Remote Patient Monitoring as a Means to Reduce 30-Day Readmissions in Skilled Patients: An Integrative Review

Sharee Birkett

A scholarly project

Submitted to the

Faculty of Liberty University

In partial fulfillment of the

Requirements for the degree

Of the Doctor of Nursing practice

By Sharee Birkett

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Lynchburg, Virginia

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Scholarly project chair approval:

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ABSTRACT

Readmissions among skilled patients are a problem nationwide with rising rates despite federal mandates. Per the AHRQ (2021), readmission costs are estimated to average $15, 200 per patient. Interventions are needed to reduce readmissions and improve patient outcomes. Remote patient monitoring (RPM), especially with continuous vital sign monitoring (CVM) is one method that could reduce readmission rates. The purpose of this integrative review is to determine whether RPM could be used to reduce emergency department and 30-day readmission visits for Medicare part A skilled nursing patients. Utilizing the Whittemore and Knafl (2005) framework, 29 articles were reviewed with resulting themes from the literature including high rates of readmission in skilled nursing facilities, acceptable vital sign measurements from RPM devices, and improved patient monitoring with CVM and RPM. This integrative review suggests RPM technology could improve readmission rates and patient outcomes with reduced complications and decreased length of stay in acute care patients; however, further research using this technology in skilled facilities is needed.

Keywords: skilled nursing facility, remote patient monitoring, readmission rates, continuous vital sign monitoring

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List of Abbreviations

Agency for Healthcare Research and Quality (AHRQ)

Congestive heart failure (CHF)

Centers for Medicare and Medicaid Services (CMS)

Chronic obstructive pulmonary disease (COPD)

Collaborative institutional training initiative (CITI)

Continuous vital sign monitoring (CVM)

Institutional Review Board (IRB)

Joint Commission on Accreditation of Healthcare Organizations (JCAHO)

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

Remote patient monitoring (RPM)

Situation Background Assessment and Report (SBAR)

Skilled nursing facility (SNF)

SECTION ONE: FORMULATING THE REVIEW QUESTION

Introduction

Thirty-day readmission rates from skilled nursing facilities (SNF) are a quality measure that the Centers for Medicare and Medicaid Services (CMS) use to rate facilities (CMS, 2021a). According to the Agency for Healthcare Quality Research (AHRQ) (2021), in 2018 there were 3.8 million readmissions within a 30-day period, 2.29 million of which were Medicare recipients, or 60% of the total readmissions. Readmissions cost an estimated $4.34 billion in 2006 alone (Ouslander et al. 2016). In 2018, each readmission was estimated to cost $15,200 (AHRQ, 2021). To combat readmission rates, the CMS published the Protecting Access to Medicare Act in 2014, which penalizes facilities that have higher-than-average rates of readmission. This factor is determined by the SNF 30-day all-cause readmission measure (CMS, 2021b). It is calculated based on the risk-standardized readmission rate of all SNFs in the value-based purchasing program, which is mandated for all facilities that accept Medicare. Each facility's rate is compared to all other SNFs and rated yearly based on performance. Facilities are compared with their own readmission data from previous years and given a score of 0-90. In addition, each is also compared with all other facilities and is given a score of 0-100. The highest score becomes a facility's performance score.

Readmissions affect patient outcomes as care is more likely to be fragmented and issues missed when a patient is transferred from facility to facility (Mor et al., 2010). The following integrative review describes technology that could be used to reduce readmissions by providing more frequent and timelier vital sign monitoring to detect patient deterioration before hospitalization is needed. Reducing readmissions can help facilities avoid monetary penalties and increase patient outcomes by preventing fragmented and missed care.

Defining Concepts and Variables

This integrated review will look at remote patient monitoring technologies. Remote patient monitoring (RPM) is defined as technology that provides data related to a person's health status. This can include wearable and contactless devices that measure biometric data. Examples include wearable wristbands, pads that can be placed under chairs and mattresses, and devices that detect respirations without contact. Vital signs measured by RPM can include any and all vital signs taken to monitor health including respirations, heart rate, blood pressure, temperature, and oxygen saturation. Thirty-day readmissions are defined as any admission to the hospital within 30 days after discharge to a skilled nursing facility, regardless of readmitting diagnosis.

Rationale for Conducting the Review

Many Medicare beneficiaries transfer to skilled nursing facilities following inpatient hospitalization when continued care is needed. Reasons for ongoing care can include rehabilitation services, intravenous medications, wound care, and the need for ongoing medical management. Because of these reasons, an estimated one in four Medicare beneficiaries is transferred to a SNF after hospitalization. Of these patients, up to 25% are readmitted to the hospital within 30 days of discharge (Minges et al., 2019). In addition to the costs to hospitals, insurance companies, and patients, readmissions also cause detrimental outcomes in care. Transitions in care from facility to facility increase the likelihood that care is missed while also increasing the chances for medication errors to occur (Mor et al., 2010).

Many readmissions from skilled nursing facilities are considered avoidable, although the percentage varies by source (Minges et al., 2019). Increased costs and poor outcomes from readmissions led to the creation of the Protecting Access to Medicare Act which fines facilities up to 2% for readmissions above the national average (CMS, 2021a). Readmissions are also

included in the Five Star Reporting system quality measures which grades nursing homes and SNFs based on care provided. These quality measures are publicly available for beneficiaries to research SNFs in their area to decide from which they want to receive care. Improving readmission rates increases points to award facilities higher star ratings.

Although not a governing body for SNFs, in 2008, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) added a patient safety goal related to earlier detection of patient deterioration (Ben-Ari, et al., 2010). This goal added measures to encourage healthcare systems to request additional assistance from providers when a patient appears to be decompensating. It also encouraged the development of rapid response teams to improve patient outcomes. The goal was specific to hospitals, but the principle can be applied to all healthcare systems (USDVA, 2008). One process that could provide earlier detection and thus improve readmissions is vital sign monitoring. Vital signs are one of the first signs of patient deterioration (Breteler et al., 2019). Vitals can change six to eight hours before other physical signs appear, and patient decompensation occurs. In some disease processes, vital signs can change up to 48 hours before deterioration. Ouslander et al. (2016) cited abnormal vital signs as one of the main reasons for emergency department transfer within 48 hours post hospital discharge to a SNF.

Per Medicare guidelines, patients in the skilled setting do not require frequent vital sign monitoring. Guidelines require skilled charting once in 24 hours, which is when vital signs are obtained (CMS, 2021a). Facilities can choose to take vitals more frequently; however, many lack sufficient staff which would enable them to do this. Unlicensed personnel, usually nurses' aides, are responsible for taking patients' vital signs in the skilled setting. These staff have differing educational backgrounds, and many have not been trained on the importance of accurate and timely measurements (Madden et al., 2017). In addition, there is a vast shortage of staffing in the

medical field for nurses and aides alike. It was estimated that by 2020, healthcare would be 800,000 nurses short of the number to operate at a reasonable capacity (Ben-Ari, et al., 2010). This staffing shortage means each staff member must care for an increased number of patients. When nurses and aids care for more patients, the gaps between measuring vital signs can greatly widen significantly.

Purpose and Review Question

The purpose of this literature review is to examine the literature on various remote patient monitoring devices that could reduce emergency department and 30-day readmission visits for Medicare part A patients in a skilled nursing facility. Remote patient monitoring, specifically devices that monitor vital signs, could decrease readmissions by identifying abnormal vital signs before clinical signs are obvious so interventions can be implemented to prevent further deterioration and the need for hospitalization. The clinical question that guides this review is the following: Can remote patient monitoring technologies reduce 30-day readmissions in Medicare part A patients who reside in skilled nursing facilities?

Formulate Inclusion and Exclusion Criteria

This review examines literature related to remote patient monitoring devices. Inclusion criteria encompassed any research articles that utilized remote patient monitoring. Devices that monitored vital signs were given preference. Any type of published research was considered for inclusion if it related to remote patient monitoring on the adult population. Other inclusion criteria were comprised of articles published within the last five years (2017-2022), peer reviewed literature, and those written in the English language. Exclusion criteria included technology that was not considered remote patient monitoring. Research related to pediatric patients and childbirth/labor and delivery was also excluded.

Conceptual Framework

The theory of symptom management can be used as a guide for this research (Smith & Lier, 2014). Signs and symptoms allow the healthcare provider to determine if a patient is experiencing an illness that requires intervention. Symptoms are the subjective complaints a patient experiences, whereas signs are the outwardly-visible abnormalities that can be detected by others. Patients seek assistance to alleviate these signs and symptoms via the healthcare system. The theory of symptom management can provide information regardless of whether the goal is to eliminate the symptom or to minimize its severity.

This theory was developed to guide clinical research and practice to improve collaboration and better describe the symptom experience, management, and outcomes (Smith & Lier, 2014). The three concepts of this theory are: symptom experience, symptom management strategies, and symptom status outcomes. The three domains of nursing science, person, environment, and health/illness are all encompassed in each concept. Symptom experience is how one perceives, evaluates, and responds to changes in usual feeling. This allows one to seek symptom management. Symptom management strategies include any efforts to avert, delay, or minimize the symptom experience. Symptom outcomes describe any obvious change in symptom status after intervention is taken.

This theory can be used to guide the research process as it seeks to find an intervention to identify patient signs and symptoms before hospitalization is required. Remote patient monitoring, especially technologies that monitor vital signs, can allow signs to be detected earlier to allow more timely intervention and thus, symptom relief.

SECTION TWO: COMPREHENSIVE AND SYSTEMIC SEARCH

Search Organization and Reporting Strategies

A search for published literature on 30-day readmissions, remote patient monitoring, and continuous vital sign monitoring was conducted via the Liberty University library search function. Search terms included "readmission and remote patient monitoring," "rehospitalization and vital sign monitoring," "skilled nursing facility and continuous vital sign monitoring," and "vital sign monitoring and skilled nursing facility." Parameters for articles included full text online, peer review, English Language, and published within the last five years. These search criteria were also used in the following databases: ClinicalKey, CINAHL with full text, and Medline.

After using the keywords, the search criteria returned 522 articles. Titles were scanned to determine applicability to either readmissions in a skilled nursing facility and/or use of remote patient monitoring (RPM) and continuous vital sign monitoring in acute care settings. After scanning titles, 189 articles fit the criteria. If the title appeared applicable, the abstract was read to determine inclusion. Seventy-five abstracts met criteria. If the abstract appeared to meet criteria, the full article was read to determine inclusion. There were no articles found that studied continuous vital sign monitoring (CVM) in a skilled nursing facility.

In total, 49 articles were analyzed that included the criteria. Of these, 29 included studies on readmissions or RPM/CVM and were used as the final sample. These articles were listed in the literature matrix included in Appendix B. These articles included a meta-analysis, systematic reviews, descriptive and observational studies, and one case series. The remaining articles did not include information needed to support or negate change in process; however, they can be

used to provide background information. These consisted of similar study designs as those included in the matrix along with several literature reviews.

SECTION THREE: MANAGING THE COLLECTED DATA

Data Collection

Articles of various levels of evidence were included in this review. This allows for a diversity of results which can better generalize findings to the population (Toronto & Remington, 2020). The review question guided the literature search. Articles were scanned by title, then abstract, and finally full text to determine inclusion or exclusion in the final sample size. This is listed in the PRISMA diagram in Appendix A. Articles used in the review were analyzed via Melnyk's level of evidence and described in a literature matrix listed in Appendix B.

Information Sources

Qualitative and quantitative research studies and one case series were utilized in this review. This allows the review to approach RPM from various angles including patient outcomes and caregiver buy -in. Utilizing diverse research methodologies can have greater impacts on evidence-based practice in nursing (Whittemore & Knafl, 2005). This allows the research to be analyzed from various perspectives to fully investigate the phenomena of interest. Combining research in this manner allows the researcher the ability to perform a wider range of research purposes including defining concepts, reviewing theories, reviewing evidence, and analyzing methodological issues on a topic. This review method will be used to review the evidence related to RPM technologies.

Eligibility Criteria

As discussed, articles were scanned to determine applicability to adult patients. Articles must have described the use of RPM technology to monitor vital signs or other biometrics.

Preference was given to articles that were focused on vital sign monitoring. Only published, peer reviewed articles were included. The articles were determined to meet criteria in a stepwise approach. Titles were scanned, then article abstracts; if the abstract appeared to relate to the research question, the full article was read to determine inclusion.

SECTION FOUR: QUALITY APPRAISAL

Integrative reviews must have quality appraisal of evidence (Toronto & Remington, 2020). The quality of articles analyzed can provide a stronger review to further research purposes. Melnyk's levels of evidence pyramid is a research tool with which articles can be analyzed for quality of research (University of Michigan, 2021). This pyramid is listed in Appendix C. The articles were examined to include strength of study based on Melnyk's Level of Evidence Pyramid. Articles were divided as follows: one level one meta-analysis, four level two randomized controlled trials, one level three controlled trial without randomization, six level four cohort studies, seven level five systematic reviews of descriptive or qualitative design, and nine level six single descriptive or qualitative designs (University of Michigan, 2021). One case series was included. These results are depicted in Table 1.

Table 1: ***Descriptive results for evidence matrix***

Level of Evidence	Type of study	Number of articles
Level one	Meta-analysis	1
Level two	Randomized controlled trial	4
Level three	Controlled trial without randomization	1
Level four	Cohort study	6
Level five	Systematic review of descriptive or qualitative design	7
Level six	Single descriptive or qualitative design	9
N/A	Case series	1

Sources of Bias

Sources of bias were identified from studies analyzed. Selection bias was apparent in many reviews, as randomized sampling was not done. This can affect the reliability and validity of the findings. This also limits the studies' abilities to generalize to the public, or their external validity (Toronto & Remington, 2020). Bias can also be introduced in this manner, as the literature search stage was a subjective approach (Whittemore and Knafl, 2005). Primary sources can be missed or incorrectly interpreted, which can skew research results.

Internal Validity

Identifying and assessing for risk and sources of bias determines the internal validity of an integrative review (Toronto & Remington, 2020). Generally, two reviewers should identify and analyze research; however, one writer analyzed articles for this review. The research question was used to guide the literature search; however, bias could have been introduced by the writer through this subjective approach.

Reporting Guidelines

A methodical approach to a literature search is needed for an integrative review. This allows the research process to be repeated (Toronto & Remington, 2020). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model was used to guide the literature search. The PRISMA diagram showing the research approach is listed in Appendix A.

SECTION FIVE: DATA ANALYSIS AND SYNTHESIS

Analysis

Analysis of research for an integrative review requires the writer to order, code, and categorize all research from multiple sources that used a variety of research methods (Toronto

and Remington, 2020). The goal of this analysis was to integrate data into an innovative synthesis of the evidence (Whittemore & Knafl, 2005). Thematic analysis was utilized to identify, analyze, and report patterns within data. This approach identified important themes and patterns across various sources of literature. These patterns allowed the reviewer to inform or answer the review question that guided the search.

The first stage of the thematic analysis included finding the 29 articles listed in the literature matrix (Appendix B). These articles were examined and analyzed based on Melnyk's levels of evidence pyramid based on strength of evidence. The last step was to find themes in the research. Themes included high rates of readmission in skilled nursing facilities, acceptable vital sign measurements from RPM devices, and improved patient monitoring with CVM and RPM. Subthemes under "patient monitoring" included improved patient outcomes with RPM and positive perceptions from staff and patients regarding RPM devices.

Descriptive Results

Twenty-nine articles were analyzed for the review. The breakdown of articles rated by Melnyk's levels of evidence is listed above in Table 1(University of Michigan, 2021). Five articles studied readmission rates in skilled nursing facilities, 23 articles studied remote patient monitoring, and one article studied continuous vital sign monitoring. Of the 23 articles that studied RPM, 12 studied CVM using RPM**.** Various remote patient monitoring devices were studied and are listed in Table 2.

Table 2:

Remote Patient Monitoring Devices and the Number of Articles in which Each was Studied

RPM device	Number of articles that studied the device
VisiMobile (Sotara Visi Mobile)	5
Vitalpatch (Sensium	8
Healthpatch (Vital Connect)	7
Other: Patient status engine (Isansys e Lifecare), Auricall monitoring system, Avant-4100, Monica Novii systems, Everon, EarlySense (Early Sense Ltd) Masimo Radius 7 (Masimo Corporation), LifeTouch, Nonin Wristox, BB-613WP, Gili probiosensor, Andesfit Bluetooth device, Circadian monitor	1 (per device)

Synthesis

High Rates of Readmission in Skilled Nursing Facilities

CMS (2021a) indicates that skilled nursing facilities need to implement interventions to decrease 30-day readmissions or face payment reductions. Owens et al. (2018) determined readmission rates from skilled nursing facilities continue to be high despite government mandates and penalties. Readmission rates rose from 1.3 million in 2000 to 1.79 million in 2006 (a 29% increase) (Mor et al., 2010). Readmission rates are 25% higher for patients who previously resided in nursing facilities/long-term care facilities than for those who resided in the community. Many of these admissions are seen as potentially avoidable. Conditions that are seen as avoidable include congestive heart failure, sepsis, urinary tract infection, electrolyte abnormalities, and respiratory infection. Despite being classified as potentially avoidable, these conditions were the cause of 78% of all 30-day readmissions, resulting in 3.39 billion dollars in healthcare expenditure.

Patients admitted to skilled nursing facilities after inpatient stays have more comorbidities, adverse outcomes, and readmissions than those discharged home. These patients

are older, with more comorbidities in general, and with higher rates of obesity, diabetes mellitus, and chronic obstructive pulmonary disease (COPD) (Owens, 2018). Transfers to hospitals from SNFs occur frequently (Ouslander et al., 2016). Of readmissions studied, 8% occurred within 48 hours of hospital discharge, 11% within three-to-six days, and 31% within seven-29 days. Patients with previous hospitalizations both within 30 days and one year prior to the qualifying skilled stay were more likely to be readmitted to the hospital within 30 days. The most common reasons for transfer back to the hospital included COPD, CHF, and polypharmacy. Other reasons included shortness of breath, falls, functional decline, respiratory infection, and urine incontinence.

Minges et al., (2019) studied the perspectives of hospital and SNF providers to determine what factors attributed to higher readmission rates. Themes for readmission included patient condition and acuity at discharge not suitable for or too high for skilled care, misaligned expectations between patients/families/providers, and complicated interfacility relations. Continuous quality improvement initiatives can impact readmission rates (Mileski et al., 2017). Initiatives found to improve outcomes like readmission rates include using specialized staff, pharmacists for medication reconciliation, mid-level providers, and situation-background-assessment-and recommendation (SBAR) reporting.

Acceptable Vital Sign Measurements from RPM Devices

Remote patient monitoring devices have shown high rates of acceptability when compared with gold standard vital sign measurements. Respiratory rate monitoring, which is often miscounted in clinical settings, showed a high rate of accuracy when using devices like Gili pro biosensor, Circadian monitor, and EverOn to count breaths even with various positions and with patients of varying body mass index. These devices all measure vital signs in different

manners, from a contactless pad placed under the mattress with a piezo-electric sensor that converts motion into electrical signals, to an optical sensing unit that detects motion, to radar technology (Ben-Ari et al., 2010; Havakuk et al., 2021; Lauteslager et al., 2021). Heart rate accuracy was also high with Gili pro biosensor, Vitalpatch, and Andesfit Bluetooth device even in patients with cardiac and respiratory disease (Havakuk et al., 2021; Kroloff et al., 2022; Selvaraj et al., 2018). Even when vital sign measurements were not found within acceptable limits of gold standard monitoring, the use can show changes in patient conditions that precede deterioration (Downey et al., 2019; Leenen et al., 2020).

Improved Patient Monitoring with RPM

Remote patient monitoring as a means to improve outcomes has increased over the last decade (Vegesna et al., 2017). Different systems for RPM have included wearable devices, bio monitors, and computerized systems, some of which measure patient vital signs. The impact of CVM and RPM varies depending on the technology used and outcomes measured. Research on various RPM technology has found a positive effect on patient outcomes when CVM or RPM technology was used (Downey et al., 2018). Several outcomes on patients in both the acute and intensive care settings improved after implementing either RPM or CVM. Hospitalizations, length of stay, 30-day readmissions, and emergency department visits have been reduced when RPM and CVM are implemented to monitor vital signs and other biological parameters, such as step count (Downey et al., 2018; Downey et al., 2019; Memon et al., 2021; Taylor et al., 2021). Even in patients with adverse events, outcomes when CVM/RPM are used are better overall. The use of RPM was associated with detection of abnormal vital signs from adverse conditions like atrial fibrillation, sepsis, anastomotic leaks, tachycardia from pulmonary embolism, pneumonia,

and pneumothorax hours earlier than when using traditional intermittent vital sign monitoring (Breteler et al., 2019; Posthuma et al., 2020).

Continuous vital sign monitoring technology increases patient monitoring without the need for increased staff and has been shown to detect abnormalities that would not have been seen with intermittent vital sign monitoring (Posthuma et al., 2020). Weenk et al., (2019) found CVM technology reported respiratory rates higher than those measured by staff. The technology reported abnormal vital signs in non-observed periods that would have resulted in nursing intervention. The time lapse from technology reporting abnormalities to nursing observation periods ranged from zero to ten hours. Duus et al. (2018) found CVM detected decreases in oxygen saturation in 98% of patients versus only 16% of patients on intermittent monitoring, which is the standard in most healthcare settings. Cardiovascular and respiratory deterioration, which often occur early in hospitalization, can also be detected through the use of RPM (Eisenkraft et al., 2021). Vital sign measurements from devices can transmit data in real time through a secure cloud-based web software that medical staff are able to see without actual patient contact.

Improved Patient Outcomes with RPM. Remote patient monitoring has been associated with improvement in various patient outcomes. Although results were not significant in some articles, the use of RPM resulted in a reduced need for ICU transfer, rapid response calls, and risk of complication in post-surgical patients (Areia et al., 2021). Other articles found significant decreases in adverse events and post-operative complications when RPM devices were used for CVM (Downey et al., 2018). Time to antibiotic administration in sepsis patients has been reduced when RPM is in use. Verrillo et al. (2017) saw a 27% reduction in post-operative complications after CVM was initiated on an acute care floor.

Positive Perceptions from Staff and Patients Regarding RPM Devices. Staff engagement was found to impact technology effectiveness (Downey et al., 2018). Several studies focused on staff perceptions of technology on patient outcomes and ease of use. Nurses reported that RPM/CVM increased patient safety and provided valuable patient data (Watkins et al., 2016). Nurses thought improved monitoring with RPM/CVM led to better decision making (Downey et al., 2018). Alarm fatigue can become an issue with technology for vital signs; however, when alarms can be customized based on patient characteristics, 92% of nurses surveyed reported alarms were appropriate and signaled the need for intervention. Staff also reported CVM provided earlier detection of patient deterioration and increased feelings of safety (Weenk et al., 2020). Staff reported common themes that had an impact on successful implementation of RPM/CVM. These included targeting populations at high risk, accurately detecting a decline in health, providing responsive and timely care, personalizing care, enhancing self-management, and ensuring collaborative care (Thomas et al., 2021).

Patients who used RPM devices appreciated the increased monitoring and feelings of safety these devices lend (Breteler et al., 2020; Downey et al., 2018). Patients have reported ease of use when wearing various devices and think these devices could be used to reduce nighttime awakenings to obtain routine vitals.

Limitations

This study has several limitations. A single researcher conducted the search strategy and analysis for this review, which can limit results by introducing subjective bias. No articles were found that directly studied RPM in the population of interest. Articles found had varying levels of quality as seen by Melnyk's levels of evidence pyramid. Most of the articles were single descriptive studies that lacked randomization, which can limit ability to generalize to the public.

Each article also studied different outcomes, and many utilized small sample sizes which could limit external validity. Although findings' results were largely positive, most of the studies did not find significant improvements with the use of RPM.

Ethical Considerations

There were no ethical considerations for this project as it did not involve human subjects. However, the writer completed Collaborative Institutional Training Initiative (CITI) training on research for human subjects. Institutional Review Board (IRB) approval through Liberty University was also sought. The CITI training certificate and IRB approval/exemption are included in Appendix D & E, respectively.

SECTION SIX: DISCUSSION

The purpose of this review was to determine whether the use of remote patient monitoring could reduce readmissions in skilled nursing patients. After analysis and synthesis, a gap was identified, as this technology has not been widely studied or utilized in this setting. All research on the topic that was found focused on patients in the acute and intensive care settings. However, findings were overall positive and showed that this type of technology can be used to improve patient outcomes. The themes from the research included high rates of readmission in skilled nursing facilities, acceptable vital sign measurements from RPM devices, and improved patient monitoring with CVM and RPM. Subthemes included improved patient outcomes with RPM and positive perceptions from staff and patients regarding RPM devices.

SNF readmissions continue to rise despite intervention. Patients who previously resided in a SNF/LTC facility were at increased risk of readmission compared to community-dwelling patients (Mor et al., 2010). Certain conditions including CHF, sepsis, UTIs, electrolyte abnormalities and respiratory infections cause 78% of all readmissions. Although there were

differing opinions, providers at the hospital and SNF level believed many readmissions were due to the acuity of patients sent from hospitals to SNF (Mileski et al., 2017).

As vital signs are used as part of the diagnostic process, accuracy of measurement is essential. Many devices used for RPM have been compared against gold standard measurements, including with clinician monitoring, and had little difference in measure (Ben-Ari et al., 2010; Havakuk et al., 2021; Lauteslager et al., 2021; Kroloff et al., 2022).

Multiple studies found improved outcomes with the use of RPM and/or CVM on patients on both acute and intensive care settings. Outcomes included reductions in overall hospitalizations, length of stay, 30-day readmissions, and emergency department visits (Downey et al., 2018; Downey et al., 2019; Memon et al., 2021; Taylor et al., 2021). Abnormal conditions including atrial fibrillation, sepsis, anastomotic leaks, tachycardia from pulmonary embolism, pneumonia, and pneumothorax have all been detected by using RPM, many hours earlier than intermittent vital sign monitoring would have caught the abnormalities. Staff were positive about device measurements and the ability to monitor their patients with RPM. Nurses reported increased patient safety with RPM, better decision making, and appropriateness of patient alarms (Weenk et al, 2020). Patients also reported positive perceptions of RPM, including feeling safer and better-monitored (Breteler et al., 2020; Downey et al., 2018).

These themes support the use of remote patient monitoring with continuous vital signs monitoring as a means to reduce readmissions in skilled patients. Devices have shown improved outcomes including risk of complication and length of stay while hospitalized. Continued monitoring in the skilled setting, which has not been studied, has the potential to see similar outcomes.

Patients in skilled nursing facilities are at high risk for readmission to the hospital within 30 days of discharge (Ouslander et al., 2016). The CMS has implemented initiatives to reduce readmissions; however, they remain a problem nationwide. The above review gives evidence to support that readmission rates are costly to the healthcare system and can increase adverse outcomes in the skilled nursing population. Patients with diseases such as COPD, CHF, and respiratory infections and those who previously resided in a skilled facility are at increased risk of hospitalization (Mor et al., 2010). Although facilities have found success with initiatives like increased staffing, the Interact system, and more frequent provider rounding, there remains a gap in care as readmissions continue to rise (Mileski et al., 2017). Although not studied in the population of interest, RPM could be used to improve this gap.

A notable finding of this review is the inconsistency with significant results when using remote patient monitoring to improve outcomes in the literature. Leenen et al. (2020) found conflicting results on patient improvement with CVM in their systematic review. Similarly, Areia et al. (2021) did not find differences in patient outcomes, rapid response calls, total and major complications, length of stay, or mortality after RPM was implemented. However, all studies in the review used different outcomes which authors conceded made analysis difficult (Areia et al., 2021). The wide variety of outcomes used in each study, along with the different devices, and small sample sizes used in the studies could have affected this.

Abnormal vital signs are one reason for recurrent readmissions. Skilled nursing facilities do not monitor vital signs frequently and often do not have the capabilities to find the cause and treat these vital signs. Interventions that can decrease the time in between vital signs could help decrease readmissions. Continuous vital sign monitoring can detect changes before patient decompensation occurs, allowing patients to be treated in the facility before hospitalization is

needed. Remote patient monitoring is one way continuous vital sign monitoring could be implemented in skilled facilities. This allows monitoring of vital signs without the need to be hooked up to machines. This is important in skilled facilities as patients require multiple hours each day of various therapy services to continue skilled care. Patients must be mobile to participate, so devices that can monitor without a physical connection are necessary.

Conceptual Framework

This review used the theory of symptom management as a framework. This theory explains how symptoms affect patient experiences, how these symptoms affect healthcare seeking, and how symptoms change with intervention (Smith & Lier, 2014). Patients in skilled nursing facilities face varying ailments and are at risk for symptom exacerbation leading to rehospitalization. Remote patient monitoring could provide a method to discover symptoms earlier and allow timely treatment.

Potential Barriers

Cost of RPM could provide a barrier to implementation in skilled settings. Downey et al. (2018) determined the use of CVM is a feasible intervention, and in studies it was cost effective to implement. This was seen because of decreased complications and length of stay.

Another barrier is the accuracy of RPM devices. As seen above, many devices have been tested against gold standard monitoring with little variation in measurements. To ensure the safety and accuracy of measurements, all devices should be compared with staff measurements of vital signs, as some devices have measurements that do not differ from observation, whereas other comparisons have resulted in measurements outside of acceptable limits (Downey et al, 2019; Lauteslager et al., 2021). Accuracy of measurements is important because it can influence whether intervention is given to prevent deterioration. If the device reports a normal vital sign

when it should flag as abnormal, this could cause detrimental effects to care and potentially result in failure to rescue events. Continuous vital sign monitoring and RPM technology must be used with caution. Devices used should be measured against standard nursing measures to determine the accuracy of results.

Implications for Practice

Reducing readmissions is important to improve patient's lives. Despite the many interventions that have been implemented in various facilities, readmissions still affect thousands of patients each year (AHRQ, 2018). This drives healthcare costs up substantially, reducing funds for other needed services. Many interventions that have been proposed require improved staffing ratios. However, staffing in medical facilities is a problem nationwide. There is a shortage of nurses and nursing assistants which will continue to grow as the baby boomer population ages and stresses an already understaffed system. Finding devices that can supplement nursing care can help ease the burden of staffing shortages.

Remote patient monitoring, especially with devices that measure vital signs, is one method that can provide needed relief. When patients have devices that monitor vital signs or other biometrics that usually require hands-on staff, these staff are free to focus on other tasks that require completion. Remote patient monitoring can also be used decrease the time spent in isolation rooms. Patients with contagious diseases often take extra time for staff with the need for donning and doffing of personal protective equipment during care. The use of RPM can decrease the times staff have to enter rooms simply for vital signs. This has been seen with success in facilities that used RPM for COVID-19 patients. RPM can decrease the need for staff interaction in times of isolation where patients need frequent monitoring but staff time in rooms is limited (Eisenkraft et al., 2021).

Conclusion

Research on remote patient monitoring, especially devices that provide continuous vital sign monitoring, is lacking in the skilled nursing population. However, various reviews have shown that RPM can improve patient outcomes, both with reduced complications and decreased length of stay in acute care patients. Skilled patients are generally more stable than acute patients but could still benefit from this technology. Future research is needed in skilled facilities to determine the feasibility of use in SNF patients, both from a cost perspective and a patient wearability perspective. Further studies are also needed to determine whether the use of RPM can detect patient abnormalities, improve treatment of symptoms, and reduce readmissions.

Dissemination

Dissemination of research is listed as an essential of doctoral practice by the American Association of Colleges of Nursing (AACN, 2006). Dissemination allows the application of research into practice, which can improve patient outcomes. This writer plans to seek publication in a journal(s) that caters to the long-term care environment in hopes that further research can be conducted on RPM to reduce SNF readmissions. This integrative review will also be submitted to Liberty University's Scholar's Crossing, a database that will archive the record and allow it to be searched via web searches by other authors interested in the subject.

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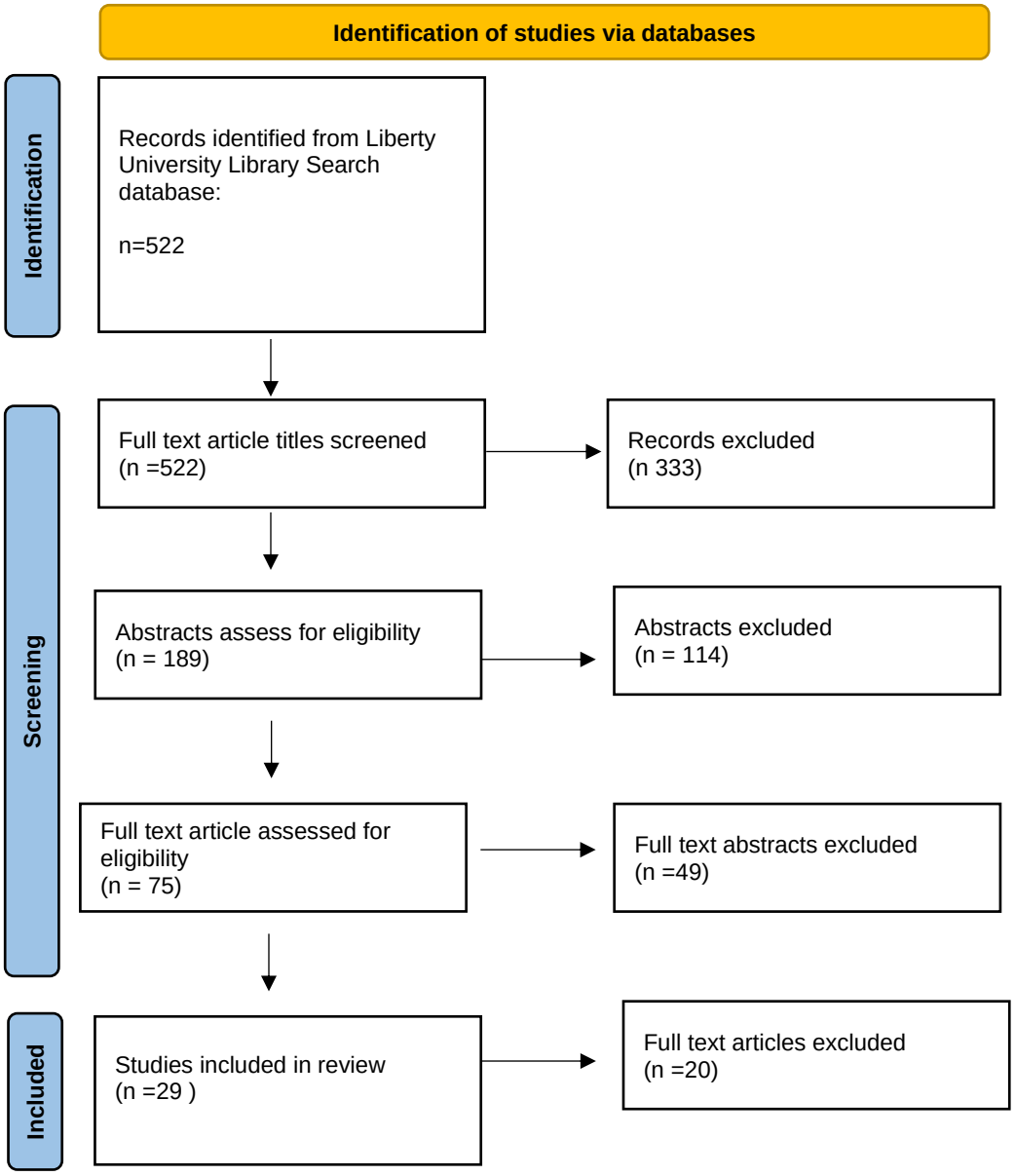
Appendix A: Prisma Diagram



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For more information, visit: http://www.prisma-statement.org/

Appendix B: Literature matrix

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
Example, A. (2015) Title etc. per Current APA	To identify the need for technology to prevent falls	A convenience sample of 44 nurses in an acute care hospital	A non-experimental , descriptive survey	Findings indicate that fall rates decreased by 2% with the introduction of technology into the care setting	Level 6: descriptive design	Conducted in only one setting, small sample size	Does provide some good foundational information even though the level is a 6.
Areia, C., Biggs, C., Santos, M., Thurley, N., Gerry, S., Tarassenko, L., Watkinson, P., & Vollam, S. (2021). The impact of wearable continuous vital sign monitoring on deterioration detection and clinical outcomes in hospitalised patients: A systematic review and meta-analysis. *Critical Care (London, England), 25*(1), 1-351. https://doi.org/10.1186/s13054-021-03766-4	To compare wearable vital sign monitoring systems against standard of care to detect patient deterioration	Seven research studies included with overall quality graded as moderate	Meta-analysis	There were no significant differences found in reduction of ICU admissions, rapid response and cardiac arrest calls, or total and	Level 1: Meta analysis	Each study used measured different outcomes which made analysis difficulty to reach a definite conclusio	This study does not explicitly support change however it used patients in the ICU setting who have

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
				major complications prevalence. There was not a significant difference in reduced mortality or hospital length of stay.		n. Studies used different designs, populations, outcomes, devices, and alert systems. Small sample sizes in some of the studies.	much higher acuities than in SNF. None of the articles included tested monitors on SNF patients.
Ben-Ari, J., Zimlichman, E., Adi, N., & Sorkine, P. (2010). Contactless respiratory and heart rate monitoring: Validation of an innovative tool. *Journal Of Medical Engineering & Technology*, *34*(7–8), 393–398. https://doi-org.ezproxy.liberty.edu/10.3109/03091902.2010.503308	Test the accuracy of the EverOn system with RR and heart rate in ambulatory and ICU patients	41 ambulatory care patients; 42 ICU patients	Descriptive design	RR accuracy in ambulatory patients was 93.1% for children and 90.6% adults; HR accuracy was 94.4%/91.5%. ICU	Level 6 single descriptive study	Small sample sizes	This supports the use of RPM to measure patient vital signs.

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
				patient RR accuracy was 82/75%;HR accuracy 94%. Values were deemed accurate in accordance with regulations.			
Breterler, M., Kleinjan, E., Numan, L., Rurrda, J., van Hillegersberg, R., Leenen, L., Hermans, M., Klakman, C., & Blokuis. T. (2019). Are current wireless monitoring systems capable of detecting adverse events in high-risk surgical patients? A descriptive study. *Injury*, 1-9. https://doi.org/10.1016/j.injury.2019.11.018	Describe the ability of four wireless sensors to detect vital sign abnormalities in high-risk surgical patients.	Descriptive statistics from 31 patients who were previously studied in an observational comparison study	Descriptive study	Twenty adverse events occurred in 11/31 patients. Abnormalities detected included atrial fibrillation and respiratory deterioration.	Level 6 single descriptive study	Small sample size and number of adverse events	This supports the use of RPM to measure vital signs.

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
Breteler, M. J. M., Numan, L., Ruurda, J. P., Richard, v. H., van der Horst, S., Dohmen, D. A. J., van Rossum, M.,C., & Kalkman, C. J. (2020). Wireless remote home monitoring of vital signs in patients discharged early after esophagectomy: Observational feasibility study. *JMIR Perioperative Medicine, 3*(2)http://dx.doi.org/10.2196/21705	Assess the feasibility of using RPM to monitor post op esophagectomy patients	20 patients	Observational study	Patients appreciated monitoring, checking in from surgeon, and thought wearing the patch was easy.	Level 6 single descriptive study	Small, specific sample	Yes- patient and provider had positive feedback. This supports feasibility on both spectrums for use of RPM.
Downey, C. L., Brown, J. M., Jayne, D. G., & Randell, R. (2018). Patient attitudes towards remote continuous vital signs monitoring on general surgery wards: An interview study. *International Journal of Medical Informatics (Shannon, Ireland), 114*, 52-56. https://doi.org/10.1016/j.ijmedinf.2018.03.014	To evaluate patient perceptions related to continuous vital sign monitoring in a surgical ward	12 patients	Qualitative study	Patients see value in RPM especially overnight, but still appreciated face to face contact with nurses.	Level 6 single qualitative study	Small sample size	Yes- patients felt comfortable with the design and thought it would increase monitoring especially with less

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
							staff available.
Downey, C. L., Chapman, S., Randell, R., Brown, J. M., & Jayne, D. G. (2018). The impact of continuous versus intermittent vital signs monitoring in hospitals: A systematic review and narrative synthesis. *International Journal of Nursing Studies, 84*, 19-27. https://doi.org/10.1016/j.ijnurstu.2018.04.013	To assess if continuous vital sign monitoring is effective in improving outcomes outside of the ICU setting	24 research articles in final sample	Systematic review	Continuous vital sign monitoring outside of the ICU could improve patient outcomes, however patient and staff engagement can affect outcomes. It is a feasible intervention, and in studies was cost effective to implement.	Level 5 - Systematic review of descriptive & qualitative studies	Studies were small patient populations; each study looked at different patient acuities	Yes- this review found VS monitors improved patient outcome in the ICU setting.
Downey, C., Ng, S., Jayne, D., & Wong, D. (2019). Reliability of a wearable wireless patch for continuous remote monitoring of vital signs in	To validate the accuracy of vital	51 post-surgical patients	Randomized controlled	Data from the vital sensor did	Level 2: randomized controlled trial	Small sample size, data	The VS monitoring system

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
patients recovering from major surgery: A clinical validation study from the TRaCINg trial. *BMJ Open, 9*(8), e031150-e031150. https://doi.org/10.1136/bmjopen-2019-031150	signs from a wearable sensor (Sensium Vitals patch) in postsurgical patients at high risk	after major general surgery at a University Hospital in UK	parallel group trial	not correlate within acceptable limits based on nursing observations		recovery from the patch was low; warning scores were user dependent	here was not accurate enough to be acceptable in patients studied. The sensor proposed is different
Downey, C., Randell, R., Brown, J., & Jayne, D. G. (2018). Continuous versus intermittent vital signs monitoring using a wearable, wireless patch in patients admitted to surgical wards: Pilot cluster randomized controlled trial. *Journal of Medical Internet Research, 20*(12), e10802-e10802. https://doi.org/10.2196/10802	To evaluate if continuous remote VSM is practical way to monitor acute surgical patients	226 randomized patients	Randomized controlled trial	Patients on continuous VSM received antibiotics faster after evidence of sepsis, had shorter length of stay, and were less likely to be readmitted	Level 2: randomized controlled trial	Small samples size, wide confidence intervals suggested results were not significant, cluster randomization created difference	Yes- this supports the use of RPM for vital signs. Although results were not considered significant, this was a small

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
				within 30 days. Confidence intervals suggested results were not statistically significant and future larger studies are needed to determine significance		s in demographics that could affect results	study with positive patient outcomes.
Duus, C. L., Aasvang, E. K., Olsen, R. M., Sørensen, H. B. D., Jørgensen, L. N., Achiam, M. P., & Meyhoff, C. S. (2018). Continuous vital sign monitoring after major abdominal surgery—Quantification of micro events. *Acta Anaesthesiologica Scandinavica*, *62*(9), 1200-1208. https://doi.org/10.1111/aas.13173	To compare microevents captured by continuous vital sign monitoring versus intermittent monitoring in postsurgical patients.	50 patients s/p abdominal surgery	Observational study	Continuous vital sign monitoring detected O2 saturation decreases in >98% of patients vs intermittent 16%($p<0.0001$) and tachycardia in 60% of	Level 4: Cohort study	SpO2 was only collected 68.5%; small sample size; technical difficulties resulted in loss of some data; data	Yes- this study supports the use of continuous vital sign monitoring to detect patient deterioration.

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
				patients vs 6% with intermittent monitoring		was missed during mobility and personal hygiene	
Eisenkraft, A., Maor, Y., Constantini, K., Goldstein, N., Nachman, D., Levy, R., Halberthal, M., Horowitz, N. A., Golan, R., Rosenberg, E., Lavon, E., Cohen, O., Shapira, G., Shomron, N., Ishay, A. B., Sand, E., Merin, R., Fons, M., Littman, R., & Gepner, Y. (2021). Continuous remote patient monitoring shows early cardiovascular changes in COVID-19 patients. *Journal of Clinical Medicine, 10*(18), 4218. https://doi.org/10.3390/jcm10184218	To determine the trajectory of nine physiological parameters amongst COVID 19 admitted to isolation units	492 COVID 19 patients in 5 units	Observational cohort study	Cardiovascular and respiratory deterioration occurred early after admission. RPM was able to detect deterioration when monitoring frequently	Level 4 cohort study	Did not have patient clinical data outcomes,	Yes- this biosensor patch was a noninvasive RPM that could improve changes in VS and allow provider intervention
Havakuk, O., Sadeh, B., Merdler, I., Zalevsky, Z., Garcia-Monreal, J., Polani, S., & Arbel, Y. (2021). Validation of a novel contact-free heart and respiratory rate monitor. *Journal of medical engineering & technology, 45*(5), 344–350.	To evaluate the accuracy of a contact free vital sign monitor for heart rate and	115 patients in cardiology and outpatient clinics	Prospective cohort study	The contact free system's accuracy was validated at 99% based	Level 4 cohort study	Small sample size, convenience sample	Yes- this shows RPM can record vital signs accurately for

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
https://doi.org/10.1080/03091902.2021.1905896	respiratory rate			on traditional vital sign measurements for both heart rate and respiratory rate even with patients with cardiac and respiratory illnesses.			patients with known conditions.
Kroloff, M., Ramezani, R., Wilhalme, H., & Naeim, A. (2022). Remote monitoring of patients with hematologic malignancies at high risk of febrile neutropenia: Exploratory study. *JMIR Formative Research*, *6*(1)http://dx.doi.org.ezproxy.liberty.edu/10.2196/33265	To determine if an RPM system could detect VS abnormalities in a specific patient population	23 patients with diagnosed leukemia and lymphoma	Descriptive design	RPM heart rate was comparable to traditional monitoring. Temperature and oxygen saturation sensitivities were less than 50%	Level 6 single descriptive design	Small sample size,	Yes this study shows that certain vital signs can be measured accurately with RPM.

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
Lauteslager, T., Maslik, M., Siddiqui, F., Marfani, S., Leschziner, G. D., & Williams, A. J. (2021). Validation of a new contactless and continuous respiratory rate monitoring device based on ultra-wideband radar technology. *Sensors (Basel, Switzerland), 21*(12), 4027. https://doi.org/10.3390/s21124027	To validate the ability of a contactless vital sign monitor against standard nursing care	50 subjects in a nonacute setting	Quasi experimental	Measurements from the device were withing acceptable ranges of RR observed showing the device could be used to monitor RR in nonacute settings such as nursing homes	Level 3: controlled trial without randomization	Any subject that met criteria for a "vulnerable population" was excluded from the study; subjects with uncontrollable involuntary movements were excluded from sample	Yes- RR from this device were comparable to observation supporting the use in nonacute environments.
Leenen, J. P. L., Leerentveld, C., van Dijk, J. D., van Westreenen, H. L., Schoonhoven, L., & Patijn, G. A. (2020). Current evidence for continuous vital signs monitoring by wearable wireless devices in hospitalized adults:	Review evidence surrounding continuous vital sign	27 studies with 13 different vital sign	Systematic review	Studies had conflicting results regarding whether	Level 5 - Systematic review of descriptive &	The quality of included studies varied;5	Yes- this study recommends more studies to

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
Systematic review. *Journal of Medical Internet Research*, *22*(6), e18636-e18636. https://doi.org/10.2196/18636	monitoring regarding validation, feasibility, clinical outcomes, and costs	monitoring devices		devices improved outcomes. More studies need to be completed to add to the evidence. None of the studies evaluated costs.	qualitative studies	studies had possible conflicts of interest from study funding; prototype devices were excluded	determine whether vital sign sensors improve outcomes.
Memon, A., Lec, P., Lenis, A., Sharma, V., Wood, E., Schade, G., & Brisbane, W. (2021). Relationship between mobile digital sensor monitoring and perioperative outcomes: Systematic review. *JMIR Perioperative Medicine*, 4(1)http://dx.doi.org.ezproxy.liberty.edu/10.2196/21571	To describe the use of mobile RPM and perioperative clinical outcomes	11 studies	Systematic review	High step counts were associated with improved outcomes.	Level 5 systematic review of descriptive/qualitative studies	Broad outcome definitions	This study supports the use of RPM to improve outcomes however articles reviewed did not have explicit data

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
							related to vital signs.
Mileski, M., Topinka, J. B., Lee, K., Brooks, M., McNeil, C., & Jackson, J. (2017). An investigation of quality improvement initiatives in decreasing the rate of avoidable 30-day, skilled nursing facility-to-hospital readmissions: A systematic review. *Clinical Interventions in Aging, 12*, 213-222. https://doi.org/10.2147/CIA.S123362	To investigate the effectiveness of quality improvement projects in SNFS to reduce 30 days rehospitalization rates	10 research articles included in the final review	Systematic review	Various QI initiatives showed some success in reducing readmissions. These included using specialized staff, pharmacist for medication reconciliation, mid-level providers, and SBAR reporting.	Level 5 - Systematic review of descriptive & qualitative studies	All articles studied were quasi-experimental, retrospective studies; articles noted QI initiatives in SNFs varied; small study samples; data was based on facility self-reporting	Yes- this project did not focus on VS monitoring but overall initiatives to improve SNF care.

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
Minges, K ., Britton, M., Clark, B., Ouellet, G., Hodshon, B., & Chaudry, S. (2019). Hospital readmission from skilled nursing facilities (SNFs): Perspectives of hospital and SNF providers. *Journal of the American Medical Directors Association, 20*(8), 1050-1051. https://doi.org/10.1016/j.jamda.2019.03.005.	To understand readmission cause from a provider perspective	Interviews at hospital and SNF: one hospital (25) and two SNFS (16)	Qualitative study	Themes included- condition and acuity at discharge not suitable for SNF capabilities, misaligned expectations among providers and families, and complicate interfacility relationships	Level 6 single qualitative study	Purposive sampling	Yes this highlights potential reasons for high readmission
Mor, V., Intrator, O., Feng, Z., & Grabowski, D. C. (2010). The revolving door of rehospitalization from skilled nursing facilities. *Health Affairs, 29*(1), 57-64. doi:http://dx.doi.org.ezproxy.liberty.edu/10.1377/hlthaff.2009.0629	To determine the frequency and cost of 30-day readmissions, how readmission	All SNF readmissions from 2000-2006 based on CMS claims data from MDS assessments	Retrospecitve cohort study	Rates of rehospitalization rose from 1.3 million in 2000 to 1.79 million in 2006 (29%	Level 4 cohort study	Data collected depended on correct billing claims;	Yes- rates of readmission continued to rise throughout the study

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
	s vary across the states, and correlation between SNF rehospitalizations and other Medicare spending			increase). Readmission rates are higher in those who had previously been in a nursing home versus community. Nine states had readmission rates greater than 25%.			period. Readmission rates are a burden to healthcare costs.
Ouslander, J., Naharci , I., Engstrom, G., Shutes, J., Wolf , D., Rojido, M., Tappen, R., Newman, D. (2016). Hospital transfers of skilled nursing facility (SNF) patients within 48 hours and 30 days after SNF admission. *Journal of the American Medical Directors Association, 17*(9), 839-845. https://www-clinicalkey-com.ezproxy.liberty.edu/#!/content/journal/1-s2.0-S1525861016301773	To describe characteristic of SNF readmissions at 48 hours and 30 days based on root cause analysis and find an area	64 SNFs with 4,659 transfers to hospital	Retrospecitve cohort study	Transfers occurred: 8% within 48 hours, 11% 3-6 days, 31% 7-29 days, 50% >30days. Patients	Level 4 cohort study	Data from selected SNFS only, data from claims	Yes- 50% of readmissions occurred within a 30-day period.

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
	of focus to improve readmission rates			with hospitalization within 30 days and one year were more likely to transfer in a shorter period. Shortness of breath, falls, functional decline, respiratory infection, and urine incontinence were also reasons for transfer.			
Owens, J. M., Callaghan, J. J., Duchman, K. R., Bedard, N. A., & Otero, J. E. (2018). Short-term morbidity and readmissions increase with skilled nursing facility discharge after total joint arthroplasty in a Medicare-eligible and skilled nursing facility–eligible patient	To determine complications after total joint arthroplasty	34,610 Med A patients who received TJA between	Descriptive study	Patients discharged to SNF were more likely to have more	Level 6 - Single descriptive or qualitative study	Retrospective data collection depends on correct billing/co	Yes- SNF patients have high rates of readmission.

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
cohort. *The Journal of Arthroplasty*, *33*(5), 1343-1347. https://doi.org/10.1016/j.arth.2018.01.002	for patients discharged to SNF vs home after hospitalization	2012-2013 with a 3-day hospital stay		comorbidities, complications, and readmissions to the hospital than patients who discharged home ($p<0.001$)		ding claims; other factors that could have influence outcomes were not considered; discharge and readmission criteria varied across the country; SNF quality of care was not considered	Initiatives to decreased readmission are needed to improve outcomes.
Posthuma, L. M., Downey, C., Visscher, M. J., Ghazali, D. A., Joshi, M., Ashrafian, H., Khan, S., Darzi, A., Goldstone, J., & Preckel, B. (2020). Remote wireless vital signs	Describe cases where RPM detected	Nine patient cases from five hospital	Case series	Various cases show RPM detected	N/A	Limited number of cases described;	Yes- RPM can be used to detect

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
monitoring on the ward for early detection of deteriorating patients: A case series. *International Journal of Nursing Studies, 104*, 103515-103515. https://doi.org/10.1016/j.ijnurstu.2019.103515	vital sign deterioration	systems that installed RPM technology		abnormalities in patient condition that required intervention before manual VS		all hospitals used the same RPM technology	patient deterioration and prevent adverse outcomes
Selvaraj, N., Nallathambi, G., Moghadam, R., & Aga, A. (2018). Fully disposable wireless patch sensor for continuous remote patient monitoring. Annual international conference of the IEEE engineering in medicine and biology society. IEEE Engineering in Medicine and Biology Society. Annual International Conference, *2018*, 1632–1635. https://doi.org/10.1109/EMBC.2018.8512569	To describe a new biosensor along with clinical testing	57 subjects	Descriptive design	Compared to traditional monitoring, the biosensor was clinically acceptable to standard measurements	Level 6 single descriptive design	Convenience sample, small sample size	Yes- RPM can be as accurate as traditional VSM
Taylor, M. L., Thomas, E. E., Snoswell, C. L., Smith, A. C., & Caffery, L. J. (2021). Does remote patient monitoring reduce acute care use? A systematic review. *BMJ Open*, *11*(3), e040232-e040232. https://doi.org/10.1136/bmjopen-2020-040232	To determine if remote patient monitoring systems reduces	91 medium-to-high evidence studies	Systematic review	49% of studies (44/90) reported reduced hospitalization, 49% reported	Level 5 - Systematic review of descriptive & qualitative studies	There was a large amount of heterogeneity among studies included	Yes- vital sign monitoring improved various patient outcomes.

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
	acute care hospital use			reduced length of stay (21/37) and 41% reported reduced ED visits (13/32) when RPM was used to monitor vital signs; use of RPM with COPD patients was more effective at reducing hospitalization than other conditions studied		which could decrease ability to generalize findings; differences in control populations used could skew data	
Thomas, E. E., Taylor, M. L., Banbury, A., Snoswell, C. L., Haydon, H. M., Gallegos Rejas, V. M., Smith, A. C., & Caffery, L. J. (2021). Factors influencing the effectiveness of remote patient monitoring interventions: A realist review.	To identify factors for RPM that relate to increased or	91 studies that were part of another systematic	Qualitative systematic review	Six theories on intervention use and success	Level 5 - Systematic review of descriptive &	Multiple study designs without the ability	Yes- this study focused on staff perspectiv

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
BMJ Open, *11*(8), e051844-e051844. https://doi.org/10.1136/bmjopen-2021-051844	decreased acute care use and to develop recommendations for RPM use	review that all reported on RPM use		were seen-targeting population at high risk, accurately detecting a decline in health, providing responsive and timely care, personalizing care, enhancing self-management, and ensuring collaborative care.	qualitative studies	to blind participants; Hawthorne effect could have occurred with patients who believed they were being watched and changed their behavior;	es which are important to consider when proposing new interventions.
Vegesna, A., Tran, M., Angelaccio, M., & Arcona, S. (2017). Remote patient monitoring via non-invasive digital technologies: A systematic review. *Telemedicine Journal and e-Health*, *23*(1), 3-17. https://doi.org/10.1089/tmj.2016.0051	Identify trends associated with RPM and noninvasive monitoring	62 articles on RPM published between 2005 to 2015	Systematic review	Many studies reported multicomponent interventions, then	Level 5 - Systematic review of descriptive & qualitative studies	Search criteria were specific which could have	Yes-RPM improved outcomes in various studies. Continuo

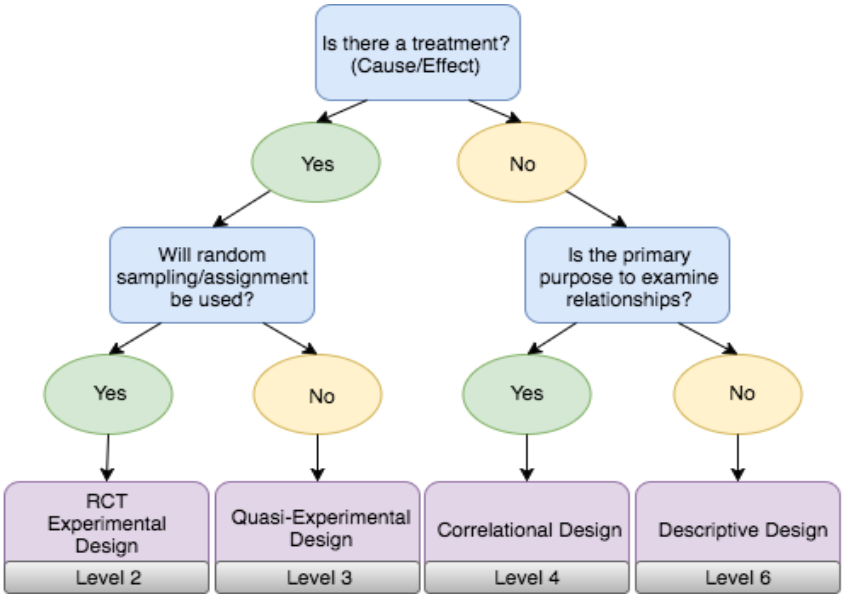
Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
	over the previous decade			smartphones, wearable devices, bio monitors, and computerized systems. There was a large variety in outcomes measured however findings were predominantly positive with use of RPM.		excluded key studies; a variety of study methods were included with varying degrees of quality; many studies were exploratory or pilot designs	us vital sign monitoring is included under this with wearable devices and bio monitors.
Verrillo. (2019). Using continuous vital sign monitoring to detect early deterioration in adult postoperative inpatients. *Journal of Nursing Care Quality*, *34*(2), 107–113. https://doi.org/10.1097/NCQ.0000000000000350	To determine if continuous vital sign monitoring could decrease failure to rescue	422 post operative patients in an orthopedic-orthospine-general surgical care ward at	Descriptive design	Use of continuous vital sign monitoring was associated with a statistically significant	Level 6 - Single descriptive or qualitative study	Short, 12-week study period with a specific patient population so	Yes, continuous vital sign monitoring increased detection of patient

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
	events in adult postoperative patients	an urban mid Atlantic academic medical center		27% decrease in complications in patients post intervention		results might not be generalizable	deteriorated.
Watkins, T., Whisman, L., & Booker, P. (2016). Nursing assessment of continuous vital sign surveillance to improve patient safety on the medical/surgical unit. *Journal of Clinical Nursing, 25*(1-2), 278-281. https://doi.org/10.1111/jocn.13102	To evaluate continuous vital sign monitoring as a means to improve patient care in medical surgical units based on nurse survey of care and alerts	Two hospital units: Utah 16 monitored beds, 123 patients monitored; Alabama 24 beds 113 patients	Prospective observational study	92% of nurses said alerts were appropriate; 100% said data monitored increased patient safety; 100% said data provided valuable patient information	Level 4 - cohort study	Small sample size, evaluating nurse opinion not outcomes	Yes- this focused on staff perspectives. Nurses thought the VS monitoring improved patient care.
Weenk, M., Bredie, S. J. H., Koeneman, M., Hesselink, G. J., Goor, H. v., & Belt, T. H. v. d. (2020). Continuous monitoring of vital signs in the general ward using wearable devices: Randomized controlled trial. *Journal of*	To identify positive and negative effects of two	90 patients admitted to internal medicine and surgical	Randomized controlled trial	Themes included earlier detection of patient	Level 2 - randomized controlled trial	Selection bias could have occurred as some	Yes- staff supported the use of technology and

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
Medical Internet Research, 22(6), e15471-e15471. https://doi.org/10.2196/15471	continuous vital sign monitoring systems along with facilitators and barriers to use	wards at a hospital in the Netherlands		deterioration, increased feelings of safety,		patients declined study participation;	thought it improved patient care.
Weenk, M., Koeneman, M., van de Belt, Tom H, Engelen, L. J. L. P. G., van Goor, H., & Bredie, S. J. H. (2019). Wireless and continuous monitoring of vital signs in patients at the general ward. *Resuscitation, 136*, 47-53. https://doi.org/10.1016/j.resuscitation.2019.01.017	To examine the differences in VS measures between sensors and nursing observation	60 patients admitted to internal medicine and surgical wards at a hospital in the Netherlands with minimal expected stay of 3 days	Quantitative study part of a separate randomized controlled trial	Device measurements were higher than nursing observation for RR. Sensors detected abnormal VS measures during non-observation times. Time from high VS scores detected by monitors and that	Level 2 - randomized controlled trial	Selection bias could have occurred as one third of patients declined participation in the study; the devices could not calculate all values needed for a MEWS score	Yes- this study showed how VS can have critical values in non-observed periods that can be detected with continuous monitors.

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
				from nursing ranged from 0-10 hours.			

Appendix C: Melnyk's Level of Evidence pyramid



Melnyk's Level of Evidence

Level 1 - Systematic review & meta-analysis of randomized controlled trials; clinical guidelines based on systematic reviews or meta-analyses

Level 2 - One or more randomized controlled trials

Level 3 - Controlled trial (no randomization)

Level 4 - Case-control or cohort study

Level 5 - Systematic review of descriptive & qualitative studies

Level 6 - Single descriptive or qualitative study

Level 7 - Expert opinion

Appendix D: CITI training

CITI PROGRAM

Completion Date 01-Dec-2021
Expiration Date 30-Nov-2024
Record ID 46205251

This is to certify that:

Sharee Birkett

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

Biomedical Research - Basic/Refresher
(Curriculum Group)
Biomedical & Health Science Researchers
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Liberty University

CITI
Collaborative Institutional Training Initiative

Appendix E: IRB approval

LIBERTY UNIVERSITY.
INSTITUTIONAL REVIEW BOARD

February 28, 2022

Sharee Birkett
Tonia Kennedy

Re: IRB Application - IRB-FY21-22-810 Remote patient monitoring as a means to reduce 30-day readmissions in skilled patients

Dear Sharee Birkett and Tonia Kennedy,

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study does not classify as human subjects research. This means you may begin your project with the data safeguarding methods mentioned in your IRB application.

Decision: No Human Subjects Research

Explanation: Your study is not considered human subjects research for the following reason:

(1) It will not involve the collection of identifiable, private information from or about living individuals (45 CFR 46.102).

Please note that this decision only applies to your current application, and any modifications to your protocol must be reported to the Liberty University IRB for verification of continued non-human subjects research status. You may report these changes by completing a modification submission through your Cayuse IRB account.

Also, although you are welcome to use our recruitment and consent templates, you are not required to do so. **If you choose to use our documents, please replace the word *research* with the word *project* throughout both documents.**

If you have any questions about this determination or need assistance in determining whether possible modifications to your protocol would change your application's status, please email us at irb@liberty.edu.

Sincerely,

G. Michelle Baker, MA, CIP
Administrative Chair of Institutional Research
Research Ethics Office