

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This is to certify that the doctoral study by

Justin Fuller

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

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Walden University
2020

Abstract

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MSN, Walden University, 2014

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Project Submitted in Partial Fulfillment

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Abstract

Health care leaders are expected to make sound decisions regarding the equipment they purchase for use by personnel. One topic of consideration is the ability of the equipment to integrate with an organization's electronic medical record, known as medical device integration (MDI). One aspect of MDI is the ability for information gathered at the patient bedside to be viewable in real time, or as close to it as possible. The real-time visibility (RTV) of information refers to the time it takes for information gathered by one individual to be visible to another. The purpose of this systematic review of the literature was to assess the evidence of MDI-ready platforms and their impact on RTV. The guiding theories for this project were planned change theory, cognitive theory, and systems theory. Health care databases, information technology databases, and nursing informatics resources were accessed during the literature review. Results were described using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis. Articles included in the study were summarized using the revised Standards for Quality Improvement Reporting Excellence criteria. Results yielded one peer-reviewed article with information on the measurable impact of MDI on RTV which demonstrated that MDI can improve RTV by allowing nurses more time to focus on important clinical tasks. An additional 10 articles provided information on other benefits of MDI including considerations when purchasing equipment for staff such as additional locations, additional tools that could be used, and reductions in documentation errors. This project will contribute to social change by helping leaders pursue technology that improves patient safety, improves nurse efficiency, and improves nurse satisfaction.

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Dedication

I would like to first dedicate this work to my Lord and Savior, Jesus Christ. I would like to thank my parents, Tom and Donna Fuller, who encouraged me to do my best and set a strong work ethic inside of me. I would also like to thank my wife, Amanda Fuller, who told me all those years ago that I should further my education so that I could be an administrator and work on fixing a broken system. I would also like to thank my children, Aimee, Kahlia, and Zander, who kept me smiling and laughing through this work.

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I would like to first thank Jennifer Moore, the first nursing leader I had who pushed me outside of my comfort zone and told me, “I won’t walk in front of you unless I need to protect you. I won’t walk behind you unless I need others to see you. I will do my best to walk beside you.” Without Jennifer, I never would have pursued my baccalaureate or master’s education.

I would also like to thank Dr. Patty Sengstack, my first true informatics leader who coached me and encouraged me during my master’s work and prepared me for the difficulties of informatics leadership and my doctoral education. I would also like to thank Dr. Ellen Amalfitano for giving me encouragement and guidance and for giving me valuable time to learn from her.

Finally, I would like to thank Drs. Deb Lewis and Marisa Wilson for being my chair and cochair, respectively, for this project and for being readily available for all of my questions.

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Section 1: Nature of the Project

Internet of Medical Things (IOMT)

In the 1990s, Kevin Ashton coined the term *Internet of Things* when making a presentation to senior management team at Proctor & Gamble. Ashton pointed out that society and business had reached a point where there was a desire for the various technologies people use in their daily lives to be connected with the internet and to exchange data for their benefit (DeNisco Rayome, 2018). The term stuck and has come to refer to devices that have the ability to connect to one another over the Internet. A related term has emerged, the Internet of Medical Things (IOMT), which refers to medical devices that have this capability (Deloitte Centre for Health Solutions, 2018). According to Markets and Markets (as cited in Deloitte Centre for Health Solutions, 2018), the IOMT arena was valued at over $41 billion in 2017 and could increase to nearly $160 billion by 2022.

Within the arena of IOMT is the phenomenon of real-time visibility (RTV). In its most basic form, RTV refers to whatever data point a person is interested in that can be viewed instantaneously in real time. Previously, many business decisions were made based on data that had aged because RTV did not exist. As the need to have real-time data visibility increased, RTV began to receive more attention in the supply-chain management industry (Coolfire Solutions, 2019).

RTV and Health Care

Doctors and nurses rely on good data integrity in order to make appropriate decisions regarding the care of their patients (Johns Hopkins Medicine, 2019). There are

eight characteristics of data that influence data integrity: timeliness, completeness, accuracy, objectivity, accessibility, transparency, reproducibility, and security (McGonigle & Mastrian, 2012). These characteristics influence four elements of data utility: reliability, verifiability, flexibility, and relevancy (McGonigle & Mastrian, 2012).

Although each characteristic is worthy of investigation, timeliness has commanded attention of frontline clinicians. Clinicians expect data to be available in a timely fashion. One technology commonly used is vital sign devices that have the ability to directly transmit readings into a patient's electronic medical record (EMR) through medical device integration (MDI; Feldman, 2011).

Several vendors provide this technology, many of whom tout the benefits of this integration. Vendors cite faster access to patient information for other clinicians, reductions in errors created as a byproduct of manual transcription (e.g., errors of commission or errors of omission), cost savings for the organization, time savings for the staff, and ability for integrated technology to support remote patient monitoring (WelchAllyn, 2018). During vendor presentations, claims may be made about the reduction in the amount of time between when clinically relevant data, such as vital signs, are generated and when those data are visible to other clinicians. Executive leaders such as chief executive, financial, medical, administrative, or nursing officers, often called C-Suite leaders (Bloomenthal, 2019), need to know whether such claims are reliable in terms of cost reductions, and clinicians need to know whether such claims are reliable in terms of improvements to patient care.

Problem Statement

Costs of Medical Equipment

Abdulsalam and Schneller (2017) found that hospitals in the United States each spent an average of $3.8 million on hospital equipment, with a median of about $9 million. Additionally, hospitals incurred approximately $4,470 of supply expenses associated with each inpatient admission (Abdulsalam & Schneller, 2017). There were over 36 million inpatient admissions in the United States in 2017 (Elflein, 2019). Most equipment does not involve one-time use, but CFOs have to plan for when equipment reaches end of life and needs to be replaced.

Health Care Reimbursements Declining

Health care reimbursement has been a more prominent concern for C-Suite leaders since the Affordable Care Act was passed in 2010. In addition to the Affordable Care Act, several other regulatory changes have been aimed at reducing health care payments. These regulatory changes could result in more than $218 billion in reductions by the year 2028 according to the Federation of American Hospitals (as cited in LaPointe, 2018).

Choosing What to Purchase

Reductions in health care reimbursement underline the point that executives must be diligent and careful when purchasing equipment. There are several questions executives ask when considering purchasing equipment, such as whether the equipment will appeal to patients and staff, whether the equipment will boost capabilities and differentiate the organization from competitors, whether the equipment stands to realize a

return on investment, and whether the organization can utilize all of the features of the equipment (Gruebele, 2018). This last question is important. Often, hospitals will purchase equipment because there are additional features that make the equipment more appealing. However, once put into practice, users of the equipment may complain that the extra features are burdensome, or they may not use them at all (Hockel, 2010). It is important for executives to define the problem they need to solve, purchase equipment that solves the problem, and choose equipment that can be scaled across the organization.

What Nurses Want

Frontline clinicians champion the purchase of equipment that makes their job easier, safer, and faster. A recent list of major issues facing nurses included the following: compensation, workplace violence, short staffing, long working hours, and workplace hazards (Gooch, 2015). Although discussions about equipment are not likely linked to improvements in compensation, workplace violence, or workplace hazards, these discussions can occur with respect to short staffing and long working hours.

Some experts estimate that for every hour a nurse spends doing patient care, they spend an additional half hour on documentation, sometimes 2-3 hours per shift (Turisco & Rhoads, 2008). With limited workforces, there is an increased focus on nursing efficiency. Turisco and Rhoads (2008) found that electronic documentation solutions could reduce the time spent on clinical documentation by 24%. Figures like those capture the attention of nurse leaders and executives who turn to vendors who claim that their product will reduce documentation time for nurses.

Medical Device Integration

MDI is the connection between medical devices (e.g., vital sign machines) and the EMR. The premise is that when nurses do clinical tasks such as the collection of vital signs, the added burden of manually transcribing that information into the EMR is a waste of time and energy (Feldman, 2011). In an ideal situation, clinically relevant data would achieve RTV by virtue of MDI between hospital equipment that collects data and the EMR that houses and manipulates data. Nursing executives are keen to persuade executives to purchase equipment that is MDI ready to reduce the time nurses spend on data transcription, which allows nurses to spend more time on other important clinical tasks. In the current project study, the gap in practice was whether MDI technologies can deliver on those promises. The practice-focused question was the following: What is the impact of medical device integration and real-time visibility on nursing workflow?

Purpose Statement

The purpose of this project study was to conduct a systematic review of the literature to evaluate studies that have addressed MDI and RTV in health care to understand the value of these technologies. The practice-focused question was the following: What is the impact of medical device integration and real-time visibility on nursing workflow?

Nature of the Doctoral Project

This doctoral project was a systematic review of the literature to generate the highest level of evidence for use in decision-making by C-Suite and nursing leaders regarding whether to acquire and implement MDI technologies in their organizations.

Significance

The significance of this systematic review of the literature was to evaluate the MDI and RTV for nursing documentation of vital signs to demonstrate whether these technologies can improve nursing efficiency and reduce documentation burden. Technologies that improve nursing efficiency and reduce documentation burden would contribute to positive social change by allowing nurses and other clinicians to focus on more important clinical tasks.

Summary

Frontline nurses faced with increasing patient acuity, reductions in patient length of stay, and decreased nurse staffing (Carayon & Gurses, 2008) are interested in technologies that can make their jobs easier, safer, and faster. At the same time, C-Suite executives are faced with decreased hospital reimbursements and challenges to maintain fiduciary responsibility. These two forces pose a conflict that needs attention. The purpose of this project study was to assess the value of MDI-ready technology to assist C-suite and nursing leaders in making decisions that promote patient safety, staff efficiency, and organizational stewardship.

Section 2: Background and Context

Applicable Nursing Theories

The purpose of this systematic review of the literature was to answer the practice-focused question: What is the impact of medical device integration and real-time visibility on nursing workflow? I used three theories to frame this project study: planned change theory, cognitive theory, and systems theory (see McEwen & Wills, 2019).

Planned Change Theory

Lewin (as cited in McEwen & Wills, 2019) was a social psychologist in the mid-20th century who developed the planned change theory. This theory was appropriate to use for this systematic review of the literature because it takes into account the fact that transitioning from the manual entry of vital signs into the EMR is a change that should be done methodically. The planned change theory comprises three main components: unfreezing, movement (or change), and refreezing (McEwen & Wills, 2019).

Unfreezing and restraining forces. In Lewin's planned change theory, the current state or situation is what must be changed. As cited in McEwen & Wills (2019), Lewin explained that this state is currently frozen in place as the normal operating process or procedure. For a change to be successful, the current norm must be unfrozen. This means that steps must be taken to prepare stakeholders who are currently working in the norm to transition to something new (McEwen & Wills, 2019). In the case of vital sign documentation, the current state would be when nursing staff are collecting vital signs and manually transcribing them into the EMR.

Lewin further explained that when considering implementing a change, there will be certain restraining forces. These forces work to prevent a change from happening (McEwen & Wills, 2019). In the case of vital signs documentation, restraining forces could be the cost of purchasing new technology, entrenched ideas about changing process or tradition, or simple refusal to change.

Movement (change) and driving forces. During this phase, the transition to the new state or situation occurs. Once the unfreezing phase has been completed, the time comes to implement the change and begin working with the new process or procedure. Converse to the restraining forces, driving forces are what support and propel the change (McEwen & Wills, 2019). Driving forces should be magnified during the change to acquire and maintain momentum. In the case of vital signs documentation, driving forces could be increased efficiency in nursing documentation, opportunity to use new technology, and the belief that new technology results in increased patient safety. These are often the points made by vendors trying to sell the technology, and are the subject of this systematic review of the literature.

Refreezing. Lewin's final phase of the planned change theory is refreezing. In this phase, the new process or procedure becomes the norm and is frozen into place like the old norm was. Over time, the new norm may need to be replaced again, and the process repeats (McEwen & Wills, 2019). In the case of vital sign documentation, the new norm will be the use of direct transmission of vital signs into the EMR in lieu of manual transcription.

Cognitive Theory

Drucker (as cited in Corporate Finance Institute, 2019) coined the term *knowledge worker*. A knowledge worker is a person who uses a significant amount of cognitive energy in nonrepetitive tasks. Knowledge workers are continuous learners as evidenced by advanced formal education, the ability to apply theories and analyses to their work, having specializations within their field, and being innovators and team members (McGonigle & Mastrian, 2012).

Based on these parameters, nurses can be categorized as knowledge workers. With that in mind, Piaget's cognitive theory was appropriate to include in the current project study (McEwen & Wills, 2019). One of the components of Piaget's cognitive theory is schema. Piaget described a schema as mental representations and patterns used to understand and react to the world. For nurses, one schema could be the process of taking vital signs. Entering the patient's room, obtaining vital signs, and transcribing the vital signs into the EMR is a schema. The schema will change for the nurse with the addition of direct transmission into the EMR. Cognitive theory posits that changes to schema can have both positive and negative downstream consequences (McEwen & Wills, 2019). It would be important for nursing leaders to understand how this new workflow would affect a nurse's cognitive load, both positively and negatively.

Systems Theory

Systems theory addresses how a system is designed, behaves, and is maintained. Key concepts in systems theory are the parts of the system (inputs, outputs, processing,

and feedback), how they interact, and how they are or are not dependent on one another (Saba & McCormick, 2011).

Inputs. In systems theory, the first component to consider is the inputs. Inputs are the data that are sent into the system for the system to execute various processes on (Saba & McCormick, 2011). In the case of nurses, vital signs are an input because they are taken from the vital sign machine and put into the EMR. The EMR is the system (a database). This is an important distinction because databases have certain requirements for them to function properly. One requirement is that data that need to be processed must be collected discretely. Discrete data in a database are both measurable and reportable (Newman, 2017). This means that each datum has its own unique location in the database, known as a field (Newman, 2017). Processing is most easily done when data are in those fields (Newman, 2017).

Vital signs are one of the most common data points collected on patients because they provide important information about the patient's clinical condition at that moment. If that information is contained on a scrap of paper in a health care worker's pocket, then the information is not visible to other clinicians who may need it to make decisions on treatment. Inputting vital signs into the EMR is a crucial step in the quest to make the information valuable and actionable. The project study addressed the time it takes for a nurse to manually transcribe those inputs versus directly transmitting those data into the EMR.

Processing. Processing refers to the activity within the system (Saba & McCormick, 2011). As vital signs are input into the EMR, the EMR can then use that

data to perform calculations. Processing is an important and valuable feature of a database like an EMR because it can perform complicated calculations quickly for the clinician.

One example is a patient's mean arterial pressure (MAP). The MAP is the average pressure within arteries over time (Huenther & McCance, 2012). This calculation is used by physicians to make decisions on medication dosing. If a patient's systolic blood pressure (P_s) and diastolic blood pressure (P_d), the calculation for MAP is as follows: "MAP = P_d + 1/3 (P_s – P_d)" (Huenther & McCrance, 2012, p. 589). Manually performing that calculation may take a minute or so and may put a strain on cognitive load, especially over a long shift with many patients; however, if the systolic and diastolic pressures are in discrete fields in the EMR, the system can perform the processing and execute the calculation.

Outputs. The third feature of a system is its outputs. Outputs are the results of completed processing (Sittig & Ash, 2011). The outputs of interest in the current project study were the calculations and downstream notifications that come from the EMR to the frontline clinicians. In a MAP calculation, processing is the performance of the calculation, and displaying the MAP result to a clinician in a discrete field is the output.

Feedback. The final feature of a system is the ability for a user to provide feedback based on outputs (Saba & McCormick, 2011). This becomes a cyclical process. Inputs go into the system, the system conducts processing, and the system creates outputs that are delivered to the end user. The end user reacts to the outputs and provides feedback in the form of new inputs, and the process repeats. In the example of a MAP, if

a patient has a high MAP reading, the provider may decide to enter medication orders into the system to address the patient's blood pressure and to continue to monitor the blood pressure. The order for new medication is feedback (and a new input) based on outputs.

All three theories (change theory, cognitive theory, and systems theory) were applicable to the current project study because they demonstrate the sequence that nursing leaders need to follow to implement a change. First, they need to understand the process of implementing a change. Second, they need to understand the impact of the change on nursing cognitive load. Third, they need to understand how the new system works to be able to support nurses in the use of the new technology.

Relevance to Nursing Practice

The efficiency and expense of delivering care in the United States continues to be a concern for C-Suite and nursing leaders. According to Salmond and Echevarria (2017), health care spending was projected to be over $4 trillion by 2017, which is nearly 20% of the United States gross domestic product. Further, the United States spends more per capita on health care than any other nation, and the United States spends over 4 times more money on health care than on national defense. Some estimates indicated that nearly 30% of these costs are wasted, or more than $750 billion annually (Salmond & Echevarria, 2017). Such figures explain pressures from the government to reduce spending on health care. The downstream effect is that as reimbursements decline, nurses are pressed to be more efficient in their work. Technologies that are alleged to improve

nursing efficiency must be scrutinized to determine whether such claims are true, and whether the technologies negatively impact the delivery of safe patient care.

Role of the Doctoral Student

In 2006, the American Association of Colleges of Nursing (as cited in Moran, Burson, & Conrad, 2017) established the Essentials for Doctoral Education for Advanced Practice Nursing. To graduate from a doctoral nursing program, candidates must be able to demonstrate skills in eight categories:

1. "scientific underpinnings for practice
2. organizational and systems leadership for quality improvement and systems thinking
3. clinical scholarship and analytical methods for evidence-based practice
4. information systems/technology and patient care technology for the improvement and transformation of health care
5. health care policy for advocacy in health care
6. interprofessional collaboration for improving patient and population health outcomes
7. clinical prevention and population health for improving the nation's health
8. advanced nursing practice" (Moran et al., 2017, p. 40).

Essential I: Scientific Underpinnings for Practice

In the first essential, the doctor of nursing practice (DNP) student must be prepared to incorporate nursing science and theory with other sciences such as biophysical, organizational, psychological, and analytical science (DNP Nursing

Solutions, 2016). In the current project study, my role was to understand the applicable theories, the analytical sciences, and the health information technology sciences.

Essential II: Organizational and Systems Leadership for Quality Improvement

In the second essential, the DNP student must understand how to translate science and theory into practice, especially regarding the disciplines of quality improvement and organizational or systems leadership (DNP Nursing Solutions, 2016). The current project was designed to provide C-suite and nursing leaders with information to improve nursing efficiency and maintain fiduciary responsibility for an organization.

Essential III: Clinical Scholarship and Analytical Methods for Evidence-Based Practice

In the third essential, the DNP student must take leadership and systems level thinking and apply it to problem-solving using the best available evidence (DNP Nursing Solutions, 2016). In the current project, a systematic review of the literature provided the highest level of evidence that could be used in decision-making. By conducting this review, I contributed to the body of nursing knowledge in a practical and clinically relevant way.

Essential IV: Information Systems/Technology and Patient Care Technology for the Improvement and Transformation of Health Care

In the fourth essential, the DNP student must have a strong understanding of how technology influences safe and efficient patient care delivery. Additionally, DNP students should understand how the use of technologies impacts nursing workflow and cognitive load (DNP Nursing Solutions, 2016). In the current project, I evaluated how the use of

technology for the direct transmission of vital signs into the EMR impacts nursing workflow, cognitive load, and the downstream effects on patient care.

Essential V: Health Care Policy for Advocacy in Health Care

In the fifth essential, the DNP student must understand how projects impact the development of public health policy and how to advocate for patients based on those policies. The fifth essential was not applicable to the current project because the project was not aimed at health policy or public health.

Essential VI: Interprofessional Collaboration for Improving Patient and Population Health Outcomes

In the sixth essential, the DNP student must understand the importance of interprofessional collaboration in health care (DNP Nursing Solutions, 2016). The current project was a systematic review of the literature to understand the impact of direct transmission of vital signs into an EMR. If a benefit can be demonstrated, it is essential to understand how to work with other specialties such as a hospital's information technology (IT) team, biomedical team, purchasing and procurement teams, education teams, and executive leadership teams. The implementation of new technologies in a hospital requires strong interprofessional collaboration.

Essential VII: Clinical Prevention and Population Health for Improving the Nation's Health

In the seventh essential, the DNP student must understand how theories and sciences in nursing and elsewhere can be applied in community and population health. Additionally, the DNP student must have the ability to understand and execute

epidemiological studies to promote community and population health by understanding environmental or occupational risks and exposures and how to mitigate them (DNP Nursing Solutions, 2016). The seventh essential was not applicable to the current project study because the project was not aimed at population or community health, nor was it aimed at epidemiological evaluation.

Essential VIII: Advanced Nursing Practice

In the eighth essential, the DNP student must be focused on improving patient outcomes. Components of this essential include conducting needs assessments, mentoring other nurses, and evaluating complex transitions (DNP Nursing Solutions, 2016). This essential is applicable to the current project study because the DNP student is conducting a systematic review of the literature to understand the best evidence. If nursing workflows can be improved with this technology, a downstream effect will be the improvement of patient outcomes by making clinically relevant data readily available to clinicians.

Promoting the Importance of Health Information Technology

Another important aspect of the DNP student is to promote the importance of HIT in the delivery of clinical care. The Office of the National Coordinator set forth a plan to promote the advancement of HIT in health care through the Health Information Technology for Economic and Clinical Health Act in 2009, as a sub-component of the American Recovery and Reinvestment Act of 2009 (Zaccagnini & Waud White, 2017). The ONC has five goals in their strategic plan for the adoption and advancement of HIT:

- “achieve adoption and information exchange through meaningful use of HIT

- improve care, improve population health, and reduce health care costs through the use of HIT
- inspire confidence and trust in HIT
- empower individuals with HIT to improve their health and the health care system
- achieve rapid learning and technological advancement" (Zaccagnini & Waud White, 2017, pg. 161)

Adoption and Information Exchange

For this project, I examined the direct transmission of vital signs into the EMR. While the ONC's statement refers more to the exchange of Protected Health Information from one entity to another (Centers for Disease Control and Prevention [CDC], 2019), conceptually this project still applies. The intent of the information exchange component is to ensure that PHI can be transmitted in a way that the data is accurate, secure, and timely.

Improve Care, Improve Population Health, and Reduce Health Care Costs Through the Use of HIT

For this project, I was not focused on population health. However, the tenet of reducing health care costs is appropriate for this project. There are upfront costs associated with purchasing technology that allows for the direct transmission of vital signs into the EMR and those costs could potentially be offset with reductions in nursing documentation time.

Inspire Confidence and Trust in HIT

The use of technology in the delivery of health care has become more commonplace in the 21st century. It is important to ensure that nurses are trained and comfortable with new technologies. One study of 200 nurses in Turkey showed that only 17% of those nurses had participated in a technology related training program, and that almost 70% of the nurses believed that they were not trained or qualified appropriately for using some technologies sufficiently (Orhan & Kaplan Serin, 2019). For the current project study, the systematic review of the literature served to identify the impact of direct transmission of vital signs into the EMR.

Empower Individuals with HIT to Improve Their Health and the Health Care System

For the current project study, I did not be focus on patients using HIT for improving their health. However, this project did bring to light the importance of up-to-date technology for the betterment of health care systems. As a result of this systematic review of the literature, I understand how a project such as this would impact the health care system, and will be able to base the advancement HIT in clinical practice on that assessment.

Achieve Rapid Learning and Technological Advancement

The DNP student must understand how this technology works, and how the implementation would impact nurses' workflow. Based on this information, an educational plan can be established to promote nurses' understanding and adoption of the technology. For this project, the DNP student would not be implementing change nor

developing an educational plan. Nonetheless, the DNP student must understand the importance of these elements in actual practice.

Role of the Doctoral Project Team

Throughout the course of this systematic review of the literature, the I had access to a group of individuals who can help with the project. The chair and co-chair served to guide me to ensure that the Walden University manual for systematic review of the literature was followed correctly. The University Research Reviewer worked with the chair and co-chair to review the project. In addition to these resources, the DNP program had a program coordinator that oversaw all DNP projects. Lastly, I had access to the Walden University librarian to help with the execution of the systematic review of the literature such as helping identify appropriate sources of evidence (e.g. databases) as well as key search terms.

Summary

I was responsible for following the Walden University Manual on systematic reviews of literature to ensure that the project was conducted appropriately. It was important for the me to understand how executing this project satisfied the eight essentials of doctoral nursing practice, as well as how the project influenced nursing practice and contributed to the nursing body of knowledge and to positive social change. The project team was available to me as resources and to coach and guide me. Once the project received Internal Review Board approval, I began working to close the gap in practice by conducting the systematic review of the literature.

Section 3: Collection and Analysis of Evidence

Systematic Review of the Literature

In the 21st century, the delivery of health care continues to change dramatically. Conflicting pressures and priorities add to the challenge for nurses to do their jobs. Increased patient acuity and decreasing hospital reimbursements put pressures on C-suite leaders when it comes to purchasing equipment. Technological advances are coming with increasing speed and regularity. As a result, C-suite leaders and nursing leaders are often in need of guidance to help make decisions when it comes to purchasing equipment. Nursing leaders need to know that new equipment will be easy to use and will improve nursing safety, quality, and efficiency. C-suite leaders need to know that new equipment purchases will be a good long-term investment and that the money put forth for capital projects will not be spent in vain. With this in mind, I chose to perform a systematic review of the literature to answer the practice-focused question.

Practice-Focused Question

For the current project study, the practice-focused question was the following: What is the impact of medical device integration and real-time visibility on nursing workflow? Numerous vendors claim that MDI can impact RTV, and the purpose of this systematic review of the literature was to identify evidence, evaluate the validity of each study's findings, and make a final interpretation and presentation of the results.

Sources of Evidence

To answer the practice-focused question, I conducted a literature search on nursing-related content and IT-related content. Several different resources were searched

to find studies on these topics. Nursing resources were databases and journals specific to the field of nursing. IT resources were databases and journals specific to the field of IT. Nursing informatics resources included both clinical and IT-focused articles.

Health Care Databases

For articles on health care and nursing, I searched databases that may have contained articles and studies that could be included in the systematic review of the literature.

Cumulative Index to Nursing and Allied Health Literature. The Cumulative Index to Nursing and Allied Health Literature (CINAHL) is a database owned and operated by EBSCO Health (2019). This database has full-text articles dating back as far as 1937, with more than 6 million records to search from. Additionally, CINAHL has databases focused on nursing, allied professionals, and others (EBSCO Health, 2019).

PubMed. PubMed is a database operated by the National Center for Biotechnology Information (NCBI, 2019) under the U.S. National Library of Medicine and National Institutes of Health. One important tool available in PubMed is the MeSH database. MeSH stands for ***Me***dical ***S***ubject ***H***eadlines (NCBI, 2019), which provided another way to identify articles for inclusion in the current study. The primary component in PubMed is the MEDLINE database, which has data from 1966 to the present (NCBI, 2019).

Information Technology Research Databases

Because this systematic review of the literature had an IT component, I also needed to consider databases besides health care. Several IT databases were available for this systematic review.

Institute of Electrical and Electronics Engineers. The Institute of Electrical and Electronics Engineers (IEEE) can trace its origin to 1884 when electricity first became a major societal influence. Over time, the organization expanded to include databases that house published IT articles for review. The IEEE has a database known as the Xplore® Digital Library that can be searched for IT-related articles (IEEE, 2019).

Computers and Applied Sciences. In addition to the CINAHL database for nursing data, EBSCO also houses a database called Computers & Applied Sciences Complete, which offers the same search engine as CINAHL but houses IT-focused articles. Additionally, these two databases are cross-referenced to include articles that have both clinical and IT interest (EBSCO Health, 2019).

Nursing Informatics-Focused Resources

The field of informatics is positioned at the juncture between clinical practice and IT practice. A number of resources contain articles with this unique combination of information.

CIN: Computers, Informatics, Nursing. Computers, Informatics, Nursing (CIN) is an organization that publishes a journal of the same name. The organization has existed for over 30 years. The journal is cross-referenced with many of the databases described in

previous sections. A primary focus of CIN is to highlight the technologies used by nurses and how those technologies have impacted nursing practice (CIN, 2018).

American Nursing Informatics Association. The American Nursing Informatics Association (ANIA) was created in 1992 and merged with another organization called the Capital Area Roundtable on Informatics and Nursing in 2010. ANIA is a professional organization composed of members whose focus is the integration of nursing practice and computer and information science. ANIA has a journal called the *Journal of Informatics Nursing*, which was searched for articles and white papers that could be included in this systematic review. ANIA also has an archive of a previous journal called *Nursing Informatics Today* (ANIA, 2019) that was also searched. In addition to these nursing, IT, and nursing informatics resources, the Walden University library was used as a resource for articles and studies.

Inclusion and Exclusion Criteria

For a systematic review of the literature, there is a need to define the characteristics of the articles that qualify for inclusion or exclusion from the study. For the current systematic review of the literature, the inclusion criteria were as follows:

- articles written in English (research may have been conducted in other, countries, but the article must be available for review in English),
- articles from a peer-reviewed journal or publication,
- articles written after the year 2000, and
- articles containing combinations of key words (*vital signs*, *timeliness*, *cost*, *quality*, *transcription*, *errors*, *machine learning*, *artificial intelligence [AI]*,

nursing documentation, *informatics*, *computer applications for medicine*, *e-health*, *telemedicine*, *telehealth*, *outcomes*, *human factors*, *medical device integration*, *real-time-visibility*, and *improvement*).

Exclusion criteria included the following:

- articles not written in English;
- vendor publications, white papers, or other such materials; and
- articles written before the year 2000.

By using these inclusion and exclusion criteria in concert with the data sources listed above, I ensured this systematic review of the literature would be comprehensive and exhaustive.

Analysis and Synthesis

PRISMA Diagram

Following IRB approval, the systematic review of the literature began. Using the key search terms, I began collecting articles from the databases and resources. To show readers how decisions were made regarding inclusion versus exclusion, I used a PRISMA diagram. PRISMA (2015) stands for Preferred Reporting Items for Systematic Reviews and Meta-Analyses. The PRISMA process allows researchers to show how the collection of resources resulted in the final number of articles included in the study by showing the researchers' progression through four main steps: identification, screening, eligibility, and inclusion (PRISMA, 2015).

Identification. In the first step, researchers begin searching relevant databases using key search terms to identify articles. After searching databases, researchers search

for additional articles through other sources that are not in the databases. The articles identified in both approaches are counted in the beginning numerator (PRISMA, 2015).

Screening. Following the identification step, the researcher than evaluates all articles collected from both databases and nondatabase sources, and crosschecks that list to remove duplicates. Of the remaining articles, the researcher looks for any exclusion criteria such as incorrect dates or articles not published in English (PRISMA, 2015).

Eligibility. Following the screening step, the researcher evaluates the remaining articles for eligibility for inclusion in the study. This step involves reviewing the articles' content to determine whether the article addresses the practice-focused question. Articles that do not address the practice-focused question might not be included in the study (PRISMA, 2015).

Inclusion. During this step, all articles that have survived the previous steps are included in the final study for analysis. This means articles are not duplicative, satisfy all inclusion criteria, have no exclusion criteria, and address the practice-focused question (PRISMA, 2015).

Organizing the Findings

The identified articles are summarized in a search results table following the criteria recommended by SQUIRE, which stands for revised "Standards for Quality Improvement Reporting Excellence" (SQUIRE 2.0, 2015). This table includes the following information:

- "Study title
- Authors

- Date of Publication
- Problem Description
- Study Aim
- Study Design & Setting
- Ethical Considerations
- Results
- Limitations
- Conclusions
- Level of Evidence
- Analysis and Synthesis" (Walden University, n.d. p. 8).

Following these steps, the researcher examines the articles to address the practice-focused question. In the current project study, all articles were reviewed to assess the information provided with respect to MDI, RTV, and impact on nursing practice with a special focus on data that addressed how the tools and technologies impact the timeliness of nursing documentation. Additionally, any qualitative information provided in the articles was included in discussion.

The researcher examines how the included articles address the practice-focused question. This section also includes the strengths and weaknesses of the available literature and whether a gap exists in the literature on the practice topic. Finally, the researcher develops recommendations based on the available evidence. If insufficient evidence exists, the researcher may recommend that additional studies be done to provide

additional evidence. If enough evidence exists, the researcher may make recommendations to nursing practice based on the available evidence.

Summary

This systematic review of the literature was conducted to answer the practice-focused question: What is the impact of medical device integration and real-time visibility on nursing workflow? A systematic review of the literature revealed the highest level of evidence and contributed to the body of nursing knowledge by helping nurse leaders understand the impact of new integrated technologies on nursing workflow. To conduct this systematic review, I identified the appropriate sources of information including health databases, IT databases, and nursing informatics resources. I also identified the key search terms to be used when searching those databases to identify articles to be considered in this systematic review. The systematic review was done with inclusion and exclusion criteria to narrow results to articles appropriate for this review. This process was illustrated using a PRISMA (2015) diagram, and each article was summarized in a table following the SQUIRE (2015) format. Finally, the articles included in the study were analyzed for their relevance to the practice-focused question.

Section 4: Findings and Recommendations

C-suite leaders are pressed to provide equipment to nurses that improves their daily workflow, while nurses are pressed to get more work done with the same or fewer resources. MDI vendors claim that use of their product, when integrated with the EMR, results in improved RTV and reduces transcription errors. The purpose of this systematic review of the literature was to identify evidence-based literature that addresses the impact of MDI on the RTV of nursing documentation.

Search Results

This search yielded 205 articles that were reviewed according to the abstract and/or title. After duplicates were removed, 203 articles were screened. There were 188 articles that were excluded based on the information contained in the abstract and/or title. Four articles were excluded based on being business news and not scholarly articles. The remaining 11 articles had full text for review. Of those, 10 did not have measurements of the impact of MDI on RTV. However, they had qualitative data that addressed MDI or RTV (or variations of those terms). As a result, these articles were included in the analysis. One article had measurements on the impact of MDI on RTV (see Figure 1 in Appendix A).

The 11 articles were categorized according to the SQUIRE criteria (see Tables 1 and 2 in Appendix B). Wager et al. (2010) was the only article that included measurements of RTV as a result of MDI (see Table 1 in Appendix B). The remaining articles are included in Table 2 (see Appendix B). All articles are described in the narrative summary.

Findings and Implications

Included Studies with RTV Measurements

As shown in Table 1 (see Appendix B), only one study focused on the reduction of RTV by virtue of MDI. Wager et al. (2010) used three modes of documentation and measured the time to RTV with each. In the first process, end users recorded vital signs in the paper medical record. The average RTV in this process was 85 seconds. In the second process, end users brought a Workstation on Wheels (WOW) into the room along with the vital signs machine. In this workflow, end users let the vital sign machine take the recording, wrote the recording on paper, and transcribed it into the EMR. The average RTV in this process was 555 seconds. In the third process, the end users substituted the WOW for a handheld personal documentation assistant (PDA) tablet affixed to the vital signs machine. This PDA tablet was integrated with the EMR. In this workflow, end users let the vital sign machine take the recording and then the end user recorded those vital signs into the EMR using the PDA. The average RTV in this process was 35 seconds.

Explanation of Results

In the first process in which nurses documented the results in the paper record, the average RTV was 85 seconds. Although the results were in the paper record, this situation requires someone to have the record in front of them to see the results. Although the RTV was 85 seconds, the paper record was not universally viewable throughout the organization.

In the second process in which nurses documented results in the EMR using the WOW, the average time was 55 seconds. Wager et al. (2010) were surprised to see this result, but upon further review were able to understand why. The use of the WOW for documentation in the EMR was problematic in that sometimes a WOW was not available. In this case, the end user would let the vital sign machine take the measurements. Then the end user would write them down on paper and wait for a WOW to become available to transcribe the results into the EMR (Wager et al., 2010).

In the third process, a tablet was affixed to the vital signs machine with direct integration into the EMR. The end user allowed the vital signs machine to take the recording. Then the end user reviewed the recording and validated the data. After validation, the end user pressed a button that sent the recording into the EMR. The vital signs recording was not visible to other clinicians until this final step was complete. The average time for RTV in this process was 35 seconds. Wager et al. (2010) observed that because there was no issue with equipment availability, the vital signs were visible in the chart much faster.

As a result of these findings, Wager et al. (2010) pointed out that the addition of WOWs to end users did not guarantee a reduced RTV if there were insufficient WOWs to perform the documentation. Additionally, the requirement of transcribing the data from the vital signs machine into the WOW, even when both pieces of equipment were in the same room, was not optimal. The option that showed the greatest reduction in RTV was the direct transmission from the vital signs machine into the EMR via the tablet affixed to the vital signs machine with this capability (Wager et al., 2010).

Included Studies Without RTV Measurements

In this systematic review, 10 peer-reviewed articles were found that addressed MDI or RTV (or a variation of those terms) and provided insight into the subject of MDI and its impact on clinical documentation. Vendors often cite additional benefits that their MDI products can provide. In my review of these 10 peer-reviewed articles, several important themes became apparent. These articles addressed how MDI can affect documentation in addition to the purported reduction in RTV. These themes are organized as follows: expected reduction of RTV (without measurements), impact of MDI on documentation errors, additional devices that may be considered for MDI, additional locations that may benefit from MDI, additional tools that benefit from MDI, and general guiding questions or principles.

Expected reduction of RTV without measurements. In six of the articles, the researchers mentioned the expectation that MDI would result in a reduction of RTV, though neither baseline metrics nor actual measurements were taken to evaluate this expectation. Despite the lack of measurement data, the consensus was that automatic transmission of data, even when including the additional step of verifying data before transmission, is faster than manual transcription into the EMR. Rausch and Judd (2006) estimated that RTV would be reduced from 300 seconds to nearly 0 seconds with the addition of MDI to vital signs machines. Witonsky (2012) estimated that through MDI, RTV would result in a savings of 2,000 hours per year in a 150-bed hospital. Although the reduction in nurse hours is not the same as a reduction in RTV, Witonsky addressed the concept of saving time.

Impact of MDI on documentation errors. The potential reduction of documentation errors was a key point made in all 11 articles. Researchers addressed errors of omission and errors of commission as key considerations for MDI. One error of omission is when a transaction (input), such as the documentation of vital signs, is not entered into the record. This could be a single data point or all of the data points from a set of vital signs. An error of commission is when the wrong data are entered into a record. This could be the right data entered into the wrong chart, or the wrong data entered into the right chart (Surbhi, 2019). Several studies, including Wager et al. (2010), indicated reductions in documentation errors as a result of MDI. Additionally, several researchers measured the impact of MDI on documentation errors and provided data showing statistically significant reductions in one or both types of errors (Hristoskova et al, 2014; Kowalski et al, 2017, Marvin, 2017, McConnell, 2000). The frequency of this subject in the literature indicates that error reduction may be a key consideration driving organizations to consider MDI.

Additional devices that may be considered for MDI. In six of the articles, researchers mentioned other devices that may be considered for MDI in addition to vital signs machines. These devices included pulse-oximetry monitors in both inpatient and outpatient settings, scales for measuring weight changes for congestive heart failure (CHF) patients, IV pumps, ventilators, anesthesia machines, monitors for infants, electrocardiogram waveform measurements, patient wearables, and smart devices such as Android phones or iPhones. In each of these articles, the researchers made the point that MDI with these devices should lead to improved efficiency, reductions in errors, and

improved RTV (Ansermino, 2013; Feldman, 2011; Moqeem et al, 2018, Smith, 2009; Villareal et al, 2018; Witonsky, 2012).

Additional locations that may benefit from MDI. In nine of the articles, there was a discussion about where MDI would be valuable. Although vital signs are often associated with inpatient measurements, they are also taken in outpatient settings such as doctors' offices, hospital outpatient departments, treatment centers, and nursing homes. In any location, the data collected are more valuable if they are accurate and timely. Several researchers discussed how MDI can improve RTV and error reduction while increasing clinician efficiency in those settings (Ansermino, 2013; Feldman, 2011; Hristoskova et al, 2014, Marvin, 2017, Moqeem et al, 2018, Smith, 2009, Villareal et al, 2018, Wager et al, 2010, Witonsky, 2012).

Two other key points arose from this review. First, in what is now commonly understood to be the digital age, patients are frequently wearing devices (known as patient wearables) that actively and passively collect discrete information about their condition. Devices such as the FitBit, Apple Watch, and Galaxy Watch allow the wearer to have a unique experience with personal health by collecting information such as heart rate and electrocardiogram rhythms. In these articles, the researchers discussed the value of these patient wearables as an easy way for health care providers to collect real-time information provided by the patient to add to their overall record (Marvin, 2017; Moqeem et al, 2018, Moscaritolo & Colon, 2020; Rausch & Judd, 2006; Villarreal et al, 2010). Additionally, there is a groundswell of interest from patients to have this information

included in their medical records. These discussions imply that RTV, in whatever form it comes, is useful to clinicians.

The second point that came from these articles was the use of mobile devices such as smart phones (Android, iPhone) as mobile platforms for data collection and transmission. Of particular interest were several points made about patients in the United States who are in rural areas and patients across the world who are in developing countries. In the digital age, more people have smart phones with the ability to transmit information digitally. In the United States, more than 80% of the population owns a smartphone, which is up from 35% in 2011 (Pew Research Center, 2019). Additionally, roughly half of the world's population (3.5 billion people) used a smartphone in 2020, and an expected 3.8 billion will use smartphones by 2021 (Statista, 2020). The discussions of mobile phones indicated that their increasing use and functionality supports claims that these tools could be invaluable for MDI provided that appropriate security measures are in place to protect PHI for patients (Ansermino, 2013; Villarreal et al, 2018). Another point made in one of the articles is the ability to share information with multiple locations once it is collected. A patient with a wearable can choose to have that information sent to their primary care provider, specialist, hospital, and others (Villarreal et al, 2018). This is especially useful to consider if each of those locations is using a different EMR platform.

Additional tools that may benefit from MDI. The collection and transmission of data from medical devices, smart phones, and patient wearables is only one aspect of MDI. In addition to collecting and transmitting the data, the ability for discrete data to be

manipulated (processing) once it is in the EMR is a major consideration for clinicians and organizational leaders. There are a number of ways that the data can be manipulated; however, in seven of these articles the two ways that were discussed were clinical decision support and predictive modeling or predictive analytics (Bresnick, 2018; Feldman, 2011; Hristoskova et al, 2014; Kowalski et al, 2017, Marvin, 2017; Moqeem et al, 2018; Smith et al, 2009).

Clinical decision support is the use of programming logic to take two disparate pieces of information that are interrelated and help clinicians make decisions, especially if clinicians are unaware of any of the information or the relationship (Saba & McCormick, 2011). Clinical decision support is a type of output from a systems theory perspective. An example of this would be a patient with CHF. In the outpatient setting, a CHF patient's weight is of particular interest to the primary care provider. If a patient had a scale with MDI integration to their EMR and did daily weights, when the provider opened the patient's chart this would help the provider determine whether the patient had weight gain. It is additionally beneficial if the provider is proactively notified of a patient's weight gain without the need for the provider to open the patient's chart. Clinical decision support logic could take the two pieces of discrete information (patient has CHF and patient has gained weight) to proactively notify the provider to open the chart and take action. Clinical decision support would be enhanced with MDI because clinicians would receive information more quickly.

Although clinical decision support is a useful tool to tell a provider about what has already happened, the second tool of interest in this systematic review was predictive

modeling or predictive analytics, which can help a provider forecast what may happen in the future. These tools are built from large amounts of data using techniques like linear regression to retrospectively evaluate data points to predict outcomes. In the health care arena, there are a number of predictive models that providers or organizations may be interested in, such as population health risk scoring for chronic diseases, predicting and preventing 30-day hospital readmissions, evaluating and adjusting to patient utilization patterns, and preventing patient clinical deterioration (Bresnick, 2018). These tools can be used in both inpatient and outpatient settings. In the current systematic review, the consistent point was that the earlier the tool has access to the patient data, the more accurately and efficiently it can notify the provider about important modeling information (Bresnick, 2018; Marvin, 2017; Moqeem et al, 2018).

General guiding questions or principles. The final theme that emerged from this systematic review was that executive leaders in the health care environment must be prepared to evaluate MDI and its impact on the efficiency of clinicians and organizations. In addition to the touted benefits, executive leaders need to be cognizant of risks of MDI to make informed decisions. Three articles in this systematic review provided sets of questions that C-suite leaders should be prepared to ask of vendors, regulatory bodies, and clinicians when developing an MDI strategy (Gruebele, 2017; Hockel, 2010, Witonsky, 2012). One recommendation from the articles was that it is important for C-suite leaders to develop a road map of where they want to go before they make decisions of how they want to get there (Rausch & Judd, 2006). Data transmission can be useful to clinicians, but it can also present risk if certain questions are not asked or answered.

One of the dominant themes in health care IT is the risk of data breach as a result of accidental or intentional PHI exposure. According to HIPAA Journal (2019), the average breach size in the United States is over 25,000 records. Mega breaches are classified as breaches of over 1 million records. In the United States, the average cost per breach is approximately $429 per record, with an average cost of nearly $4 million per breach (HIPAA Journal, 2019). With that in mind, it is crucial that C-suite leaders understand the risks and balance those with the benefits before making a final decision on what types of MDI strategies should be deployed at their facilities.

Recommendations

Both C-suite leaders and nursing leaders are interested in whether medical device integration (MDI) improves nursing workflow and efficiency. The purpose of this systematic review of the literature was to identify evidence that showed a reduction in RTV as a result of installing MDI technology.

The results of this systematic review of the literature yielded only one published study wherein a time-motion observational study collected baseline data from three data entry approaches. The results of that study showed a statistically significant improvement in RTV by reducing the RTV from 85 seconds in a paper-based process to 35 seconds (a nearly 60% improvement) in the process leveraging MDI (Wager et al, 2010). Due to the paucity of appropriate studies, the recommendation is that further study needs to be done to collect more evidence to support this claim. Additionally, it is recommended that more than one type of MDI-ready platform be tested, and that testing occur in multiple locations such as inpatient, outpatient, and other such locations.

In this systematic review of the literature and analysis of results, it has become clear that reducing RTV is only one component of MDI. An additional 10 peer-reviewed articles discussed further benefits of MDI that should be considered regarding MDI-ready platforms. Reductions in transmission errors, improvements in the usability of other tools such as clinical decision support and predictive analytics, as well as an expanded footprint for where care can be delivered are all benefits cited in support of MDI-ready platforms. Therefore, in addition to the recommendation that further study be conducted to validate the reduction in RTV, it is also recommended that C-suite leaders and nursing leaders consider these concepts when evaluating MDI-ready platforms in order to develop a list of needs for their organizations.

Strengths and Limitations of this Project

The results and recommendations of this systematic review of the literature must be viewed through the lenses of both the strengths and limitations. This systematic review of the literature is strengthened by the findings that support the claim that MDI can improve RTV for vital signs. Additionally, narrative results indicate that there are multiple proven benefits of MDI-ready platforms that health care leaders should consider.

The review is limited by the fact that only one article contained a study that provided baseline and interventional metrics (Wager et al, 2010) that showed the impact of MDI on RTV. This may not represent a large enough sample in order to make the findings generalizable. Additionally, the facility in question only tested one application and one location (inpatient). Additional studies that included multiple MDI-ready

platforms and multiple locations would make the evidence stronger and more generalizable.

Summary

In the 21st century and beyond, health care will become increasingly dependent on technological advances. As these advances happen it is equally important for health care leaders to understand how new technologies can impact their organizations and their staff. This systematic review of the literature was performed in order to collect information related to Medical Device Integration and how that technology can impact Real Time Visibility for nurses in the collection of vital signs. Evidence found suggests that MDI can help reduce RTV for vital signs but additional study is needed to evaluate different MDI-ready platforms and their impact on locations such as outpatient settings, nursing homes, and others.

Section 5: Dissemination Plan

The purpose for this systematic review of the literature was to provide evidence that supports MDI-ready platforms to increase efficiency for nurses. In a large Catholic health system with over 50 hospitals, it is important that health care leaders understand the value of these tools. My plan for dissemination is to share this information with several key stakeholders in the organization. The chief nursing officer, chief nursing informatics officer, and chief information officer share responsibility for ensuring that nurses have equipment that makes their jobs easier, safer, and faster. These C-suite leaders can share the findings from the project study with additional leaders such as the chief financial officer and chief executive officer to guide future decisions. With the evidence showing the benefit of MDI-ready platforms, these leaders can make decisions on other considerations such as how much money the organization is willing to spend, technical infrastructure needed to support MDI, risk, and support.

Analysis of Self

More than 10 years ago, I made a decision to change my focus in nursing and begin working in nursing informatics. At that time, the use of EMRs was emerging, and I found that many coworkers and other clinicians were frustrated with these tools. Contrary to the stereotypes often cited, these were not old doctors nurses ready for retirement. Instead, these were people my own age, some even younger, who were smart and great problem solvers. However, for them the advent of EMR technology served to increase their burden instead of lightening it. Over time, it became clear that the voice of the clinician was often missing from discussions on the need for technology and the designs

that followed. The system, as my wife said, was broken and needed people like me to step in and help to fix it. At that time, I held only an associate's degree in nursing and had almost a decade of experience as a floor nurse.

Realizing that I needed more than hands-on experience if I wanted to improve the system, I started school to get my baccalaureate degree and followed shortly with my master's degree in nursing. At the same time, I continued to advance in my career, slowly rising in the organization to a point where I had the opportunity to work regularly with key decision-makers, and eventually becoming a decision-maker myself. But as my view of the health care landscape expanded, it became clear that I had more learning and growing to do to understand how I could help in the health care system. I evaluated my options, understood that I was passionate about implementing change, and realized I was better suited for a DNP degree than a doctor of philosophy degree, so I began my pursuit of a DNP.

After several years of study and hard work, I had the opportunity to conduct a systematic review of the literature on a topic that has real-world applicability. I learned about the eight DNP Essentials and spent time honing my skills in each. Some are easier and more natural than others, but I imagine that is true for each person. On this journey, I have also found myself coaching and mentoring others inside and outside of the classroom. I have coached and been coached by my instructors and other students at Walden, and have served as a mentor for colleagues pursuing their master's degrees in nursing.

My education has given me a wide view of the health care landscape, and I have a better understanding of cause and effect, as well as the drivers and constraints, that I did not appreciate when I was practicing as a floor nurse. I understand the forces at work in health care finance, health care regulation, supply and demand, technology, and government oversight. Although my compassion for patients has not waned, my compassion for health care leaders who face incredible scrutiny has increased.

As a result of over 12 years of education, I believe I have a better understanding of the aspects of health care that need to be fixed. Additionally, I have come to understand that fixing health care is not a goal but a journey. As a DNP, my job will be to look at the situation, identify the problems and the ways to fix them, and predict where the next problem might turn up and how to prevent it. In that way, I can help improve the situation for the people delivering care to patients. It is with gratitude to everyone who has helped me on this road that I finish this portion in my journey as a nurse and scholar.

Summary

As I type this, I am days shy of the 200th anniversary of the birth of Florence Nightingale (May 12, 1820). In her time, the lady with the lamp had very little technology to help her in her nursing rounds. Almost 200 years later, I have the privilege of working in a subspecialty of nursing in which the focus is the evaluation and implementation of technology to help frontline nurses. Every day, new technologies are proposed to help nurses and other health care staff do their jobs.

However, technologies need to be evaluated to ensure that they help those they claim to help. Additionally, technologies need to be evaluated for their cost-effectiveness,

longevity, and ease of use. Using a methodological approach, nurse leaders can continue the legacy of Florence Nightingale by evaluating the tools to make patient care easier, safer, and faster.

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Appendix A: PRISMA Flow Diagram

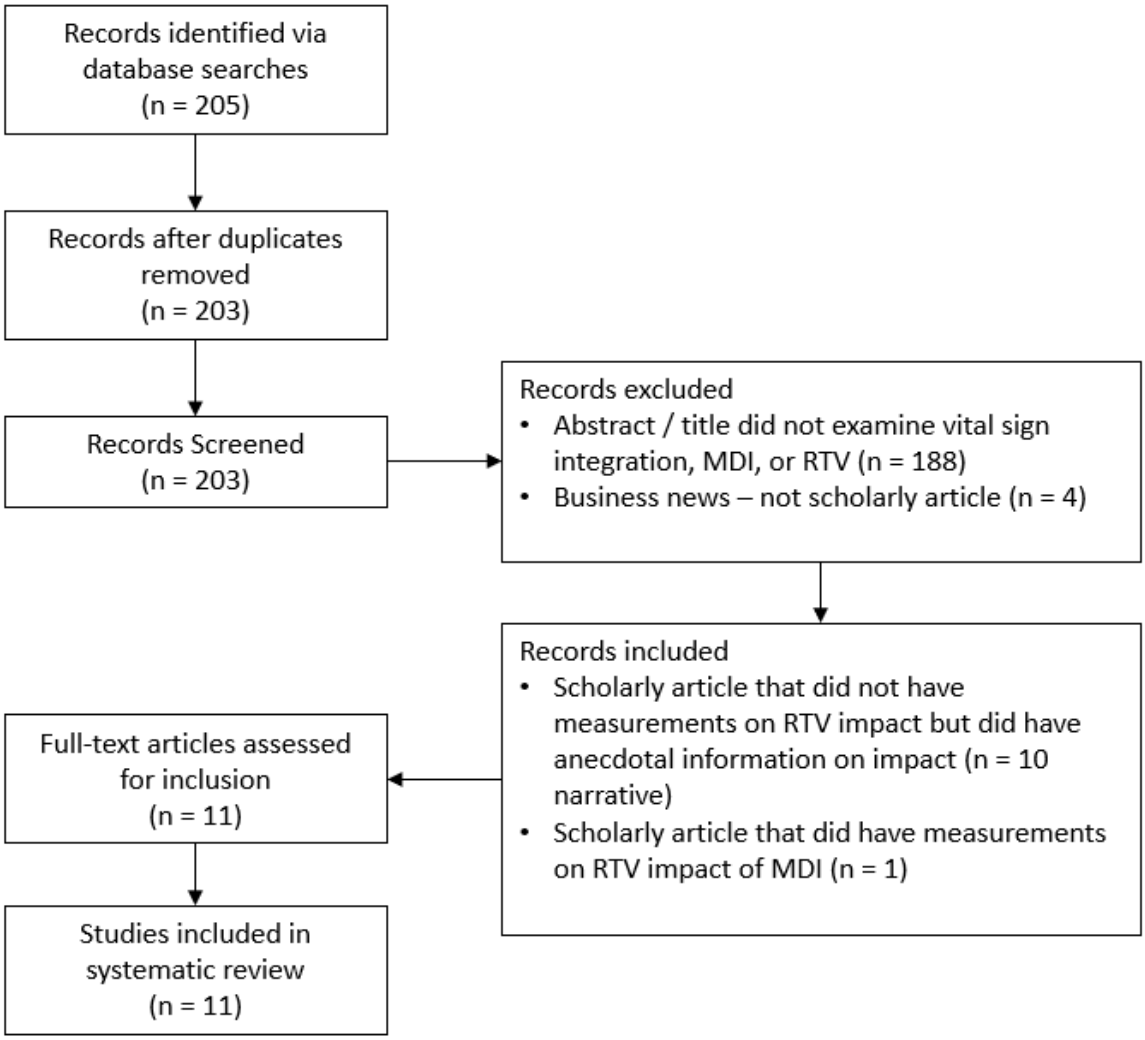

Figure 1. PRISMA flow diagram of search and study selection.

Appendix B: Search Result Tables

Table 1

Characteristics of Included MDI / RTV Studies With RTV Measurements

Title	Study Author	Date of Publication	Problem Description	Study Aim	Study Design & Setting	Ethical Considerations
Comparison of the Quality and Timeliness of Vital Signs Data using Three Different Data-Entry Devices	Wager, Shaffner, Foulois, Swanson Kazley, Parker, Walo	2010	Study aimed at evaluating the impact of MDI on RTV and transcription errors.	Evaluating the RTV using paper to document and then transcribing data later into the Electronic Health Record (EHR), tablet / Personal Data Aassistatn (PDA), and Workstation On Wheels (WOW).	Observational study at Medical University of South Carolina	None

Title	Results	Limitations	Conclusions	Level of Evidence	Statistical Analysis
Comparison of the Quality and Timeliness of Vital Signs Data using Three Different Data-Entry Devices	Paper record transcribed mean = 84 seconds WOW documentation outside of room mean = 555 seconds PDA documentation in Real Time mean = 35 seconds	Potential risk of the Hawthorne effect taking place since the personnel being observed may have changed their behavior as a result. Another possible limitation is that different Patient Care Technicians had different workflows, which may make the resultant decrease in time different.	Study showed that electronic documentation tools outside of the room was worst, hand-written documentation transcribed was second-worst, and real-time documentation with a portable PDA was best	Single Cohort Study. Level IV.	Paper record SD 137 seconds WOW documentation SD 445 seconds PDA documentation SD 102 seconds P < .001

Table 2

Characteristics of Included MDI / RTV Studies Without RTV Measurements

Title	Study Author	Date of Publication	Problem Description	Study Aim	Study Design & Setting	Ethical Considerations
Universal access to essential vital signs monitoring	Ansermino	2013	Article discussed remote monitoring of pulse oximitry and the importance of creating a mobile platform for helping patients in the outpatient setting.	Not a study	Article described the need for mobile pulse oximetry, especially in developing countries and discussed several platforms being developed. The goal is to provide clinicians with real time information in order to make good clinical decisions.	None

Title	Results	Limitations	Conclusions	Level of Evidence	Statistical Analysis
Universal access to essential vital signs monitoring	Author describes several vendors working to create mobile platforms for remote monitoring of pulse oximetry in order to give clinicians real time visibility into clinical changes. Author stresses the importance of these platforms in developing countries.	Not a study. Article discusses real time visibility as a goal that needs to be achieved for developing countries and providers who rely on pulse oximetry data to make decisions on care.	Real time visibility is a goal that should be achieved. Platforms being developed should be mobile, secure and relay information quickly to providers.	Opinion. Level VII.	None

Title	Study Author	Date of Publication	Problem Description	Study Aim	Study Design & Setting	Ethical Considerations
Ontology-driven monitoring of patient's vital signs enabling personalized medical detection and alert	Hristoskova, Sakkalis, Zacharioudakis, Tsiknakis, and De Turck	2014	Article discussed remote monitoring of vital signs and other information for CHF patients and how the process improved the timeliness of clinical decision support for providers. The article, however, did not provide data on improvement of RTV.	Article explained the need for Real Time Visibility in the course of monitoring outpatients with chronic diseases such as CHF. Then, by using Clinical Decision Support, the authors propose logic that would notify providers of important results. The authors refer to this as "Ambient Intelligence" or AmI. The article primarily discussed the technical considerations needed for developing a system for secure transmission and verifiability by the provider.	Not a study	None

Title	Results	Limitations	Conclusions	Level of Evidence	Statistical Analysis
Ontology-driven monitoring of patient's vital signs enabling personalized medical detection and alert	Authors provide an extensive description of Clinical Decision Support logic that would be used to establish a remote vital sign monitoring and reporting platform to help providers care for patients with CHF remotely.	Not a study, but a strong technical article discussing steps needed with the expressed idea that clinicians need access to data as close to real time as possible in order to make sound clinical decisions, and then go on to describe a mechanism for establishing such a platform.	RTV continues to be considerd a very important goal in order to help clinicians provide appropriate care to patients - both in inpatient and outpatient settings.	Opinion. Level VII.	None

Title	Study Author	Date of Publication	Problem Description	Study Aim	Study Design & Setting	Ethical Considerations
Optimizing usability and signal capture: a proactive risk assessment for the implementation of a wireless vital sign monitoring system	Kowalski, Capan, Lodato, Mosby, Thomas, Arnold & Miller	2017	Authors describe the value of patient wearables in achieving RTV in order to provide clinicians with important information.	Study was designed to evaluate the mechanics and coding needed to set up and maintain interoperability between patient wearables and the Electronic Medical Record.	Authors conducted a Healthcare Failure Mode and Effect Analysis (HFMEA) to assess the performance of the patient wearables platform at Christiana Care Health System in Delaware.	None

Title	Results	Limitations	Conclusions	Level of Evidence	Statistical Analysis
Optimizing usability and signal capture: a proactive risk assessment for the implementation of a wireless vital sign monitoring system	The benefit of leveraging patient wearables in RTV is demontrated by providers having access to important clinical information quickly. In addition, predictive analytics models can perform better when data is supplied more frequently.	Study is an HFMEA on the platform. It does not measure the impact patient wearables and MDI have on RTV.	Patient wearables have the potential to add to the data set that can be included in MDI and RTV improvements. These can help providers get information faster, have information that is trended over time, and can be used in both inpatient and outpatient areas.	Descriptive Study. Level VI.	None

Title	Study Author	Date of Publication	Problem Description	Study Aim	Study Design & Setting	Ethical Considerations
Health Information Technology: Integration, Patient Empowerment, and Security	Marvin	2017	Article discusses rationale for pursuing interoperability with devices such as pumps and monitoring devices.	Survey about the future of interoperability and MDI	Not a study. Survey of "Forecast Panelists"	None

Title	Results	Limitations	Conclusions	Level of Evidence	Statistical Analysis
Health Information Technology: Integration, Patient Empowerment, and Security	Author provides results from "Forecast Panelists" that indicate they expect the following by 2021: 89% of health systems will have "Very or somewhat likely" reorganized IT infrastructure towards systemwide integration 74% of systems will have "very likely or somewhat likely" have achieved interopability between EHR and medical devices	The article discusses the "Forecast Panelists" who participated in the survey, but does not indicate their backgrounds, or the number of people who constitute the survey.	Systemwide integration of Medical Device Integration (MDI) is expected to improve end-user efficiency, and the downstream effect should be better patient outcomes and care coordination.	Survey (Qualitative study). Level VI.	None

Title	Study Author	Date of Publication	Problem Description	Study Aim	Study Design & Setting	Ethical Considerations
Vital signs' vital integration	McConnell	2000	At the turn of the century, it was already evident that MDI would be necessary to help facilitate the accurate and timely transmission of vital signs data into Electronic Medical Records.	Not a study	Not a study	None

Title	Results	Limitations	Conclusions	Level of Evidence	Statistical Analysis
Vital signs' vital integration	Author provides a list of factors that C-suite leaders should review which provides questions that should be asked in the pursuit of MDI.	Not a study, but a recap of other studies to demostrate the value of MDI.	Executives need to be mindful of a number of factors that influence the overall value of MDI-ready platforms.	Opinion. Level VII.	None

Title	Study Author	Date of Publication	Problem Description	Study Aim	Study Design & Setting	Ethical Considerations
Medical Device Integrated Vital Signs Monitoring Application with Real- ime Clinical Decision Support	Moqeem, Baig, Gholamhosseini, Mirza, and Linden	2018	The increasing populatity of smart phones has made it important to consider their use in MDI.	Study designed to evaluate the use of Android smartphones for improving RTV through Bluetooth integration	Not described in the article	None

Title	Results	Limitations	Conclusions	Level of Evidence	Statistical Analysis
Medical Device Integrated Vital Signs Monitoring Application with Real- ime Clinical Decision Support	Author describes the process used to develop a smartphone app that will allow for the nurse to perform basic documentation on the patient's EMR record using a hand-held smartphone rather than a WOW. RTV is achieved when the nurse documents directly in the smartphone.	The use of a smartphone in this article is in lieu of a WOW, therefore it cannot be said that using a smartphone achieves RTV better than a WOW or any other documentation platform. It does speak to ease-of-use for a nurse for those elements, but is incomplete and would require the nurse to continue use of other documentation platforms in order to document any content not contained in the limited smartphone app.	Smartphone technology can help clinical personnel from an ease-of-use standpoint.	Opinion. Level VII.	None

Title	Study Author	Date of Publication	Problem Description	Study Aim	Study Design & Setting	Ethical Considerations
The Development of an Interoperable Roadmap for Medical Devices	Rausch and Judd	2006	Authors describe the importance of interoperability between medical devices and electronic medical records, and describe a roadmap that can help organizations achieve that goal.	Not a study	Authors describe the landscape of interoperability between medical devices and electronic medical record for numerous different device types such as diagnostic machines, physiologic monitors (vital signs), cardiology, ventilators and infusion pumps.	None.

Title	Results	Limitations	Conclusions	Level of Evidence	Statistical Analysis
The Development of an Interoperable Roadmap for Medical Devices	Article outlines the importance of interoperability between various devices in an effort to provide clinicians with real time visibility into many different aspects of a patient's clinical presentation.	Not a study. Article describes many different devices types that would benefit from interoperability in order to give providers faster access to physiological changes.	Real time visibility is important for more than just vital signs. Physiologic monitors should also be designed in a way to help providers see data faster.	Opinion. Level VII.	None

Title	Study Author	Date of Publication	Problem Description	Study Aim	Study Design & Setting	Ethical Considerations
Connected Care: Reducing errors through automated vital signs data upload	Smith, Banner, Lozano, Olney, and Friedman	2009	Vital signs are an important part of health care. When they are incorrect, poor decisions can be made. Therefore it is important to ensure that the data collected is accurately input into the EHR.	Investigation on whether MDI reduces transcription errors.	20-bed cardiac unit. Three week observational study. Nurses were trained on how to use a PDA to input data	None

Title	Results	Limitations	Conclusions	Level of Evidence	Statistical Analysis
Connected Care: Reducing errors through automated vital signs data upload	Out of a total of 9084 individual data points, MDI resulted in just 53 omission errors. Of those, 16 were respiratory rate values because those cannot be captured by the vital signs machine. Three full sets of vital signs were omitted because, while they were collected and transmitted, they were never validated by a nurse and did not officially become part of the patient's EHR record. Overall, a total of 53 omission errors for a rate of 0.58%. There were seven transcription errors for a rate of 0.08%. There were no transmission errors (meaning that the interface did not cause a failure). Baseline data showed an error rate of 4.4% prior to the study.	There is a chance that the Hawthorne Effect could have changed how nurses performed since they knew they were a part of a study.	MDI reduces errors of documentation in the patient chart, thereby improving accuracy of data and reducing the chance that a poor decision might be made on faulty data.	Single Cohort Study. Level IV.	Chi test for independence compared the error rates between methods. The reduction in error rate using MDI was statistically significant ($P < .001$)

Title	Study Author	Date of Publication	Problem Description	Study Aim	Study Design & Setting	Ethical Considerations
Sensing and Storing the Blood Pressure Measure by Patients through A Platform and Mobile Devices	Villareal, Nielsen, and Samudio	2018	Vital signs are important in outpatient settings as well as inpatient settings. In rural areas, it is important to make it easier for patients to self-monitor and report results to providers - especially if they are far away geographically.	This study was the creation and evaluation of a mobile platform for patients to use for the measurement and reporting of blood pressure and weight readings to their providers.	63 patients were selected to evaluate the usability of the mobile blood pressure and weight platform using their smart phones in Panama. Following the development of the platform, users filled out a survey with Likert questions to answer questions related to usability and quality	None were obvious, but it is unclear if study design and IRB approval are required in Panama as they are in the US.

Title	Results	Limitations	Conclusions	Level of Evidence	Statistical Analysis
Sensing and Storing the Blood Pressure Measure by Patients through A Platform and Mobile Devices	Patients aged 47 to 68 years old had the hardest time using the mobile devices. Nearly 77% of responses were "strongly agree" that the platform had a high quality and was easy to use.	Study is of only 63 patients and is not related to improving RTV compared to manual processes. Also, it is unclear if studies in Panama have the same rigor as in the US. Additionally, there is no data from providers who would receive this information so it is unclear whether this data was actually transmitted, or only done as a proof-of-concept.	Mobile platforms offer a good opportunity to improve patient outcomes in the outpatient setting - especially in rural areas where patients do not have easy access to providers. However, care should be taken to include providers' input in the design and validation of these platforms.	Single Cohort Study. Level IV.	None

Title	Study Author	Date of Publication	Problem Description	Study Aim	Study Design & Setting	Ethical Considerations
Leveraging EHR investments through medical device connectivity	Witonsky	2012	Article discusses other studies that showed the value of MDI	Not a study	Not a study	None

Title	Results	Limitations	Conclusions	Level of Evidence	Statistical Analysis
Leveraging EHR investments through medical device connectivity	Study at University of Alabama Birmingham Health System showed a reduction in Real Time Visibility from 240 seconds to 20 seconds. Article from HIMSS New Jersey presentation cites a 15-bed hospital could save 86,000 nursing hours per year. Wise Regional Health system found that 12 hours could pass from when patient monitor information was generated and when it was validated in the EHR. Following device integration, that time dropped to 2 hours. Article also cites several other studies that discuss the reduction of transcription errors as a result of MDI.	Not a study, but a recap of other studies to demostrate the value of MDI.	MDI improves clinician efficiency. It also allows for additional tools to be leveraged (such as predictive models) which can work in real-time to improve patient outcomes.	Opinion. Level VII.	None