2018

Implementation of Bedside Technology May Influence Satisfaction with Nurse-Patient Communication

Kathleen Habig Nippert
Medical University of South Carolina

IMPLEMENTATION OF BEDSIDE TECHNOLOGY MAY INFLUENCE SATISFACTION WITH NURSE-PATIENT COMMUNICATION

BY

Kathleen Habig Nippert, RN, MSN, FACHE

A doctoral project submitted to the faculty of the Medical University of South Carolina in partial fulfillment of the requirements for the degree
Doctor of Health Administration
In the College of Health Professions

IMPLEMENTATION OF BEDSIDE TECHNOLOGY

MAY INFLUENCE SATISFACTION WITH NURSE-PATIENT COMMUNICATION

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Approved by:

Karen A Wager		4/23/18
Chair, Project Committee	Karen Wager, DBA	Date
Tamala S. Bradham		4/23/18
Member, Project Committee	Tamala S. Branham, DHA, PhD.	Date
		4/24/18
Member, Project Committee	Erin Winstanley, PhD.	Date
		4/23/18
Dean, College of Health Professions	James S. Zoller, PhD.	Date

Acknowledgements

I would like to acknowledge and thank the members of my dissertation committee for their guidance and assistance: Committee chair Dr. Karen Wager, and committee members Drs. Tamala Branham and Erin Winstanley. I would also like to thank my dear friends Dr. Darlene Anderson, Dr. Linda Workman, Carol King, Mary Ann Cook, Paula Detterman, Kara Fleming, Judy Steele Mitchell, and Lynn Rueve who provided encouragement each day, as well as all my other RN friends/colleagues who continuously supported my efforts. I especially want to acknowledge my special friend, Becky Sykes, who as the former Chief Information Officer for Mercy Health, greatly supported my doctoral education and research. Everyone's continued words of encouragement helped me complete this project.

Finally, I want to recognize my husband, Alfred K. Nippert, Jr., JD, without whom I would never have initiated my doctoral journey. He has been a constant source of love, support, strength, and understanding throughout the years.

Abstract of Doctoral Project Presented to the Executive Doctoral Program in Health Administration & Leadership Medical University of South Carolina In Partial Fulfillment of the Requirements for the Degree of Doctor of Health Administration

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Chairperson: Dr. Karen Wager, DBA
Committee: Dr. Tamala S. Branham, DHA, PhD.
Dr. Erin Winstanley, PhD.

Abstract

Health care consumers expect high quality care and outcomes that are cost effective, while hospitals focus on improving patient engagement and satisfaction and optimizing reimbursement. The nurse-patient communication process is a critical component of care for hospitalized patients. Use of technology applications to communicate patient needs may increase patient engagement in their own care while improving patient satisfaction. An expanded use of the electronic record capability has been implementation of a new patient-centric application embedded in the electronic record technology known as MyChart Bedside ©. The objective of this study was to determine if there was an association between hospitalized patients using the MyChart Bedside© application and Hospital Consumer Assessment of Healthcare Providers and Systems survey (HCAHPS)

nurse-patient communication scores. This was a retrospective cohort study. The setting was an acute care hospital with 415 beds and the application was studied on three medical-surgical nursing units. There were 1520 patients who responded to HCAHPS surveys over a three-year time period, of which 290 patients (14%) activated the bedside application. The measurements were patient satisfaction scores for three questions related to the Communication with Nurses domain on the survey. The results of the study demonstrated a statistically significant association between the patients who activated the MyChart Bedside© application and satisfaction with nurse-patient communication compared to the satisfaction scores for those who did not activate the application during hospitalization. The activators had .26 higher satisfaction scores than non-activators (p value <.005). There was no significant association with the bedside application and satisfaction scores with age, race, or gender. In conclusion, the activation of MyChart Bedside© application, as an interactive application for patients, was associated with improved patient satisfaction and may be considered a strategy to enhance patient engagement in their own healthcare, improve satisfaction with nurse-patient communication, and support hospital reimbursement through meeting Value-Based Purchasing (VBP) initiatives.

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Chapter I: Introduction

Transformative changes are occurring in healthcare due to the increasing demand for high quality and lower cost healthcare services. The U.S. is the only country without a national public-funded healthcare system yet has among the highest costs per capita and lower than expected quality outcomes (Commonwealth Fund, 2015). Changes driving transformation include fragmentation of healthcare services, waste, recurring communication failures, and unacceptable error rates in care delivery (Salmand & Echevarria, 2017).

In 1999, the Institute of Medicine released a key report, *To Err is Human: Building a Safer Health Care System* (IOM, 2000). At the time of the publication, they found that between 44,000 and 98,000 people die in hospitals each year from preventable medical errors. In addition to the alarming loss in humans' lives, the costs of medical errors were estimated to result in $17 billion to $29 billion per year for hospitals nationwide. The report concluded that most of these preventable errors did not result from acts of individual carelessness. Instead, they were more commonly caused by system failures, poorly designed or broken processes, poor communication, and environmental conditions that increased the likelihood of people making mistakes or not preventing them. To address this end, IOM recommended the urgent need for health care organizations (HCOs) to employ the use of engineering tools and technologies to reduce serious medical errors; to create a culture of patient safety that promotes the reporting, analysis, and preventions of errors; and to implement standardized clinical protocols and

evidence-based health care processes to ensure safe practices at the service delivery level (IOM, 2000).

A key part of health transformation in the U.S. included the evolution towards the use health information technology (HIT), which serves as an enabler in the transformation process. In 2009, the American Recovery and Investment Act (ARRA) was signed into law and created an economic stimulus package to improve HIT for health care organizations. The legislation provided funding for hospitals, clinics, and community health centers across the U.S. to invest in the implementation of HIT. An innovative outcome of moving towards embedding technology into the healthcare system has been the introduction of technology applications or "apps," as they have come to be known. There are over 318,000 health-related application available with over 200 health apps added per day (HealthIT News, 2017). These healthcare applications are anticipated to improve patient engagement and reduce health care costs. Furthermore, these reports have not mentioned the potential use of applications at the patient's bedside (HealthIT news, 2017).

Another major driver in healthcare transformation pertains to patient satisfaction. With financial reimbursement now being tied to the patient's perception, more is at stake for hospitals to find innovative ways to engage patients in their healthcare needs. The Hospital Consumer Assessment of Healthcare Providers Survey (HCAHPS) is a survey questionnaire sent to patients following their hospitalization. It is designed to assess patient satisfaction with overall hospital experience (HCAHPS Fact sheet, 2015). The Joint Commission found that the top 25% of hospitals in the U.S. with higher HCAHPS survey scores had higher profitability and clinical outcome quality scores compared to

hospitals with lower HCAHPS scores (Dempsey, Reilly, & Buhlman, 2014). Hospitals' poor performance in the HCAHPS survey is significant in terms of their amount of reimbursement for achievement of the annual CMS standards. Furthermore, research suggests that there is an association between HCAHPS performance and other quality-based healthcare measures, such as readmission reduction and hospital acquired conditions (Press Ganey Associates, 2013; Dempsey, et. al.,2014).

In 2013, the Centers for Medicare and Medicaid Services (CMS) initiated a Value-Based Purchasing (VBP) program for the approximately 3,000 hospitals across the U.S in order to reward value, outcomes and innovation in care. CMS adjusts the hospitals' annual Medicare payment (reimbursement). For 2018, the risk-adjusted payment can impact up to 2% of a hospital's base reimbursement payments (CMS Fact Sheet, 2015). The VBP payment program is a "carrot and stick" approach that provides financial rewards to incentivize improved quality outcomes and increase value rather than volume of care provided. The four key domains used to measure success include the following:

1. Clinical Care (25%)
2. Patient Safety (25%)
3. Patient and Caregiver Experience (25%)
4. Efficiency and Cost Reduction (25%)

The VBP incentive payment criteria include the above clinical outcomes, core measures (patient outcomes), and patient satisfaction results as measured by HCAHPS. Up to 2% of hospitals' Medicare (CMS) payments will continue to be at risk through

2019 if certain metrics are not met. The total value-based incentive amount available for 2018 is estimated to be $1.9 billion (CMS Fact Sheet, 2017).

Going forward, there are potential benefits for hospitals implementing innovative interactive technologies to help improve patients' experience/satisfaction during hospitalization. New technology is important as an enabler of communication for patients, their families, and caregivers in hospital settings. The challenge is to determine if there is an association between interactive technologies and patient satisfaction scores. As the VBP program matures, hospitals will continue to seek strategies by which app technology can impact HCAHPS scores in a positive way (Werder, 2015).

Background and Need for the Study

An example of an interactive technology for hospitalized patients stems from a secure online health management tool which can connect patients to their health systems' electronic medical records. A new interactive application (app) known as MyChart Bedside © had its initial world-wide pilot and implementation in early 2014 in a community-based hospital in central Ohio (Personal communication, Rebecca Sykes. CIO, 9/22/2015). The MyChart Bedside © application allows the patient to gather information on their care providers, check on test results, review their medication regimes, check on schedules and upcoming procedures, and communicate with their clinical providers. It also can connect to educational information related to patients' conditions and treatments. With Bedside, patients can identify members of their care team, which may help to build trust and rapport with health care providers. It may promote self-management by patients or family members who normally would not ask staff questions because they did not want to bother nurses. Furthermore, it can reduce the

distance between the patient and nurse and promote transparency among patients and family members, all of whom have access to the same information directly from the source. Little empirical research, however, is available on the impact of implementing type of application in the inpatient setting and its role in the nurse–patient communication process. Prior to undertaking this study, the researcher found there is an underrepresentation of literature evaluating the potential benefits and effectiveness of the bedside patient portal on the nurse-patient communication process for hospitalized patients.

Problem Statement

There is a lack of evidence supporting the usage of applications that can facilitate communication between patients and bedside nurses.

Purpose

The purpose of this study was to determine if there was an association between hospitalized patients using MyChart Bedside© application and HCAHPS nurse-patient communication scores.

Research Questions and Hypotheses

1. Is there an association between the MyChart Bedside © app and patient satisfaction with nurse–patient communication, as evidenced in the HCAHPS Satisfaction with Nurse Communication domain scores (NCDS)?

   H_0: There is no significant relationship between activating the Bedside Application and NCDS.

   H_0: $\beta 2 = 0$

H_1: There is a significant relationship between activating the Bedside App and NCDS.

H_1: $\beta_2 \neq 0$

2. Does activation of the MyChart Bedside © application differ by the patient's age, race, gender, or length of stay (LOS)?

   H_0: There is no significant difference in NCDS between the patient age, race, gender and LOS.

   H_0: $\beta 2=0$

   H_1: There is a significant difference in NCDS between the patient age, race, gender, and LOS.

   H_1: $\beta_2 \neq 0$

Population

The population size for the study was 1,520 patients from three medical-surgical nursing units at Mercy St. Rita's Hospital. The sample included surveys received from inpatients from July 1, 2014 through June 30, 2017 admitted to 6K- Renal/Telemetry, 5K-Medical Oncology, and 4K- ICU Step-down/Telemetry units. These patients were discharged from these nursing units and completed the survey process conducted by Press Ganey.

Assumptions

1) These three units are representative of units generally to make conclusions about the application's impact on nurse/patient communication.

2) There was no change in training/staffing/goals or other local circumstances that might have an impact on scores. The application is the only plausible cause for any altered patient/nurse communication scores.

Chapter II: Review of the Literature

Health information technology (HIT) is a broad topic area. To adequately review the needs and evidence-based practices associated with usage of HIT, this literature review is organized into four major sections. The first section reviews published research specific to healthcare in the U.S. This section includes review of the Institute of Medicine (IOM) reports that initiated national quality and safety recommendations. In 2010, the Affordable Care Act initiated reimbursement mandates from The Centers for Medicare and Medicaid (CMS) as defined in the value-based purchasing (VBP) program for hospitals. Lastly, the nationally mandated Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey was implemented in 2008 in order to provide hospitals feedback about patient experience. The second section discusses the importance of patient engagement, patient satisfaction, and the communication process within the nurse-patient relationship and its influence on quality/safety outcomes. The third section reviews the importance of HIT related to nursing, the healthcare-related uses of web-based and electronic tools (tablets and other electronic devices), and how mobile applications can enable patient satisfaction and engagement. The final section presents the conceptual framework used to guide this descriptive study.

The literature search included articles published between 2000-2018 through Scopus, PubMed, Medline, and CINAHL, Google Scholar, and OVID in consultation with the MUSC Library. Key search terms included “patient participation,” “patient engagement and satisfaction,” “computerized medical records systems,” “hand held computers/satisfaction by patients, and nurses,” “nurse-patient satisfaction,” “HCAHPS and patient satisfaction,” “patient portals”, “patient experience”, and “value-based

purchasing incentives program." Scopus provided the largest sample of articles and included the terms of patient satisfaction/engagement and application for tablet devices and satisfaction. Neither Ovid, Medline, nor PubMed revealed any literature specifically related to hospital-based bedside applications for patients. Many articles were available through PubMed on the other search items and served as valuable resources for this study.

Throughout this review process, there appeared a gap in the literature related to understanding how the use of HIT and new web-based technology, such as emerging electronic applications in hospitals, can enhance patient-centered care and impact patient satisfaction. Therefore, the purpose of this study is to investigate the association between the activation of the MyChart Bedside © application (app) and patient satisfaction scores within the *Communication with Nurses* domain of the HCAHPS survey, as compared to satisfaction scores of patients who did not activate this app during their hospitalization. The literature review was written to illustrate this gap.

Healthcare in the United States

The Institute of Medicine (IOM). This non-profit organization was established by the National Academy of Sciences in 1970 to secure the services of individuals with the best and most appropriate scientific expertise to advise the federal government on policies pertaining to the general health and well-being of the public. Over the past two decades, the IOM's cadre of prominent researchers, practitioners, and educators from the health sciences, engineering, management, and other relevant disciples have produced a number of major reports focused on addressing the nation's most pressing public health care problems. In 2000 and 2001, the IOM published two widely cited reports that

brought the issue of medical errors and their impact on patient safety and quality of care in health care organizations (HCOs) to the forefront of national concern. The first report, *To Err is Human: Building a Safer Health Care System* (IOM, 2000*),* found that between 44,000 and 98,000 people die in hospitals each year from preventable medical errors. In addition to the alarming cost in lives, medical errors were further estimated to result in total economic costs of $17 billion to $29 billion per year in hospitals nationwide. The report concluded that most of these preventable errors did not result from acts of individual carelessness. Instead, they were more commonly caused by system failures, poorly designed or broken health care processes, poor communication, and environmental conditions that increase the likelihood of people to make mistakes or fail to prevent them from occurring. Recommendations in the report included the urgent need for HCOs to employ the use of engineering tools and technologies to reduce serious medical errors; to create a culture of patient safety that promotes the reporting, analysis, and preventions of errors; and to implement standardized clinical protocols and evidence-based health care processes to ensure safe practices at the service delivery level (IOM, 2000). In 2016, Makary and colleagues published the medical error death rates from four published studies from 2000 to 2011 to estimate a medical error rate for hospital admissions in 2013. Using this approach, they found that medical errors accounted for about 251,454 deaths which is more than double the IOM report. Another study from James (2013) estimated more than 400,000 premature deaths per year associated with medical error.

The second IOM report, *Crossing the Quality Chasm: A New Health System for the 21st Century* (IOM, 2001), revealed the presence of a wide chasm between the quality of care the nation's current health care system should be capable of delivering and the

quality of care most patients actually received. The report concluded that failure of the health care sector to take advantage of the astounding advances in medical science and technology in the prior half century resulted in the deterioration of health care delivery to a level that posed serious threats to the health and well-being of many Americans. The report provided additional evidence of the deep quality chasm or crises related to the safety, efficacy, efficiency, and patient-centeredness of health care in America and called for fundamental reform of the nation's health care system. The report set forth a vision for a transformed health care system capable of delivering safe, effective, patient-centered, timely, efficient, and equitable health care in a system capable of achieving the six quality aims of a successful 21st century health care system. This report called attention to the critical role information and communications technologies must play to achieve major improvements in the key performance dimensions. However, many United States (U.S.) health facilities were functioning at far lower levels on these key performance dimensions when the IOM report was distributed due to the lack of information technology transformation in the health care arena (IOM, 2001). This study indicated that information technology is one of the necessary components for comprehensive health care delivery transformation since technology applications enable automation of patient-specific clinical information.

In 2004, the IOM published a third report, *Keeping Patients Safe: Transforming the Work Environment for Nurses*, which builds on recommendations set forth in the two prior reports. That report provided health care organizations a "blueprint" to transform work settings that employ registered nurses. This study is significant for three reasons (IOM, 2004):

1. It identified the key role nurses have in the delivery of safe care and provided recommendations for changing the work environment.
2. It clarified the role of governing boards, organizations' executive boards, and executive leadership roles in creating safe work environments.
3. It identified workplace processes that are central for creating an environment for patient safety for all health care practitioners.

Specific recommendations were provided for nurse staffing to create and sustain a culture of safety within healthcare organizations, thus highlighting how important nurses are to improving patient safety (IOM, 2004).

This report was followed by IOM's study, *The Future of Nursing: Leading Change, Advancing Health* (IOM, 2010), which focused on the critical role the nursing profession plays in the provision of health care delivery. The report highlighted the importance of nursing in providing leadership in health care delivery transformation in the United States and conveyed four key messages for the Nursing profession:

1. Nurses should practice to their fullest extent of their license.
2. Nurses should achieve higher levels of education.
3. Nurses and physicians should partner in redesigning healthcare in the United States.
4. Workforce planning and policy-making require better data and technology/information infrastructure.

Overall, the various IOM reports concluded that both nurses and information technology play a central role in the redesign of healthcare systems in order to create substantial improvements in safety and quality outcomes for patients. Automation of clinical work processes and transactions are essential in improving quality, efficiency, and

consumer confidence in the nation's health system (IOM, 2001). Each IOM report was built upon the previous work to provide guidance to improve health care overall in the U.S.

HCAHPS: After the release of the initial IOM report on quality and safety risks for patients, CMS partnered with the Agency for Healthcare Research and Quality (AHRQ) in 2002 to develop a standardized consumer survey process to determine hospitalized patient satisfaction after discharge. The overall HCAHPS survey asks discharged patients 32 questions about their recent hospital stay. The survey contains 18 core questions about critical aspects of patients' hospital experiences (communication with doctors, communication with nurses, the responsiveness of hospital staff, the cleanliness and quietness of the hospital environment, pain management, communication about medicines, discharge information, overall rating of hospital, and if the hospital is recommended).

By 2008, hospitals across the country were provided with valid comparisons of patient experiences of care, with this information available for consumers to review. These survey reports are posted publicly on Medicare's Hospital Compare website for healthcare consumers to compare quality and hospital experiences across eleven standard measures (www.medicare.gov). The CMS website states the main goals of the HCAHPS survey are as follows:

> *"First, the survey is designed to produce data about patients' perspectives of care that allow objective and meaningful comparisons of hospitals on topics that are important to consumers. Second, public reporting of the survey results creates new incentives for hospitals to improve quality of care. Third, public reporting serves to enhance accountability in health care by increasing transparency of the*

quality of hospital care provided in return for the public investment" (CMS HCAHPS Fact Sheet, 2015).

As seen in Figure 1. below, hospitals' HCAHPS performance can potentially impact 25% to 30% (note change by year) of the VBP score based on patients' satisfaction within the eight care dimensions or processes of care (POC) that define patients' hospital experiences. One of the key dimensions measured in the HCAHPS survey is nurse–patient communication, reflected in three of the survey questions in the *Communication with Nurses* domain: (Q1) "How often did nurses treat you with courtesy and respect?", (Q2) "How often did the nurses listen carefully to you?", (Q3) "How often did the nurses explain things in a way you could understand?" (HCAHPS survey, 2015).

Research by Press Ganey Associates (2013) found that a positive patient experience, as measured in the *Communication with Nurses* survey items, can increase satisfaction with the hospital experience. In fact, improvement in the *Communication with Nurses* survey items has been shown to be related to other patient experience measures as well, including responsiveness of staff, pain management, communication about medication, and overall satisfaction with the hospital experience. As a result, nurse–patient communication is now referred to as a "rising tide" measure, which denotes how critically important an effective nurse–patient communication process is in driving overall HCAHPS scores (Dempsey, Reilly, & Buhlman (2014). It is critical to understand how patients perceive and evaluate their care, which, in turn, influences hospitals' VBP scores and incentive payments (Dempsey et. al, 2014). Therefore, the implication of HCAHPS survey performance is significant for a hospital's financial revenue from CMS reimbursement.

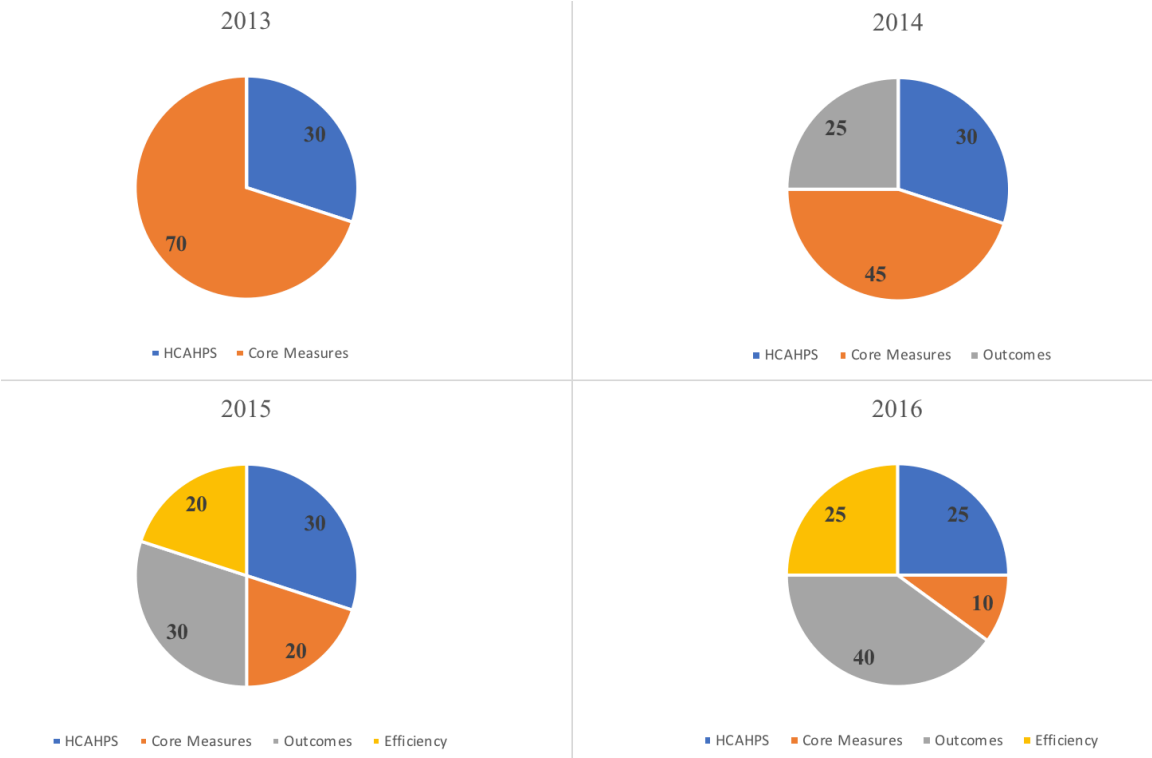

Figure 1: CMS Domain Weighting Changes by Year (Press Ganey, 2013)

Value-Based Purchasing Program (VBP)

In 2010, the Affordable Care Act (ACA) initiated the VBP program, which mandates hospital reimbursement based on value provided to consumers. Through this program, CMS financially rewards hospitals for the quality of care provided to Medicare patients based on how clinical practices are implemented, and how well the hospitals provide care for patients during a hospital stay. CMS determines the hospitals' performance based on the outcome measures as included in the HCAHPS survey. The Patient Experience of Care domain is weighted at 25% for scoring reimbursement (CMS, 2015).

In terms of health care transformation, the ACA has proven to be the catalyst for moving from volume to value-focused care. With these changes, success in a value-based model means providers are rewarded by meeting specific quality performance requirements, such as improved health outcomes, improved efficiency, and effective management of chronic conditions. Transformation of the healthcare delivery model has fostered systems and processes that focus on patients' needs.

Since the implementation of VBP, patient satisfaction has moved to a higher level of attention and expectation in hospitals. Key metrics monitored by HCAHPS include patient outcomes (70%) and patient satisfaction (30%). These metrics now directly impact the financial reimbursement of hospitals (CMS, 2015). As a result, healthcare leaders and administrators are more conscious of patients' experiences. The HealthLeaders Media 2013 Industry Survey found that 54% of healthcare executives now have patient experience and patient satisfaction in their top three priorities (Rice, 2013).

Patient Satisfaction and Nurse-Patient Communication

Patients' perceptions of the hospital experience have become critical determinants of financial reimbursement since the introduction of the Affordable Care Act of 2010. HCAHPS measures their satisfaction with their overall experience (CMS, 2015). Research conducted by The Joint Commission found that the top 25% of hospitals in the U.S. with higher HCAHPS survey scores had higher profitability and clinical quality scores compared to hospitals with low HCAHPS scores (Dempsey et. al, 2014). Hospitals' poor performance in the HCAHPS survey is significant in terms of the amount of reimbursement for achievement of the annual CMS standards. Furthermore, research

suggests that there is an association between HCAHPS performance and other quality-based healthcare measures (Press Ganey, 2013; Dempsey et. al, 2014).

Nursing is a profession with a focus on the bio-psychosocial and spiritual needs of patients. The practice of professional nursing not only has a scientific basis but also requires interpersonal, technical, and communication skillsets. Creating a trusting nurse-patient relationship is a foundational expectation in nursing practice. Consistent with this professional definition, *"Satisfaction with nursing services is the only hospital service identified as having a direct relationship with overall patient satisfaction"* (Wagner & Bear, 2008, p. 693). Patients can equate poor nursing services to poor quality in a hospital experience and their dissatisfaction is reflected in low scores on the HCAHPS after discharge (Lo, Berman, Rodin, & Zimmerman, 2009). An ineffective relationship and poor nurse-patient communication can hinder the professional credibility of the nurse and reduce the effectiveness of patient care (Orem, 2001).

Fosbinder (1994) created a theory of "interpersonal competence" based on patients' perspectives regarding the interpersonal competence of nurses who cared for them. This qualitative study included 40 patients and twelve nurses from orthopaedic and cardiac units in a teaching hospital. Interestingly, the patients discussed the interpersonal interaction rather than specific nursing care. The key themes that emerged from this research included "translating (informing, explaining, instructing, and teaching), getting to know you (personal sharing, being friendly, kidding), establishing trust (being in charge, anticipation of needs, being prompt, following through, and enjoying the job), and going the extra mile (being a friend and doing "extra")" (Fosbinder, 1994, pp. 1085-

1093). This research recognized the importance of the subjective patient experience in the nurse-patient communication process.

An increasing body of research has shown the importance of nurse communication to overall patient satisfaction (Kourkouta & Papathanasiou, 2014). Communication has intrinsic value in terms of the nurse-patient relationship and it is a bi-directional interaction. Failure to recognize the value of these key relationships can lead to negative perceptions (Kourkouta, 2011). Effective communication also improves the quality of care for patients and is considered a prerequisite for meaningful relationships between nurses and patients (Diamantopoulou, (2009).

In terms of how nurses communicate with patients, Peplau (1998), Fosbinder (1994), Wilkinson & McNeil (1996), Attree (2001), and Thorsteinsson (2002) found that communication includes both providing information to patients and acknowledging patients' needs. These researchers supported the perspective that communication is a fundamental part of nursing care and a requirement in delivery of patient care services. McCabe and colleagues (2004) focused on the patients' experiences with the nurse-patient communication process in an acute care hospital. Specifically, they explored how nurses communicate with patients. Data were collected using unstructured interviews and a purposive sampling method with eight patients. The researchers found that patients were highly satisfied with nurses' communication, but nurses were not perceived as great communicators in terms of sharing information back to patients. However, a key positive difference emerged when the nurses' approach included a patient-centered rather than task-centered interaction. A patient-centered approach refers to the nurse giving their

time and “being there” for the patient in an interpersonal way rather than focusing specifically on the task at hand (e.g., drawing blood).

Another valuable aspect of care delivery is the development of effective relationships between patients and nurses in hospital settings. An essential component of this relationship is the nurse–patient communication process, particularly during the patient admission process. An effective communication process can influence not only the satisfaction of patients with their hospital experience but also their health outcomes (Park & Song, 2005). Effective communication includes verbal exchanges with patients and their families, the verbal transmission of feelings, and the acknowledgement of those feelings between the patient and the nurses caring for them (McCabe, 2004). Studies by Woolf, Kuzel, Dovey, & Phillips (2004), Leonard (2004), and Dempsey et. al (2014) found that ineffective communication among health care providers and their patients is one of the leading causes of medical errors and patient harm. The Joint Commission on the Accreditation of Healthcare (TJC) refers to this ineffective communication as “communication failures” (The Joint Commission, 2009). These failures are implicated as the root cause of over 70% of sentinel events in hospitals (Joint Commission, 2005). To provide more reliable and higher value care, effective professional communication is essential between patients, physicians, and especially nurses, who provide direct care to patients (Dingley, Daugherty, Derieg, & Persing, R., 2008).

Tejero (2010) studied the importance of the nurse-patient bonding experience and patient satisfaction within the healthcare environment, with attention on providing safe care in the context of a patient’s wellbeing. They found that the bonding experience creates a nurse-patient linkage through their interactions in meeting care needs. Tejero

(2010) evaluated 210 nurse-patient dyadic interactions using the Nurse-Patient Bonding Instrument. This instrument determines the nurse-patient bonding based on openness to each other and their engagement in their care. Nurse and patient characteristics were obtained through interviews, observations, and chart reviews. Path analysis was used to determine whether there was a statistical association between satisfaction with the nurse-patient interaction and satisfaction with care. The findings indicate this "nurse-patient dyad" (nurse-patient pairing) is associated with positive outcomes, i.e., facilitation of patient learning and patient satisfaction with care.

In 2013, Press Ganey conducted research on what specific strategies drive HCAHPS scores. Using a hierarchical clustering analysis, findings indicated that a hospital's performance on the *Communication with Nurses* domain was associated with performance on the other measures related to perceptions of care (Press Ganey Associates, 2013). This finding resulted in the communication processes between nurses and patients being identified as the "rising tide measure" which lifts all others (Dempsey, et.al. 2014). As discussed earlier, HCAHPS scores can impact hospitals' performance and revenue, and thus, it is a valuable measure. One strategy could involve improving HCAHPS scores overall, with a focus on the *Communication with Nurses* domain, which is statistically associated with other key measures (Dempsey et. al, 2014; Press Ganey Associates, 2013). Press Ganey research has shown the following five key HCAHPS dimensions that consistently cluster together statistically:

- Communication with nurses
- Responsiveness of hospital staff
- Pain management

- Communication about medication
- Overall satisfaction rating

As displayed in Figure 2, the *Communication with Nurses* dimension leads the other four measures that "follow the leader" and provide the full force to influence the "Overall Rating" of satisfaction on the HCAHPS survey. *Communication with Nurses* can provide a trajectory to improve performance as it correlates with movement of the other four measures (Press Ganey Associates, 2013).

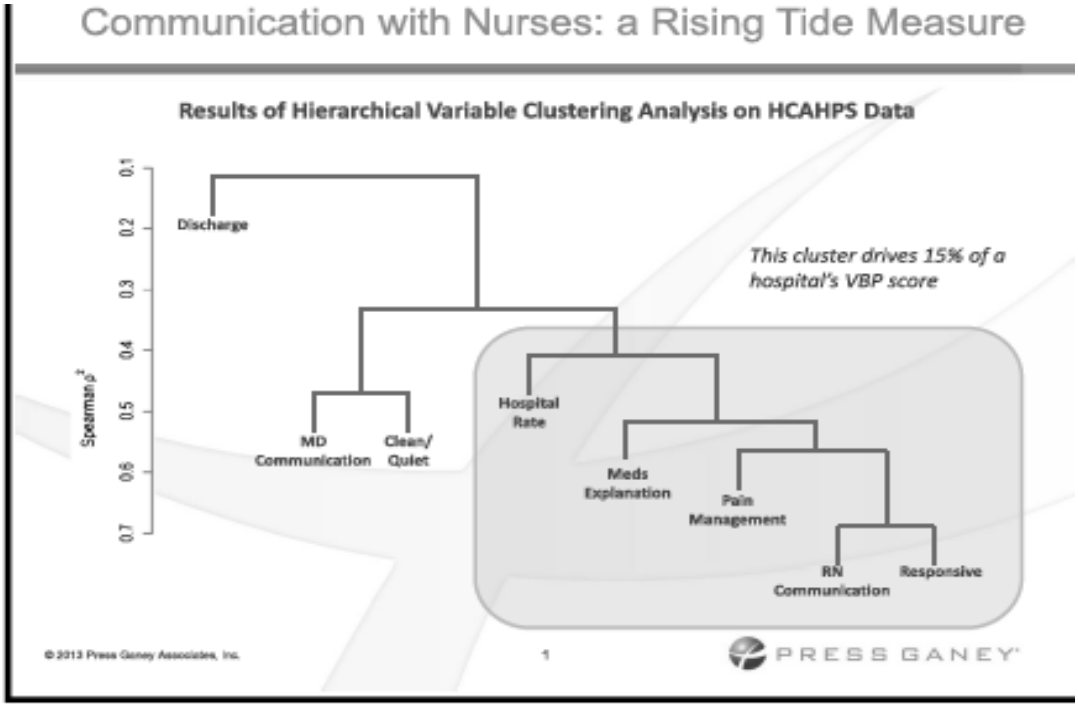

Figure 2 Nurse Communication Cluster (Dempsey et. al, 2014 p.145)

Patient Satisfaction and Impact on Outcomes: Research suggests that hospital culture and nurses' interpersonal skills are as important as or more important to the "quality experience" as the clinical and technical interventions in the hospital (Dykes & Collins, 2013). Many hospitals now implement patient experience "interventions" to improve

patient satisfaction (e.g., nurse hourly rounding, follow-up phone calls after the patient is discharged, executive rounding, noise reduction efforts, creation of "healing environments", and other recommended practices).

Patient Engagement and Impact on Outcomes: Research in the early 1990's showed family centered care anxiety levels and cardiovascular health were positively affected leading to fewer medical interventions (Damboise, & Cardin, (2003).

A study undertaken at the University of Virginia's Children's Hospital showed that sharing information and involving family in a patient's care (via the family-centered care model described previously) had the following effects: A rise in staff satisfaction due to reduced phone calls by security at night; improved consistency of information given to family members; a decrease in clinical workload; and a significant rise in patient satisfaction scores on the Press-Ganey scale in the areas of Accommodations and Comfort of Visitors (93 to 98), Information provided to Family (87 to 99), Staff Attitudes Towards Visitors (62 to 75), and Safety and Security felt at the Hospital (86 to 88). But even today, some research suggests that there is still a disconnect between actual family participation and the desired participation where families want to participate more in the care processes but often are not afforded this opportunity (Romaniuk, O'Mare, & Akhtar-Danesh, 2014; Crais, Roy, & Free, 2006). The core of patient engagement today is professionals and families working hand-in-hand to provide services to achieve optimal outcomes for their patient. In support of this concept, Doyle, Lennox, & Bell (2013) found that engagement through access of information and communication with providers' builds patients' confidence and empowered them to participate in their own health care. Jha (2017) identified several outcome variables that can optimize patient experience.

These variables included patient engagement, patient satisfaction (patient and staff), clinical effectiveness, and patient safety (Jha, 2017). In light of these findings, patient experience can be improved with a focus on all the variables rather than an individual variable since patient experience is the *"sum of all interactions"* (Jha, 2017, p. 38).

Technology and Health Care

In 2010, US hospitals were strongly incentivized to implement electronic health record (EHR) systems to comply with the national government standards set forth in the American Recovery and Reinvestment Act of 2009 (ARRA). At that time, Congress passed the Health Information Technology for Economic and Clinical Health Act (HITECH Act, 2009) to stimulate the adoption of EHR across the health care system and to enhance privacy and security for health information exchanges, electronic applications, and insurance entities. An EHR can be defined as:

"*an electronic record generated by a health care provider to document patients' medical and health information on a continuing basis. It may contain demographic data, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, and radiology reports. The EHR can support clinical activities including evidence-based decision support, quality management, and outcomes reporting. It can automate and streamline clinicians' workflow. An EHR is not directly accessed by patients, although certain data may be made available through a patient portal"* (Emont, 2011, p. 2).

The U.S. Secretary of Health and Human Services developed specific "meaningful use" criteria on EHR implementation (Table 1) with the intention of improving implementation and subsequent outcomes tied to individual and population-

level health (HITECH Act, 2009). Incentive payments from CMS to HCOs are paid at the successful achievement of each meaningful use stage. The standards for rating and meeting objectives are set by the government and defined in phases or stages. Stage 1 standards for meaningful use include the objective of electronically capturing health information coded to track key clinical conditions, as well as initiating reports on public health information and clinical quality measures. Information includes patient demographics, payer source, installment of drug interaction software, and electronic prescribing. Stage 2's meaningful use expanded Stage 1 capabilities to provide clinical decision support, medication management support for patient access to their medications, access to their health information through a patient portal quality measurement and research, and bi-directional communication capabilities with public health agencies and other enhanced information exchange activities. Stage 3's meaningful use provides focus on enhancement of quality, safety and efficiency improvements, and patient access to self-care management tools in order to support population health and patient access to comprehensive health data (HITECH Act, 2009). A summary of these meaningful use criteria is provided in the table below:

Table 1: Stages for Meaningful Use Criteria

Stage 1	Stage 2	Stage 3
Electronically capturing health information in a standardized format	More rigorous health information exchange (HIE)	Improving quality, safety, and efficiency, leading to improved health outcomes
Using that information to track key clinical conditions	Increased requirements for e-prescribing and incorporating lab results	Decision support for national high-priority conditions
Communicating that information for care coordination processes	Electronic transmission of patient care summaries across multiple settings	Patient access to self-management tools

Initiating the reporting of clinical quality measures and public health information	More patient-controlled data	Access to comprehensive patient data through patient-centered HIE
Using information to engage patients and their families in their care		Improving population health

ONC, 2015

The electronic health record moves from organizing basic technical data into meaningful information (Stage 1), to developing a rigorous health information exchange that enables clinical care decisions and patient data transmissions (Stage 2), to focusing on decision-support applications, improving quality, safety, and patient outcomes, and enabling patient self-management through mobile application tools (Stage 3) (Blumenthal & Tavener, 2010). The shift from paper patient records to digital platforms created greater opportunity to increase efficiency, convenience, and effectiveness of health care delivery in meeting patients' needs (Blumenthal & Tavener, 2010).

In light of these increasing digital platforms, personal technology use has never been higher. Today, 95% of all Americans own a cell phone of some sort, and smart phone usage is up to 77% in 2017 from 35% in 2011 (Pew, 2017). Technology is also enabling transformation of the health care system in the U.S. There are new patient mobile applications (apps), not only for communication but also for educating patients and their families, sharing data, and information exchange. It is increasingly important to understand how new patient-centric applications, such as remote telehealth monitoring and health education applications, can affect patients' and clinicians' interactions and communication. A 2015 survey found that over 50% of cell phone users had downloaded a health-related application on their phones (Krebs & Duncan, 2015), and there are currently more than 150,000 healthcare applications on the

market (Dias, Ribeiro, & Furtado, 2016). As consumers increase their usage of mobile health information technology (Figure 3) and new health applications, patients can obtain more comprehensive information about their disease processes and enhance connections with their providers (Office of the National Coordinator for Health Information Technology (ONC, 2015). Figure 2 depicts how individuals used certain types of information technology to interact with their health care providers, view personal health information, and track their health (ONC, 2015). Using health information technology to communicate with healthcare providers rose notably (18%) between 2013 and 2014. The total number of individuals using text messaging to communicate with health care providers tripled from 2012. Individuals accessing their personal health information online grew 50% from 2013-2014. Mobile health app usage on smart phones increased from 13% in 2013 to 17% in 2014. The graphs below reflect an overall increase of 13% in the use of any types of these health information technologies from 2012 (35%) to 2014 (48%) (ONC, 2015).

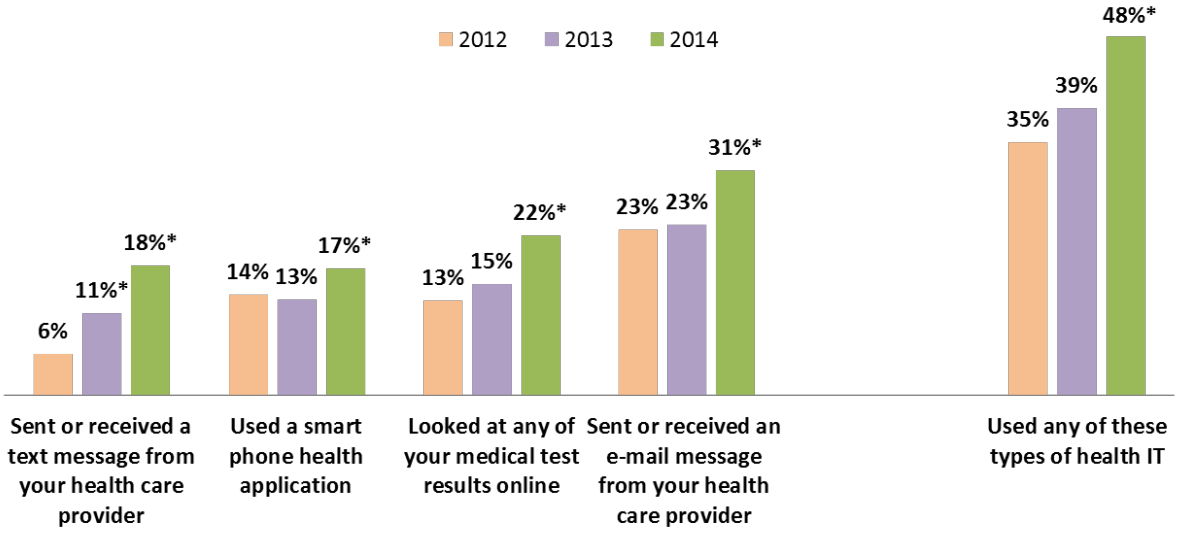

Figure 3: Trends in Individual Use of Health IT: 2012-2014. (Health IT Dashboard, 2015)

Web Technology and Electronic Mobile Device

In 2009, the American Recovery and Reinvestment Act (ARRA) allocated over $35 billion dollars in stimulus money to implement information technology in hospitals. This new technology promotes patient–provider communication and decision support in healthcare environments (Hillestad, Bigelow, & Bower, 2005). This national effort benefits healthcare settings with effective electronic records and also enables the initiation of the personal health records (PHR) comprised of a patient's health information communicated through a health information exchange (HIE) (Kumar, 2011). New health information sharing processes allow patients and providers to coordinate care, monitor a patient's progress, reduce errors and improve patient safety (Menachemi & Collum, 2011). Sharing patient information can reduce the redundancy and duplication often seen with paper-based documentation. However, there are some drawbacks with the electronic transition of care processes, including patients' increased concerns about privacy and inappropriate information sharing. In order to address these risks, the government implemented specific regulations to protect information. These practices are embedded in the existing Health Insurance Portability and Accountability Act (HIPAA), and violation of these policies and practices results in large monetary fines (Menachemi & Collum, 2011).

Patients/consumers have become engaged in regular use of the Internet as a health resource to gather information, understand symptoms, and become better informed about their health conditions. In fact, the basic nature of health communication has changed due to the Internet (Gallant, Irizarry, Boone, & Kreps, 2011). A Pew research study (2011) of the 14 top-ranked U.S. hospitals studied how these leading institutions use technology-

based tools to attract and engage consumers. The study included a review of 1,330 web pages and performed an inductive content analysis to characterize the nature of hospitals' technology use for the purpose of communication. Online communication tools identified include videos, social media connections, podcasts, and other interactive media. The study found that patients became more engaged in their health experience when using these various electronic tools and social media such as Facebook, Twitter, and YouTube. There were few (less than 50%) mobile applications available on the hospitals' websites at the time (Gallant, et. al., 2011). Overall, 80% of Internet users looked for health-related information online, which ranked third among reasons for internet use behind email and search functions (Fox, 2011). Web-enabled communication tools allowed patient-provider interactions, e.g. email, chat, and texting. While 13 of the 14 hospitals relied upon email communication between the hospital and patients, 3-4 organizations provided tools for chatting and text messaging. In terms of providing mobile applications to support messaging and education on smartphones or tablets, only 5 of the 14 had mobile apps available for patients to use. The statistics were not available on the extent to which these mobile applications were used by patients.

Vest and Miller (2011) conducted research on the association between health information technology and its impact on patient satisfaction. The study included 3,278 hospitals and measured whether hospitals who participated in a health information exchange (HIE) (inter-organizational sharing of patient information) would have higher levels of patient satisfaction with health providers "always communicating well" as measured by the HCAHPS survey tool. The study found that hospitals that participated in

a HIE were positively associated with measures of communication and patient satisfaction with nurses' communication (Vest & Miller, 2011).

Vawdrey, Wilcox, Collins, Bakken, Feiner, Boyer, & Restaino (2011) conducted a study in a large New York hospital with five cardiology step-down unit patients. The aim of this study was to determine whether tablet technology would provide an effective platform for information and improve patient participation in their care. The health system built a custom patient application accessible using mobile devices. Patients who were selected to use this new technology were very enthusiastic regarding its applicability in providing patient education and other health information, including medication history and photographs of their care providers. Semi-structured interviews were conducted, and patients completed a 25-question survey on patient satisfaction and knowledge of their care. The survey was derived from the Telemedicine Satisfaction and Usefulness Questionnaire. The findings indicated that tablets could provide patients with a sense of trust, increase adherence to regimens, and improve patient satisfaction. Therefore, Vawdrey, et. al., (2011) concluded, patients participated more actively in their own care. Limitations to this study were its small sample size of five patients on a single inpatient cardiology unit.

Greysen, Khanna, Jacolbia, Lee, & Auerbach, (2014) conducted a pilot study with 30 patients to examine the potential impact of electronic tablets (e.g., Apple iPad) on hospital patients' engagement in their care. The two web-based programs on the tablet included an interactive video to improve education about patient safety and access to the patients' medical information to promote inpatient engagement in discharge planning (Greyson, et. al., 2014). Structured interviews and pre- and post-administered self-report

questionnaires were used to determine if patients accessed their electronic PHR in order to improve engagement in their care. This study demonstrated positive patient satisfaction (90%) with use of the tablet. The authors recommended embedded use of tablets in patient care and engagement of providers to increase communications with patients and gain work efficiencies. In sum, tablet-based educational modules and can increase patients' ability to access their health records (Greysen, et. al., 2014).

Irizarry and colleagues (2015) conducted research related to patient portals (PHR) and patient engagement. The key drivers for the development of the patient portals were the "meaningful use" criteria of the CMS EHR incentive program. Meaningful use criteria mandate that patients must have a clinical summary after each visit and secure electronic messaging between the patient and provider (Blumenthal, 2010). A patient portal is defined as electronic personal health record tethered to institutional electronic health records (Irizarry, Dabbs, & Curran, 2015). The patient portal provides a mechanism for patients to gain awareness of their medical situation and communicate with healthcare professionals regarding their personal health. The researchers conducted a comprehensive review of the literature on patient portals and/or electronic PHR from 2006 through 2014. The authors concluded that patients' utilization in portals was influenced by age, ethnicity, education level, health literacy, health status, and role as a caregiver. While this information is preliminary, it helps provide an overview of potentially influential factors on patients' willingness and ability to use patient portal systems.

Health Information Technology (HIT)

The ACA encourages the integration of technology in health care to improve care and increase efficiency. As part of this legislation, hospitals have been financially incentivized to implement electronic health records (EHR) in order to improve care delivery by the reduction of errors (Piscotty, Kalisch, & Gracey-Thomas, 2015). In 2008, Kaiser Permanente Institute, along with the American Medical Informatics Association and the AHRQ, initiated and sponsored research on how integrated personal health records (PHR) accessed through a patient portal, can become transformative tools for consumers (Detmer, Bloomrosen, Raymond, & Tang, 2008). A patient portal is web-based way patients can view some of their information from their electronic medical record (EMR). When a patient portal is added to an EMR, it can then be called an electronic health record (EHR). The review found that a PHR would increase patients' ability to manage their own health care by enabling them to view some of their health information. The objective was to design the PHR to be a "consumer–centric" health tool as a framework for the future. Research efforts began to focus on the concept of interoperability, through which the EMR information would be able to be shared across health care entities and among providers. The outcome was considered transformational in terms of the next phase of the electronic health records (Detmer, et. al., 2008).

Another longstanding type of technology has facilitated the nurse-patient communication process. In many hospitals across the country, the "call light technology" is still in place and provides a direct link from the patient to call for assistance while in the hospital. Call light technology has been the main vehicle for patients to communicate their needs to nursing for decades (Galinato, Montie, Patak, & Titler, 2015).

Historically, most hospitalized patients have not had the ability to connect directly with their caregivers through a mobile device. Many hospitals have unsatisfactory HCAHPS patient satisfaction scores in terms of the *Communication with Nurses* dimension (Altman, Clancy & Blendon, 2004). In fact, this performance has become a national concern for hospitals following the Center for Medicare and Medicaid (CMS) linkage of satisfaction scores to reimbursement. Information technology solutions now have the potential to make care safer through strategies for information sharing (Altman, et. al., 2004).

Hospitals continue to expand their capability and use of EHR in order to continue meeting "meaningful use" objectives. A particular expanded use of the electronic record capability has been implementation of a new patient-centric application embedded in the electronic record technology known as MyChart Bedside ©. The screenshot below (Figure 4) illustrates an example of the type of information and interaction available between the nurse and the patient and/or family during hospitalization (www.epic.com, 2015). While not an actual patient, it provides a representative view of the application as patients or family members would view caregivers on their mobile tablet device.

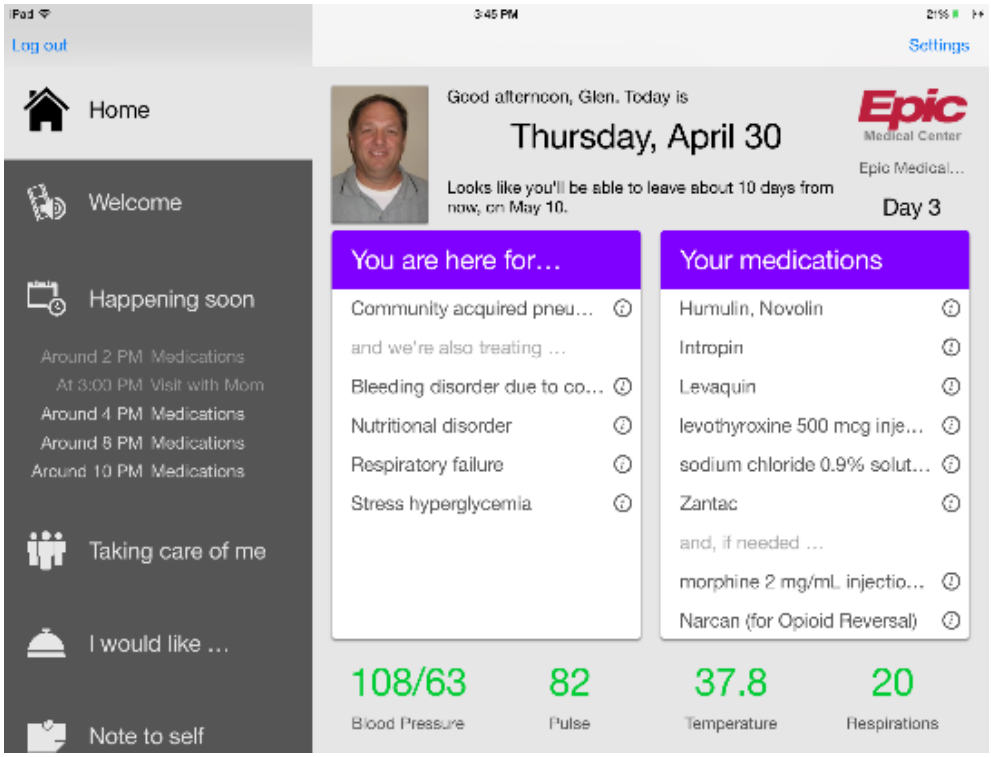

Figure 4: Screenshot of an example of a patient's view in the MyChart Bedside© application

This new and innovative app is able to connect to the *MyChart* patient record (MyChart Bedside©) and the electronic medical record system. As discussed previously, a patient portal is an extension of the vendor's core electronic health record system and can be defined as *"a secure website through which patients can access a personal health record and certain information from an EHR"* (Emont, 2011, p. 2). To initiate the MyChart Bedside© app, the nurse asks patients if they are interested in activating it during their hospital stay. A special code is generated on a workstation laptop that is scanned by the iPad's camera to launch the MyChart Bedside© app on a mobile device. The patient is able to create a four-digit personal identification number to open the app each time it is used. All patient data is encrypted for security. Upon discharge, the hospitals' medical record system triggers a message instructing the patient's mobile

device to erase all patient data on the hard drive. At this time, the application is only able to be connected using android and iPad devices, which the hospital loans to patients upon admission to the nursing unit.

The first MyChart Bedside© application was piloted and then fully implemented in early 2014 at a community-based hospital in central Ohio. The MyChart Bedside© application allows the patient to gather information on their care providers, test results, medication regimes, schedules and upcoming procedures. It enables patient communication with their clinical providers and can connect to educational information related to patients' conditions and treatments. Patients use it to review their recent vital signs and send requests via text to their nurses for items such as ice chips or warm blankets. With MyChart Bedside©, patients can see photos and read personal information about the members of their care teams, which may help to build trust and rapport with health care providers. A calendar feature lets patients know when they will receive medications, see visitors, or receive diagnostic tests. In addition to serving as a communication tool, patients can also use the app to access information about their medications, as well as report side effects of these medications to their physicians and nurses. It may promote self-management by patients or family members who normally would not ask staff questions because they would not want to bother nurses with call buttons designated for urgent matters. Furthermore, it can promote transparency among patients and family members, all of whom have access to the same information directly from the source. There is no empirical research available on the impact of implementing this application in the inpatient setting and influence on satisfaction with the nurse–patient communication process.

Conceptual Framework

The health care delivery system is undergoing major changes, including a transformation from a volume-based care delivery model to one based on value and quality. Now that hospitals are reimbursed based on specific performance parameters, the focus on quality outcomes, such as patient satisfaction, has become critically important. The ACA raised the bar in terms of creating the "pay for performance" mandates for specific quality measures, mandates enforced by CMS. Specifically related to this study, health care organizations that improve their performance on the HCAHPS survey will be financially rewarded and recognized publicly.

Based on the current health care transformation, a greater emphasis is often placed on patient safety and satisfaction. The IOM reports provide the new paradigm and guidelines needed to improve quality for patients. The conceptual framework selected to guide this study evolves from the quality improvement literature that resulted from the early works of Avedis Donabedian. The Donabedian Model (1966) provides a foundational approach to evaluate the importance of quality and how the meaningful use of technology may enhance provider-patient communication (Dykes, et. al., 2013). The Institute of Medicine has defined "quality of care" as *"the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge"* (Lohr, 1990, p. 375). Quality assessment is focused on a systematic approach to quality evaluation within the context of a quality *structure* of a system, on *the process* of delivering care, and on *clinical or organizational outcomes* (Donabedian, 1966). Based on a synthesis of the body of work necessary for examining, defining, and measuring relationships among the

research variables, this framework will provide the context for reporting and analyzing the outcomes of this study.

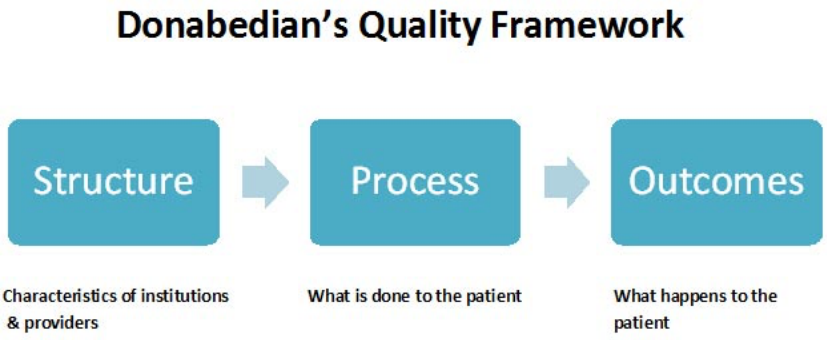

Figure 5: Donabedian Model of Quality

The Donabedian Model has been used as a successful framework for evaluation of management of both the practitioners' performance and interpersonal relationships (Donabedian, 1988). This triad is based on the supposition that quality in health care is the result of both science and technology (Grossbart & Agrawal, 2011). The framework has three categories in which quality of care can be evaluated:

Structure is defined as facilities, equipment, or information technology interventions. In this study, the structure will refer to the use of the MyChart Beside © application as part of health information technology available to hospitalized patients. The application is used in order to enable care processes and communicate with nurses while hospitalized. It is a requirement before *Process* and *Outcomes* (Kunkel, Rosenquist, & Westerling, 2007).

Process can be defined as those activities that involve care delivery/medical care, including care providers and patients. In this study, the care process is the relationship between the nurse and patient and their communication while in the hospital. Requests

for personal needs, review of medications, and shift-specific caregivers, etc., are included in the care processes and information sets within the MyChart Bedside© application.

Outcomes can be defined as the effect of the care delivery on patient care experiences and are reflected in the patients' satisfaction with that care in the HCAHPS survey scores.

The basic premise of this three–part approach is that Donabedian's model provides a supposition that a "good structure increases the likelihood of good process, and good process increases the likelihood of good outcome" (Donabedian, 1988). According to Donabedian, the outcome of patient satisfaction as a measurement of quality is an expression of the judgment of patients' experience of care, especially as it relates to interpersonal relationships and the communication process. Based on this assumption, *"it is futile to argue about the validity of patient satisfaction as a measure of quality…information about patient satisfaction should be indispensable to assessments of quality as to the design and management of healthcare systems"* (Donabedian, 1988, p. 1744).

Donabedian's framework is effective for this research in that it emphasizes the importance of structure, processes, and outcomes of care on the quality of care. HCAHPS can be defined as a valid standard of measure for evaluation of process-outcome interventions on the outcome defined as patient satisfaction (Dykes, et al, 2013). Within the context of Donabedian's framework, MyChart Bedside © becomes an integral part of the patient's care delivery process using the application technology embedded in the EMR. The patients in this study are hypothesized to become engaged in their own care

using the application while hospitalized and then provide feedback through the HCAHPS survey process about their experience of care after discharge.

Summary of Literature Review

The review of the literature supports the importance of hospital patients using technology including tablets, computers, and cell phones to increase their education and improve participatory care. The National Research Council (Stead, & Lin, 2009) report outlined important themes required to achieve the Institute of Medicine's vision for 21st century healthcare. One of the stated requirements is: *"Empowerment of patients and families in effective management of health care decisions and execution…education about the individual's conditions and options, and support of timely and focused communication with professional health care providers"* (Vaudrey, et. al., 2011, p. 1429).

Research suggests that the nurse-patient communication process is an essential part of care delivery and one key to developing a trusting relationship with hospitalized patients. Patients who had positive nursing care interactions reported higher satisfaction with their overall care experience. A Press Ganey study found higher scores on *Communication with Nurse* questions was associated with higher the overall satisfaction scores on the HCAHPS survey (Press Ganey Associates, 2013).

The literature related to health information technology and patient engagement/satisfaction shows that nationally recognized health systems are exploring how to engage patients in their care in order to increase engagement and satisfaction. In these studies, there were several different research methods. Interviews with providers and patient users of technology, as well as questionnaires, content analysis, and survey

tools were examples of methods used to collect and analyze the information. Overall findings identified the nurse-patient communication process is essential for hospitalized patients, health IT is important to consumers and increasing in usage, and it is likely that new mobile applications will continue to expand in health care.

Conclusion

Healthcare reform has created an impetus to develop different strategies in which consumers can be more actively involved in in their own health care. The focus on quality of care and patient satisfaction has moved to the top of the list for leaders in healthcare organizations. As discussed by Grossbart and Agrawal (2011), *"the conceptualization and definition of quality is undergoing a dramatic change. Since Donabedian first provided a framework for assessing quality, our conceptualization and definition of quality has matured. In order for health care providers to influence the direction of health care quality …and continue to adopt tools and approaches to implement change as outlined in the (Chasm) report and as embodiment of health care reform"* (Grossbart & Agrawal, 2011, p. 20).

CMS has created financial incentives for hospitals and health systems to implement certain benchmarks in their capability and performance using an electronic health record. As noted in the literature review, research studies have found that patients who have access to their electronic record have had increased overall satisfaction and convenience (de Lusignan, Mold, Sheikh, Majeed, Wyatt, Quinn, & Blakey, 2014). The MyChart Bedside© application is one such strategy. The potential benefit and impact of this innovative technology on patients' overall satisfaction with the nurse-patient communication process during their hospitalization is most important for this study. As noted earlier, patient

experience drives 30% of the VBP strategy for hospitals (Dempsey, et. al., 2014). There is a plethora of literature on the importance and impact of the nurse-patient communication process as noted in the literature review. Studies have shown that the better the communication process between the nurse and patient, the more satisfied the patient will be with the care received and the "experience" in the hospital. Another finding of this review is that there is more available literature about the nurse-initiated communication process rather than patient-initiated communication. However, there was no evidence-based research found specifically related to the MyChart Bedside© application and its influence on the nurse-patient communication process. From this perspective, this study will make a valuable contribution to the literature

Chapter III: Methodology

Study Setting

This research study occurred at a 415-licensed bed, not-for-profit community hospital, which serves as an adult Level 2 regional care provider and is part of a larger health system. The organization has implemented an electronic health record (Epic). An innovative technology component available as part of the EHR is the application known as MyChart Bedside ©. This application was the first in the world to be piloted and then implemented in this hospital in early 2014. There are no previous studies examining the association between use of bedside applications and patient satisfaction as measured by HCAHPS scores in the nurse-patient communication arena.

Study Design

The study design was a retrospective cohort analysis of responses to three HCAHPS survey questions related to nurse-patient communication among patients who activated the new app compared to those who did not activate the application. The HCAHPS survey scores from a non-random sample of patients hospitalized during the implementation of the application are the units of measure. The study utilized the Press Ganey satisfaction scores for the three nurse communication survey questions on the three nursing units from the three-year timeframe (2014-2017). The scores from each of the questions for each respondent were added together to create a global communication score for patient satisfaction (0=lowest and 9=highest). A linear regression model was

created to analyze the patient satisfaction responses with the patient covariates to determine the predictors of satisfaction.

The survey samples included monthly HCAHPS scores from July 2014 through June 2017 from three nursing units. The initial start-up with the nursing staff and implementation of the bedside application occurred in January 2014 as a pilot. In consideration of this start-up period and the transition process for the staff on the three nursing units that implemented the bedside application process, six months gave the nursing staff sufficient time to become proficient with the new app. Therefore, the data collection period was from July 2014 through June 2017. The individual patient HCAHPS scores for the *Communication with Nurses* scale served as the outcome for comparison.

Population and Sample

The proposed sample included all inpatients from July 1, 2014 through June 30, 2017 admitted to 6K- Renal/Telemetry, 5K-Medical Oncology, and 4K- ICU Step-down/Telemetry units. The following process determined which patients had used the MyChart Bedside©. Upon admission to each nursing unit, patients were invited by their nurse to participate in use of the bedside application using a mobile device. If the patients were mentally alert, able to communicate verbally, and agreed to use the mobile device with the downloaded bedside application, the nursing staff provided verbal information and initially enabled the application through the hospital intranet. Patients were excluded from using the MyChart Bedside© app if they did not understand the instructions (as judged by the nurse on that floor). During this time period, patients were given the option to use their own personal device or one provided by the hospital. Family members were

instructed about how the patient would be able to access the application and could also obtain a username allowing them to access the patient's record (with their hospitalized family member's approval).

Definition of Variables

The MyChart Bedside© application usage (defined as *activation* of the app) is the independent variable and differences in patient satisfaction scores on the *Communication with Nurses* domain served as the dependent variable. Additional independent variables included the following patient demographic characteristics:

Age: Measured in years.

Race: Designated as white, black/African American, Hispanic. Asian or other

Gender: Designated as male or female.

Length of Stay: Number of days that the patient is hospitalized until discharge.

Data Collection

The patient satisfaction data related to the *Communication with Nurses* domain was retrieved from the HCAHPS surveys collected by Press Ganey. Electronic files of survey responses are sent to the hospital on a weekly basis. This study used the hospital's HCAHPS survey data to examine if there was an association/relationship between patients' use of MyChart Bedside© and patient satisfaction with nurse-patient communication as reflected in survey responses. The patients' demographic data source was also from the Press Ganey files from patients surveyed. Press Ganey Associates who serve as the hospital's agent provided the HCAHPS results. The MyChart Bedside© patient activation data was obtained and matched with the HCAHPS data through the Mercy Health associates using unique identifiers for visits provided by Press Ganey.

For this study, the composite scores related to the *Communication with Nurses* domain were used to measure the association between those patients who did and did not use the MyChart Bedside© application based on results from the three questions pertaining to patients' satisfaction with nurse-patient communication. The following three questions provided responses based on a four-point Likert scale where 1 was scored as Always, 2 was scored as Usually, 3 was scored as Sometimes, and 4 was scored as Never.

1. (Q1) "How often did nurses treat you with courtesy and respect?"
2. (Q2) "How often did the nurses listen carefully to you?"
3. (Q3) "How often did the nurses explain things in a way you could understand?"

(Source: HCAHPS survey, 2015).

After the HCAHPS survey response data was downloaded, respondents' scores were analyzed over the 36-month time period to understand the extent to which respondents were satisfied with the communication process with nurses as defined in the three related survey questions. The two groups for comparison were those who did and did not activate the MyChart Bedside© app.

Data Analysis

The survey was administered to a randomized sample of all inpatients per requirement of the Centers for Medicare and Medicaid (CMS). Individual patient surveys were matched through a unique identifier for visits provided by Press Ganey Associates and Mercy Health associates provided only de-identified application activation (matched) data for this study.

Statistical Method

The study sample targeted patients who have been discharged from three nursing units 6K Renal/Telemetry, 5K Medical Oncology, and 4K ICU stepdown from July 1, 2014 through June 30, 2017 (3 fiscal years). Patient factors (age, race, gender, length of stay, etc.) were summarized using means (with standard deviations) and proportions as appropriate. Univariate analysis compared communication satisfaction among patients who activated the application versus non-activation by patients using categorical factors and percentages. Differences were tested using the Pearson's chi-square test. Quantitative variables were summarized using means ± standard deviations. Differences on quantitative variables were analyzed using a simple linear regression model and tested for significance using the t-test for the model's regression coefficient. Tables were used to reflect the associations between the outcome variable and the individual predictor variables.

Multivariate analysis used the significant patient factors from the univariate analysis to develop a multi-linear regression model of communication satisfaction and its potential associations with length of stay, trend over years of the study, and MyChart Bedside© app activation. A table was created to report the associations between outcomes and MyChart Bedside© app activations, adjusted for any significant covariates. The models were designed to adjust for imbalances in patient factors related to outcomes (satisfaction responses for three nurse-patient communication elements). As stated above, the t-test for the regression coefficient determined if MyChart Bedside© app activation correlations with satisfaction were statistically significant when adjusting for other covariates.

Results of the three logistic regression models are reported as coefficients with a 95% confidence level. A p-value of <0.05 indicates a significant result. Results of these analyses for the combined nursing units are prepared and presented using appropriate charts, tables, and/or graphs. The "R" Foundation for statistical Computing software (version 3.2.4; 2016, Vienna, Austria) was used for these statistical analyses.

Instrument

The HCAHPS survey was administered to a randomized sample of adult inpatients within 48 hours to six weeks post hospital discharge and was not restricted to Medicare patients. Hospitals must have at least 300 surveys completed over four calendar quarters.

The overall HCAHPS survey asked discharged patients 32 questions about their recent hospital stay. The survey contains 18 core questions about critical aspects of patients' hospital experiences (communication with nurses and doctors, the responsiveness of hospital staff, the cleanliness and quietness of the hospital environment, pain management, communication about medicines, discharge information, overall rating of hospital, and if the hospital is recommended). For this study, only the three questions related to the nurse-patient communication domain were included in analysis. The survey tool is presented in its entirety in Appendix A and has been deemed reliable and valid (CMS, HCHAPS Fact Sheet, 2015).

Press Ganey served as the CMS-approved vendor for administering the HCAHPS survey for this hospital and provided individualized HCAHPS results for each of the member hospitals on a weekly basis via electronic files. This community hospital's data

was provided in that context for each of the nursing units within the hospital, as well as the other overall scores.

Limitations

The current study may be limited by its design, which involves selecting groups upon which an intervention will be tested without a random prospective selection process. There are likely extraneous factors that predict whether or not someone will have access to the app in the first place (personal comfort level with technology, severity of medical condition, etc.).

Institutional Review Board Approval (IRB)

The HCAHPS survey was administered to a random sample of discharged adult patients and did not include a consent form. The surveys were conducted by Press Ganey Associates who served as the agent for Mercy Health and was completed by a random sample of patients discharged from maternity, medical, and surgical care services. No personal health information or personal identifiers were collected. Mercy Hospital and Medical University of South Carolina Institutional Review Board deemed that this study did not constitute human subject research and thus was exempted.

ORIGINAL MANUSCRIPT

JOURNAL OF HOSPITAL MEDICINE

ABSTRACT

Health care consumers expect high quality care and outcomes that are cost effective, while hospitals focus on improving patient engagement and satisfaction and optimizing reimbursement. The nurse-patient communication process is a critical component of care for hospitalized patients. Use of technology applications to communicate patient needs may increase patient engagement in their own care while improving patient satisfaction. An expanded use of the electronic record capability has been implementation of a new patient-centric application embedded in the electronic record technology known as MyChart Bedside©. The objective of this study was to determine if there was an association between hospitalized patients using the MyChart Bedside© application and Hospital Consumer Assessment of Healthcare Providers and Systems survey (HCAHPS) nurse-patient communication scores. This was a retrospective cohort study. The setting was an acute care hospital with 415 beds and the application was studied on three medical-surgical nursing units. There were 1520 patients who responded to HCAHPS surveys over a three-year time period, of which 290 patients (14%) activated the bedside application. The measurements were patient satisfaction scores for three questions related to the Communication with Nurses domain on the survey. The results of the study demonstrated a statistically significant association between the patients who activated the MyChart Bedside© application and satisfaction with nurse-patient communication compared to the satisfaction scores for those who did not activate the application during hospitalization. The activators scored .26 higher satisfaction than non-activators (p value

<.005). There was no significant association with the bedside application and satisfaction scores with age, race, or gender. In conclusion, the activation of MyChart Bedside© application, as an interactive application for patients, was associated with improved patient satisfaction and may be considered a strategy to enhance patient engagement in their own healthcare, improve satisfaction with nurse-patient communication, and support hospital reimbursement through meeting Value-Based Purchasing (VBP) initiatives.

I. INTRODUCTION

Health care consumers are demanding change due to the U.S. having one of the highest costs per capita and lower than expected quality outcomes (Commonwealth Fund, 2015). Finding solutions to engage consumers in their health care needs, is now at the forefront of service delivery models. Engaging health care consumers directly impacts overall quality of care, optimum clinical outcomes, and patient satisfaction (Iannuzzi, Kahn, Zhang, Gestring, Noyes, & Monson, 2015). The Hospital Consumer Assessment of Healthcare Providers Survey (HCAHPS) questionnaire was developed by The Center for Medicaid and Medicare Services (CMS) and Agency for Healthcare Research and Quality (AHRQ) in 2006. Research has shown that better communication between nurses and patients yields higher patient satisfaction with the care received and the hospital experiences (Kourkouta & Papathanasiou, 2014, Dempsey et al., 2014, Kourkouta, 2011, Diamantopoulou, 2009, Park & Song, 2005).

With the endorsement by the Institute of Medicine (IOM), health care organizations (HCOs) have been encouraged to employ the use of tools and technologies to improve evidence-based health care processes to ensure safe practices at the service delivery level (IOM, 2000). To encourage this shift to using technology within HCOs, the

American Recovery and Reinvestment Act (HITECH) (ARRA, 2009) included financial stimulus for implementation of health information technology (HIT) as electronic health records (EHR). HITECH focused on five goals; improve the quality, safety and efficiency of patient care, engage patients in their care, improve coordination of care, improve the health status of the population, and create a system of accountability through privacy and security of patient information (Blumenthal, 2010). In concurrence with embedding new technology into the healthcare system, there has been the introduction of innovative technology applications. There are over 318,000 health-related applications available, with approximately 200 added each day (HealthIT News, 2017). Beyond the adoption of EHR and focus on patient satisfaction, CMS also initiated a Value-Based Purchasing (VBP) program in 2013 to incentivize payments for services if certain criteria were met for clinical outcomes, core measures, and HCAHPS results to further underscore the important of consumer engagement in their health care. If metrics are not met, hospitals' Medicare (CMS) payments would continue to be at risk for non-payment of reimbursement up to 2% through 2019 (CMS Fact Sheet, VBP, 2017).

In light of the need for innovative technology in healthcare, an expanded use of the electronic health record capability has been implementation of a new patient-centric application embedded in the electronic record technology known as MyChart Bedside ©. The application allows the patient to gather information on their care providers, test results, medication regimes, schedules and upcoming procedures. It enables patient communication with their clinical providers and can connect to educational information related to patients' conditions and treatments.

Finding innovative solutions to engage health care consumers in their care are essential for HCOs to remain viable. With the evolution of health care applications (apps), there is hope that these can be used to improve patient engagement and reduce health care costs but at this time, evidence is lacking.

Purpose

The purpose of this study was to determine if there was an association between hospitalized patients using MyChart Bedside© application and HCAHPS nurse-patient communication scores.

To better understand the relationship between the interactive application and its influence on patient satisfaction the researcher examined the following:

1. Is there an association between the MyChart Bedside© application and patient satisfaction with nurse–patient communication, as evidenced in the HCAHPS Communication with Nurses domain (NCDS) satisfaction scores?
2. Does activation of the MyChart Bedside© application differ by age, race, gender, or length of stay (LOS)?

II. METHODS

Mercy St. Rita's Hospital is a not-for-profit community hospital with 415-licensed bed which serves as an adult Level 2 regional care provider and is part of a larger health system in Ohio. The study drew from a non-random sample of hospitalized patients on three medical-surgical nursing units (during a three-year timeframe (2014-2017). Data was collected from July 1, 2014 through June 30, 2017. A retrospective cohort study was used to assess the association between responses to three HCAHPS survey questions related to patients who activated the MyChart Bedside© application

compared to those surveyed who did not activate the application. Mercy Hospital and Medical University of South Carolina Institutional Review Board deemed that this study did not constitute human subject research and thus was exempted.

Upon admission to each nursing unit, patients were invited by their nurse to participate in use of the bedside application using a mobile device. If the patients were mentally alert, able to communicate verbally, and agreed to use the mobile device with the downloaded bedside application, then the nursing staff provided verbal information and initially enabled the application through the hospital intranet. Patients were excluded from using the MyChart Bedside© application if they did not understand the instructions (as judged by the nurse on that floor). Patients were given the option to use their own personal tablet or the hospital provided a mobile tablet to access the application. Family members were instructed about how the patient would be able to access the application and could also obtain a username allowing them to access the patient's record (with their hospitalized family member's approval for access).

The patient satisfaction data related to the Communication with Nurses domain were retrieved from the HCAHPS surveys collected by Press Ganey. The results from the survey included three questions specific to measurement of patients' satisfaction with nurse-patient communication. The following three questions were considered relevant from the HCAHPS survey: (Q1) "How often did nurses treat you with courtesy and respect?", (Q2) "How often did the nurses listen carefully to you?", (Q3) "How often did the nurses explain things in a way you could understand?" The post hospitalization survey was administered by Press Ganey Associates to a random sample of discharged patients and were asked 32 questions about their recent hospital stay and the respondents

rated their satisfaction with their hospital experience. Specific responses for the Communication with Nurses domain were examined to assess the patients' satisfaction with those that had and had not activated the MyChart Bedside© application while hospitalized (application activation). These three questions identified from surveys had responses that used an ordered four-point Likert scale and a sum of the three items to create a total nursing satisfaction score were coded: Never =0, Usually =1, Sometimes=2, and Always= 3 (0=lowest and 9= highest possible score). The total nursing satisfaction score related to the Communication with Nurses domain was coded to measure the satisfaction between those patients who did and did not activate the application. Press Ganey Associates, who served as the hospital's agent, provided HCAHPS results to Mercy Health. The MyChart Bedside© patient activation data was obtained and matched with the HCAHPS data through the Mercy Health associates using unique identifiers for patient visits provided by Press Ganey. In addition to *Nurse Communication Satisfaction* scores, the hospital's HCAHPS surveys provided several variables which were included as covariates in the analysis. These covariates included gender, age, race, and length of stay in the hospital. All data received for this study were de-identified.

Data was imported into the R statistical software and prepared for analysis. Descriptive tests were run to explore the sample's demographic characteristics. Group differences were tested using Pearson's chi-square test. The resulting group differences were tested using a simple linear regression model. A multivariable analysis was conducted using relevant patient factors from the univariable analysis to test three models using regression analysis. The three multivariable models include only those predictor variables that showed significance. These three models report the adjusted association

between the composite nurse communication score and MyChart Bedside© application activation. The models were designed to adjust for unbalances in patient factors related to the outcome variable (satisfaction responses for three nurse-patient communication elements). As stated above, the t-test for the regression coefficient determined if the MyChart Bedside© activation was statistically significant when adjusting for other covariates. All statistical analyses were carried out using the R statistical software and statistical significance is defined as $p < 0.05$.

III. RESULTS

There were 1,520 total HCAHPS completed during this study period of which 209 participants had activated the MyChart Bedside© app. Twenty-nine survey responses had one question response missing so these responses were imputed by the researcher and were included in the population. Three responses were of those who activated the app so did not impact the results as tested. Almost 14% of the patients activated the application during their hospitalizations. Table 1 reflects the mean age of 70.08 years for non-activators and 60.23 years for activators, which reflects a significant difference between groups at $p < .001$. Males (55.98%) were more likely to activate than females (44.02%) $p< 0.20$. The sample was mostly white (92.34%) compared to non-white (7.66%) $p< 0.34$. Mean length of stay was longer (4.40 days) for activators and (3.77 days) less for non-activators, which reflected a significant difference between the groups at $p <.001$.

Table 1. Descriptive statistics of key variables

Variable	Response Categories	Bedside App Activators N=209	Bedside App Non-Non-Activators N=1,311
Age in years Mean (SD)**		60.23 (13.68)	70.08 (13.70)
Gender N (%)	*Male*	117 (55.98)	643 (49.05)
	Female	92 (44.02)	668 (50.95)
Race N (%)	*White*	193 (92.34)	1,236 (94.28)
	Non-White	16 (7.66)	75 (5.72)
Length of stay in days M (SD)**		4.40 (3.24)	3.77 (2.85)
Length from project start in years Mean (SD)**		1.59 (0.82)	1.15 (0.82)
Nurse Communication Satisfaction* Score Mean (SD)		8.53 (0.95)	8.29 (1.27)

**p<.01*

***p<.001*

Figure 1a. illustrates the distribution of study patients, including both app activators and non-activators over the time period of the study, while Figure 1b. illustrates the total proportion of patients using the Bedside app during the same time period.

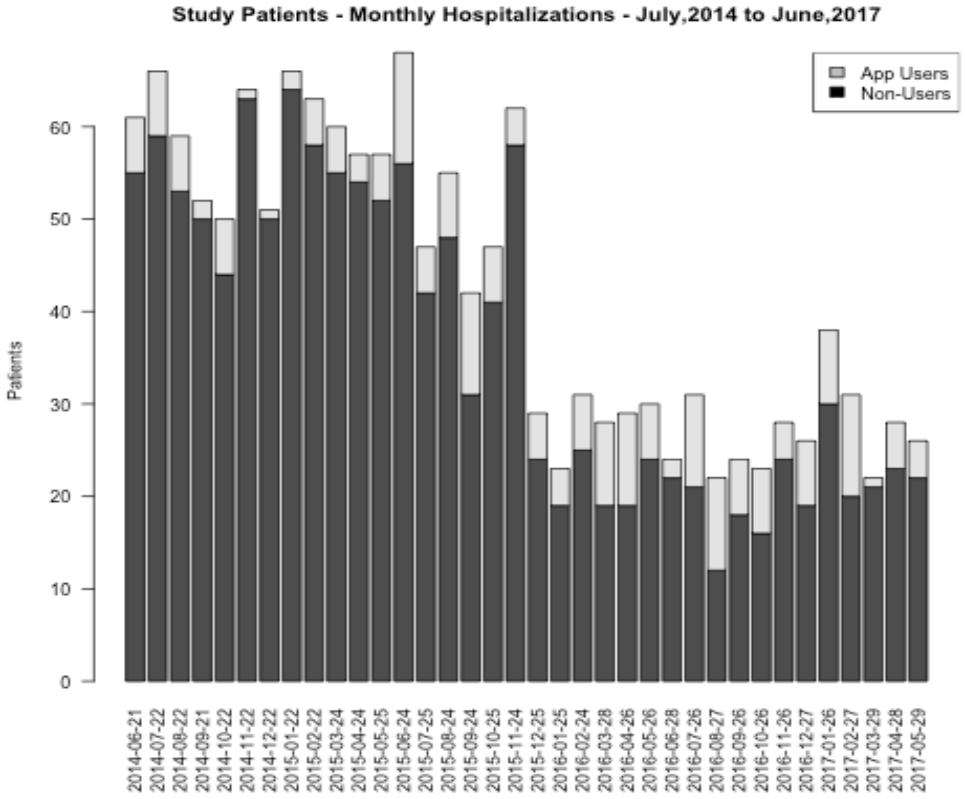

Figure 1a. Study Patients: July 2014-June 2017

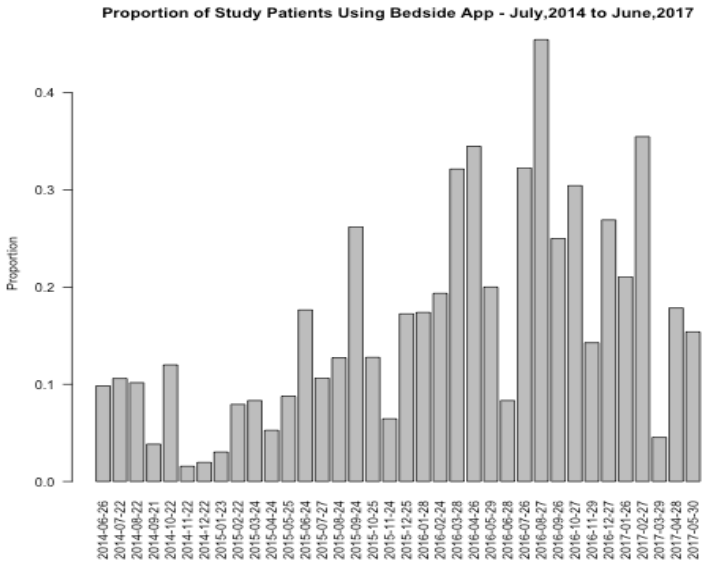

Figure 1b. Proportion of study patients who activated the MyChart Bedside Application

Results of the analysis of the proportion of patients who activated the application can be seen in Figure 1b. With further analysis to identify activation over the time period of the study, Figure 1c demonstrates that application activation continued to increase even after the number of HCAHPS surveys collected were reduced from 50% of discharged patients to just 8.33% of patients surveyed. The reduction in survey collection can be seen in between December and January 2015. The results demonstrate the odds of application activation increasing over time of this study and is represented as statistically significant ($p < 0.001$). Specifically, for each year of the study, the odds of activation increased by 1.82 (CI: 1.53 to 2.16).

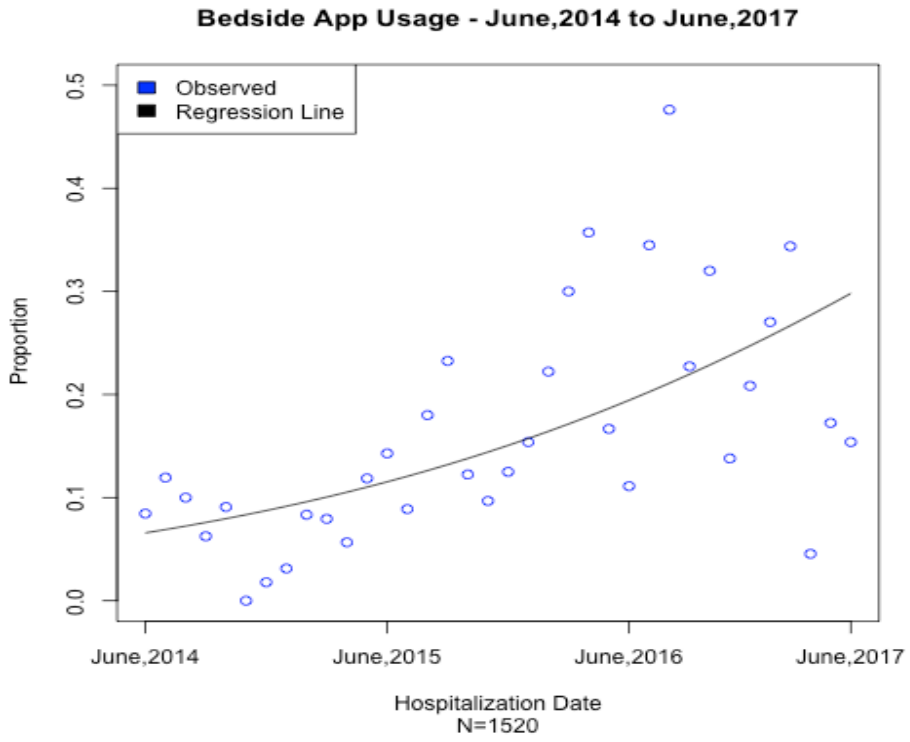

Figure 1c. Bedside Activation Significance

Figure 2 below reflects the distribution of *Nurse Communication Satisfaction* scores where the activators' mean was 8.53 and non-activators was 8.29 (p = .01) and shows the frequency distribution of scores. The results were heavily skewed to a response of "Always" in terms of the total (summed) nursing satisfaction score.

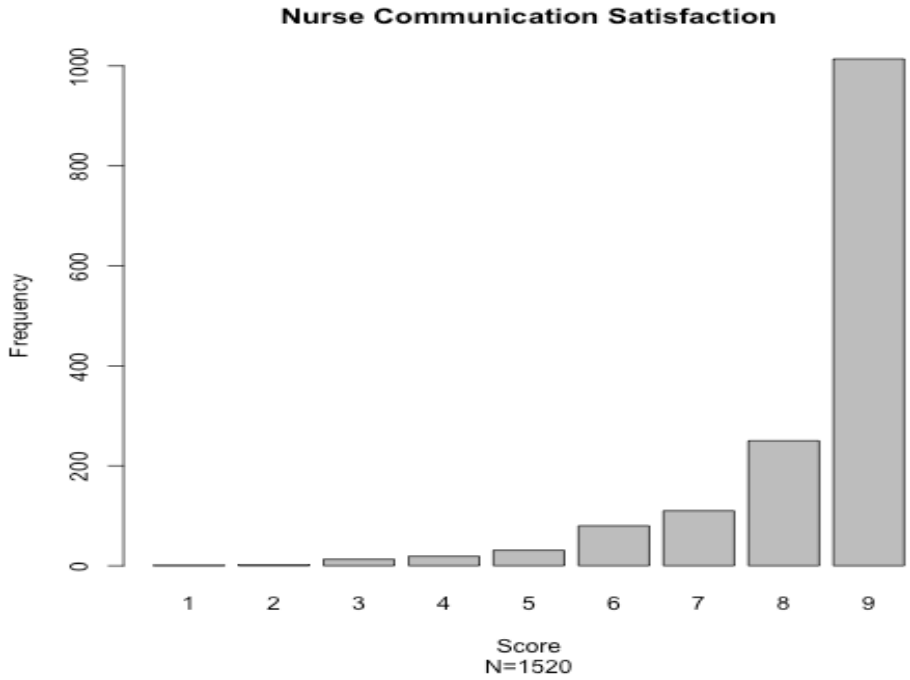

Figure 2. Distribution of Nurse Communication Satisfaction scores

Table 2 reports the associations between the outcome variable and the individual predictor variables related to the *Nurse Communication Satisfaction* score. There was no significant association with age, race, or gender. There were significant associations found with length of stay and application activation by patients. The regression coefficient reports the mean differences on the nurse score for the categorical factors and a change of one unit on the continuous factors. For example, activators scored 0.24 of a point higher than non-activators while patients with a longer hospital stay scored 0.03 of a point lower.

Table 2: Nurse Communication Satisfaction Score

Source	*Estimate*	*Std. Error*	*t*	*p*
Age	-0.001	0.002	-0.659	0.51
Gender (male)	-0.03	0.06	-0.43	.665
Race (white)	-0.02	0.13	-.014	.888
Length of stay (days)**	-0.03	0.01	-2.84	.005
Trend (years)	0.07	0.04	1.80	.073
App Activator*	0.24	0.09	2.57	.010

Table 3 reports three models which demonstrate that activators scored on average, significantly higher than non-activators, on the *Nurse Communication Satisfaction measure,* while controlling for relevant covariates. In model 1, activators scored significantly higher than non-activators ($p< 0.012$), controlling for LOS and Trend. Also, the *Nurse Communication Satisfaction measure* decreased significantly over length of stay as shown. In model 2, activators scored significantly higher ($p<0.02$) than non-activators controlling for Trend. Further, model 2 reports that, on average nurse communication score remained the same over the study period as Trend was not statistically significant. In model 3, activators scored significantly higher ($p<0.005$) controlling for LOS. Further, the nurse communication score significantly declined ($p<0.002$) for patients with longer length of stay while controlling for activation. Thus, the three models in Table 3 demonstrate a statistically significant association of the *Nurse Communication Satisfaction* score and activation of the application under various patient experiences.

Table 3 Associations with Nurse Communication Satisfaction: Multivariate Linear Regression

	Model 1(LOS + Trend+ Activator)			Model 2 (Trend + Activator)			Model 3 (LOS+Activator)		
Variable	*B*	*SE B*	*p*	*B*	*SE B*	*p*	*B*	*SE B*	*p*
Length of stay (days)	-0.03	0.01	0.003*	----	----	-----	-0.03	0.01	0.002*
Trend (years)	0.05	0.04	0.198	0.05	0.04	0.17	----	----	----
Bedside App Activation	0.24	0.09	0.012*	0.21	0.09	0.02*	0.26	0.09	0.005*
R^2	1.1%			0.6%			1%		
F for change in R^2	5.84**			4.23**			7.93**		

*** Significant at p<.001, *Significant at p<.01*

The scatterplot and regression lines in Figure 3 illustrate the relationship between length of stay and the *Nurse Communication Satisfaction* scores for activators and non-activators. The regression line is defined by those who activated the Bedside application and is the predicted mean at that LOS. Activators scored an average of 0.26 higher satisfaction than non-activators, regardless of LOS. Patients who activated Bedside reported higher satisfaction scores across the continuum of their stays. Although the findings are statistically significant, the model only explains a small part of the variability in Nurse Communication Satisfaction scores, therefore, these findings cannot predict individual patient satisfaction due to the nursing composite (sum total) scoring process.

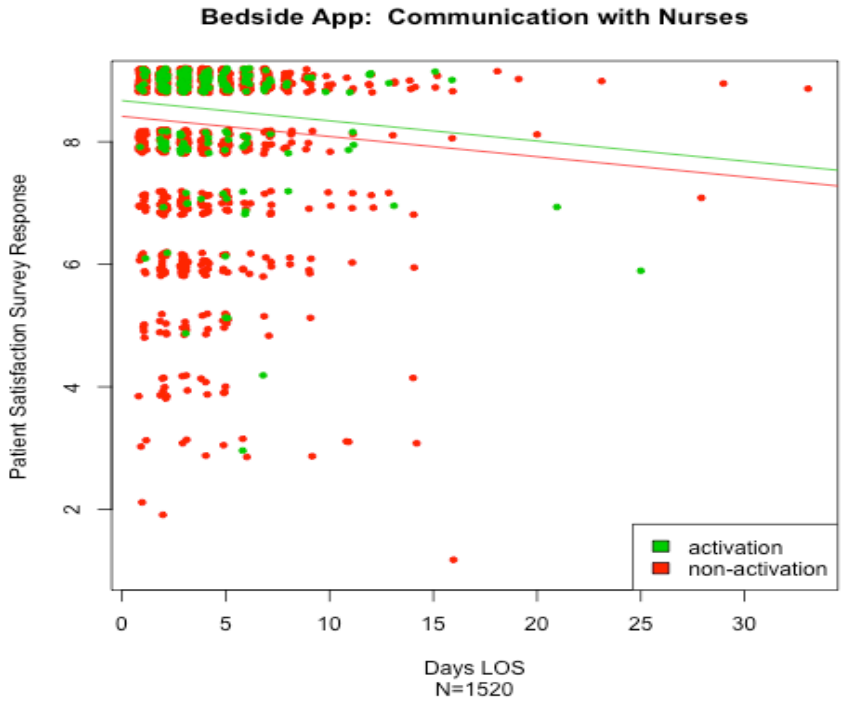

Figure 3. Scatterplot of Relationship Between Bedside Activators/Non-Activators' Nurse Communication Satisfaction and LOS

III. DISCUSSION/CONCLUSION

This study hypothesized an association between the MyChart Bedside© application and patient satisfaction with nurse–patient communication, as evidenced in the HCAHPS Communication with Nurses domain (NCDS) satisfaction scores. Results show that there was a statistically significant association with activation of the application and satisfaction with nurse-patient communication using simple linear regression. In fact, those patients that activated the application scored nurse-patient communication an average 0.26 higher than those who did not activate. The use of this application reported in the literature, however, reflects similar findings as found in the Vest and Miller (2011) research on the association between health information technology and its impact on patient satisfaction. Their study included 3,278 hospitals

and measured whether hospitals who participated in a health information exchange (HIE) (inter-organizational sharing of patient information) would have higher levels of patient satisfaction with health providers "always communicating well" as measured by the HCAHPS survey tool. Researchers found that hospitals that participated in a HIE were positively associated with measures of communication and patient satisfaction with nurses' communication (Vest & Miller, 2011; Kazley, Diana, Ford, & Menachemi, 2012).

In terms of the second hypothesis, the question asked if activation of the MyChart Bedside© application differed by age, race, gender, or LOS. The results demonstrated a statistically significant association between the application activation, length of stay (LOS) in days and higher patient satisfaction scores. (Maher, Wong, Woo, Padilla, Zhang, Shamloo, Rosner, et. al., 2015; Tevis & Kennedy, 2013) found LOS and patient satisfaction were positively associated with shorter lengths of stay. Similarly, the current study demonstrates in Figure 4 that LOS and HCAHPS patient satisfaction results were significantly associated when activation occurred. However, as the length of stay increased in this study, patient satisfaction decreased incrementally by day. The researcher found no relevant literature to support the incremental decrease (0.03) in satisfaction scores as the length of stay increased. However, patients may become more dissatisfied due to unexpected longer hospital stay due to serious findings or results related to their current diagnosis, a new unexpected diagnosis, increased boredom or frustration with the hospital environment (noise, different team members, additional tests and scheduling issues, feelings of lack of attention from staff, etc.).

A multivariate analysis was conducted between the Nurse Communication score and activation of the application while controlling for length of stay. These results support this study's research questions and hypothesis and are similar to the literature. For example, where it is reported older, white patients report greater satisfaction on HCAHPS scores as well as patients cared for in hospitals, if hospital has Magnet status, and if they are part of a health system. (Chen, Birkmeyer, Saint, & Jha, 2014; Ford, Huerta, Diana, Kazley, & Menachemi, 2013). The demographic variable of age, race and gender were not found to be significant in terms of predicting patient satisfaction with MyChart Bedside© activation.

Another robust finding in this study relates to the proportion of patients that activated the application increased over the three-year timeframe of the study. Further analysis represented a highly significant increase in the odds of application activation over time. For each year of the study, the activations increased by 1.82 (CI:1.53 to 2.16). This may have occurred with more patients opting for the mobile information technology or with the nursing staff's increased comfort teaching patients about the functionality and benefits of using the technology. In most hospitals, patient rooms have white boards for enhanced communication and patients use call lights to contact their nurse when needed. Over the three-year period of implementation, the tablet and MyChart Bedside© application could have been viewed as an alternative communication process compared to the static call button and white board and patients preferred the more interactive application to receive and send communications to their nurse. In this regard, Patients/consumers have become engaged in regular use of the Internet as a health resource to gather information, understand symptoms, and become better informed about

their health conditions. In fact, the basic nature of health communication has changed due to the internet (Gallant, et. al., 2011). This same study also found that patients became more engaged in their health experience when using these various electronic tools and social media such as Facebook, Twitter, and YouTube. The findings in this researcher's study concur as evidenced by the greater proportion of activators over time (Figures 1a-c) and who had scored higher on nurse-patient communication. The findings of a statistically significant association of MyChart Bedside© with satisfaction with nurse-patient communication constitutes a significant new contribution to the body of knowledge for health care.

Healthcare reform has created an impetus to develop different strategies in which consumers can be more actively involved in in their own health care. The focus on quality of care and patient satisfaction has moved to the top of the list for leaders in healthcare organizations. As discussed by Grossbart and Agrawal (2011), "*the conceptualization and definition of quality is undergoing a dramatic change. Since Donabedian first provided a framework for assessing quality, our conceptualization and definition of quality has matured. In order for health care providers to influence the direction of health care quality, we must continue to adopt tools and approaches to implement change as outlined in the (Chasm) report and as embodiment of health care reform"* (Grossbart & Agrawal, 2011, p. 20).

CMS has created financial incentives for hospitals and health systems to implement certain benchmarks in their capability and performance using an EHR. As noted in the literature review, research studies have found that patients who have access to their electronic record have had increased overall satisfaction (de Lusignan, et. al.,

2014). The MyChart Bedside© application is one such strategy for consideration to engage patients in their care. The potential benefit and impact of this innovative technology on patients' satisfaction with the nurse-patient communication process during their hospitalization is reflected in this study and is supportive to the fact that patient experience drives 30% of the VBP strategy for hospitals (Dempsey, et. al., 2014).

Limitations

The current study has several inherent limitations. First, research is limited, in nature, by the fact that it only collects data from a specific sample at a specific moment in time. With the retrospective data, the researcher was limited by the variables provided by the hospital's HCAHPS data for the three medical-surgical units. The study results cannot be generalizable across all other hospitals and patient care units. A randomized control trial would be needed to test the potential impact of the MyChart Bedside© application in a broader, more generalizable way. Furthermore, only a small proportion of the sample (209 patients) activated the application, representing approximately 14% of the overall study respondents. In addition, there were likely extraneous factors that influenced whether someone chose to access the application in the first place (personal comfort level with technology, severity of medical condition, cognition and willingness, etc.).

A major limitation of the study is that it could not be determined how patients who activated the application specifically used the application (texting the nurse, reviewing their medications, using the MyChart© portal to access medical results, etc.) and therefore, we are unable to conclude, with certainty, whether MyChart Beside© exposure affects improvement in patients' satisfaction with nurse-patient communication. These limitations are not unexpected as this is the first study of MyChart Bedside© and its

relationship to nurse patient communication as measured by HCAHPS in a contemporary hospital setting.

Directions for Future Research

In terms of the MyChart Bedside© application, future research with a larger sample size and definitive activities related to patients' engagement while activated will possibly identify other predictors of patient satisfaction (ex., communicating with caregivers, communications about medications, activation of the educational tools available, making a complaint about care through texts, etc.). Nursing's perception of patient satisfaction based on activation may provide insight to how "patient demands" and the interactive experience impacts nursing work for staff at the bedside. As health care apps for hospitalized patients are emerging, evidence-based research related to the impact of interactive applications on bedside care, nurse engagement, and patient satisfaction will benefit health care leaders in the future.

Other recommendations for future research would be to study the activation of the application across clinical areas such as ED, Women's Services, pediatric hospitals (adolescents) or hospital-based units, such as, long term care services, stroke unit, and inpatient rehab services in order to identify other predictors of satisfaction related to HCAHPS survey questions.

Another potential study would be to validate the Press Ganey research that nurse-patient communication is a "rising tide" measure and can lift scores in four other HCAHPS survey questions across an organization or health system with extended MyChart Bedside© activation experience.

Application to Practice

Although not generalizable to all hospitals based on the limitations noted earlier, interaction with patients using this application requires nursing's attention and response to patient needs. Findings in this study identified the significant association between application activation and nurse-patient communication, which has been found to be a rising tide measure for other four measures on the HCAHPS survey. These interactive applications can enable patients and family engagement in their own care. For example, patients who need "contact precautions" may find activation of the application enhances their virtual connection to care providers as well as enables social interaction thru Facebook and other web-based experiences. As mobile apps are added to the patient care menu, caregivers will have additional learning needs to optimize the technology and be required to educate the patients and families in terms of the application's functionality, etc. which could be stressful to the care team. However, younger health care providers may experience increased engagement due to the interactive technology experience with patients and families. Similarly, other opportunities may emerge for hospital leaders to better understand how work processes may impact HCAHPS scores positively or negatively. The current effort towards "standard work" (manager daily rounding, executive rounding, internal patient surveys, etc.) may be of interest for future research on patient satisfaction results.

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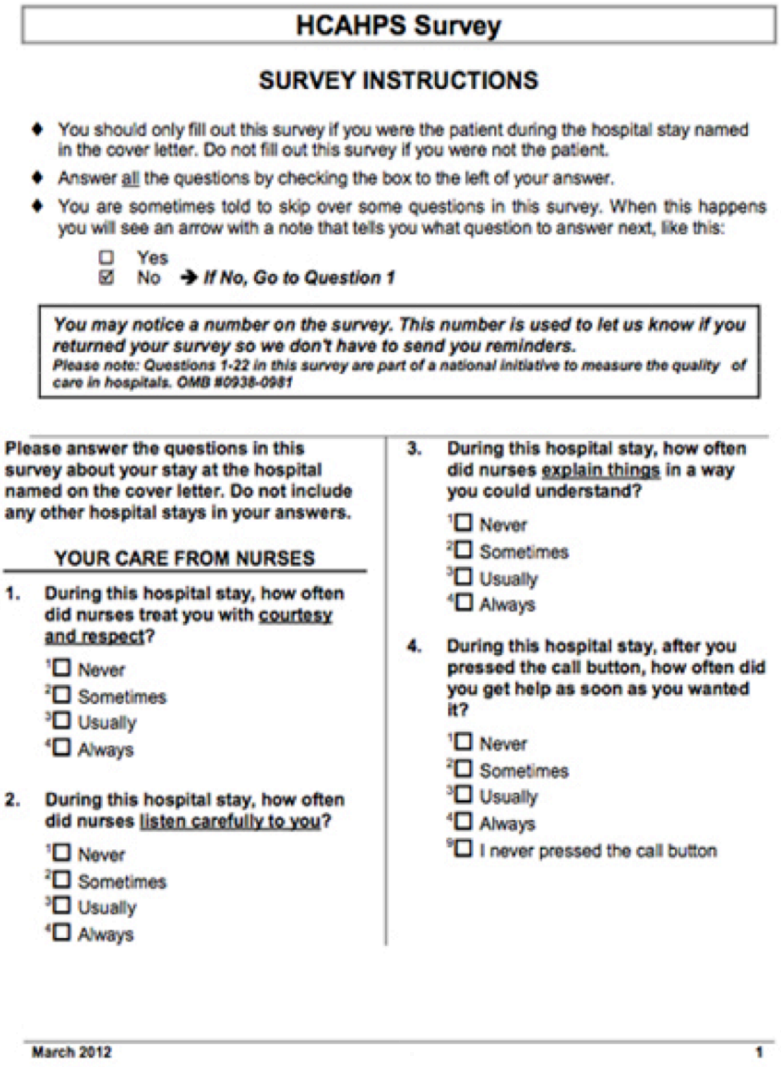
APPENDICES

Appendix A: HCAHPS Survey



HCAHPS Survey

SURVEY INSTRUCTIONS

- You should only fill out this survey if you were the patient during the hospital stay named in the cover letter. Do not fill out this survey if you were not the patient.
- Answer all the questions by checking the box to the left of your answer.
- You are sometimes told to skip over some questions in this survey. When this happens you will see an arrow with a note that tells you what question to answer next, like this:

  ☐ Yes
  ☑ No → *If No, Go to Question 1*

You may notice a number on the survey. This number is used to let us know if you returned your survey so we don't have to send you reminders.
Please note: Questions 1-22 in this survey are part of a national initiative to measure the quality of care in hospitals. OMB #0938-0981

Please answer the questions in this survey about your stay at the hospital named on the cover letter. Do not include any other hospital stays in your answers.

YOUR CARE FROM NURSES

1. **During this hospital stay, how often did nurses treat you with courtesy and respect?**
   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always

2. **During this hospital stay, how often did nurses listen carefully to you?**
   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always

3. **During this hospital stay, how often did nurses explain things in a way you could understand?**
   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always

4. **During this hospital stay, after you pressed the call button, how often did you get help as soon as you wanted it?**
   [1] ☐ Never
   [2] ☐ Sometimes
   [3] ☐ Usually
   [4] ☐ Always
   [9] ☐ I never pressed the call button

March 2012 1

Appendix B: R Code and Analysis

```
[1] "Investigator: Kathleen Nippert, RN"
[1] " Imputation 29 Patients - Communication Satisfaction - Press Ganey, Bedside App Users, 2
Level"

[1] "Bed Side App Users"

NotActivate    Activate
      1311         209


[1] "Demographics - Users vs Non Users"

[1] "Demographics Age  - Comparison"

$NotActivate
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  18.00   63.00   72.00   70.08   80.00   91.00

$Activate
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  19.00   53.00   60.00   60.23   69.00   91.00

[1] "Age -standard deviation"
NotActivate    Activate
   13.69533    13.68350

linear model

Call:
lm(formula = age.num ~ users.fact, data = dat1491)

Residuals:
    Min      1Q  Median      3Q     Max
-52.076  -7.116   1.924   9.924  30.766

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       70.0763     0.3782  185.29   <2e-16 ***
users.factActivate  -9.8418     1.0199   -9.65   <2e-16 ***
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1
```

```
Residual standard error: 13.69 on 1518 degrees of freedom
Multiple R-squared:  0.05779,       Adjusted R-squared:  0.05717
F-statistic: 93.11 on 1 and 1518 DF,  p-value: < 2.2e-16

[1] "Demographics Gender"

       NotActivate Activate  Sum
Female         668      117  785
Male           643       92  735
Sum           1311      209 1520


       NotActivate  Activate
Female   0.5095347 0.5598086
Male     0.4904653 0.4401914


        Pearson's Chi-squared test with Yates' continuity correction

data:  dat1491$Gender and dat1491$users.fact
X-squared = 1.6286, df = 1, p-value = 0.2019


[1] "Demographics Race"

         NotActivate Activate  Sum
NonWhite          75       16   91
White           1236      193 1429
Sum             1311      209 1520


        NotActivate   Activate
NonWhite  0.05720824 0.07655502
White     0.94279176 0.92344498


        Pearson's Chi-squared test with Yates' continuity correction

data:  dat1491$white.fact and dat1491$users.fact
X-squared = 0.87968, df = 1, p-value = 0.3483


[1] "Hospital Factors Users vs Non Users"

[1] "Hospital Factors Nurse Station"

    NotActivate Activate  Sum
4K          441      107  548
5K          448       51  499
```

```
 6K         422       51  473
 Sum       1311      209 1520


   NotActivate  Activate
 4K   0.3363844 0.5119617
 5K   0.3417239 0.2440191
 6K   0.3218917 0.2440191



        Pearson's Chi-squared test

data:  dat1491$Discharge.Nursing.Station and dat1491$users.fact
X-squared = 24.168, df = 2, p-value = 5.648e-06


[1] "Hospital Factors Length.of.Stay Days  - Comparison"

$NotActivate
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.000   2.000   3.000   3.773   5.000  33.000

$Activate
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.000   2.000   3.000   4.397   5.000  25.000

[1] "LOS -standard deviation"
NotActivate    Activate
   2.854983    3.235945

linear model

Call:
lm(formula = Length.of.Stay ~ users.fact, data = dat1491)

Residuals:
    Min      1Q  Median      3Q     Max
-3.3971 -1.7735 -0.7735  1.2265 29.2265

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)      3.77346    0.08037  46.949  < 2e-16 ***
users.factActivate  0.62367    0.21675   2.877  0.00407 **
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 2.91 on 1518 degrees of freedom
Multiple R-squared:  0.005425,    Adjusted R-squared:  0.004769
F-statistic: 8.279 on 1 and 1518 DF,  p-value: 0.004066
```

```
[1] "Hospital Factors App Trend - Years - Comparison"

$NotActivate
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 0.0000  0.4956  0.9911  1.1527  1.6879  2.9979

$Activate
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  0.000   1.018   1.692   1.586   2.264   2.998

[1] "Trend -standard deviation"
NotActivate    Activate
  0.8208826   0.8220256

linear model

Call:
lm(formula = yrs ~ users.fact, data = dat1491)

Residuals:
    Min      1Q  Median      3Q     Max
-1.5863 -0.6516 -0.1451  0.5768  1.8453

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       1.15266    0.02268  50.832  < 2e-16 ***
users.factActivate  0.43368    0.06115   7.092 2.02e-12 ***
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 0.821 on 1518 degrees of freedom
Multiple R-squared:  0.03207,      Adjusted R-squared:  0.03143
F-statistic: 50.29 on 1 and 1518 DF,  p-value: 2.021e-12


[1] "Hospital Factor - Survey Responses Composite - Comparison Users, Non Users "

[1] "Nurse Communication - User Comparison"
$NotActivate
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.000   8.000   9.000   8.291   9.000   9.000

$Activate
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  3.000   8.000   9.000   8.526   9.000   9.000

[1] "Nurse Communication -standard deviation"
```

```
NotActivate    Activate
  1.2710141   0.9509744

linear model

Call:
lm(formula = nurcom ~ users.fact, data = dat1491)

Residuals:
   Min      1Q  Median      3Q     Max
-7.2906 -0.2906  0.7094  0.7094  0.7094

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)        8.29062    0.03403 243.639   <2e-16 ***
users.factActivate  0.23570    0.09177   2.568   0.0103 *
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.232 on 1518 degrees of freedom
Multiple R-squared:  0.004327,    Adjusted R-squared:  0.003671
F-statistic: 6.597 on 1 and 1518 DF,  p-value: 0.01031




[1] " Admission/Discharge Dates"

[1] "Dates - Admission Dates by Users"
$NotActivate
       Min.      1st Qu.       Median         Mean      3rd Qu.         Max.
"2014-06-28" "2014-12-26" "2015-06-20" "2015-08-22" "2016-03-06" "2017-06-28"

$Activate
       Min.      1st Qu.       Median         Mean      3rd Qu.         Max.
"2014-06-21" "2015-07-05" "2016-03-03" "2016-01-27" "2016-09-30" "2017-06-26"


[1] "Dates - Discharge Dates by Users"
$NotActivate
       Min.      1st Qu.       Median         Mean      3rd Qu.         Max.
"2014-07-01" "2014-12-29" "2015-06-28" "2015-08-26" "2016-03-08" "2017-06-30"

$Activate
       Min.      1st Qu.       Median         Mean      3rd Qu.         Max.
"2014-07-01" "2015-07-08" "2016-03-10" "2016-01-31" "2016-10-05" "2017-06-30"



[1] "Survey Responses - Items"
```

[1] "CMS Item 1-3 Responses"

[1] "During this hospital stay, how often did nurses treat you with courtesy and respect? "
[1] "Response CMS 1"

Always	Never	Sometimes	Usually
1334	4	24	158

[1] "Response CMS 2"
[1] "During this hospital stay, how often did nurses listen carefully to you?"

Always	Never	Sometimes	Usually
1185	2	45	288

[1] "Response CMS 3"
[1] " During this hospital stay, how often did nurses explain things in a way you could understand?"

Always	Never	Sometimes	Usually
1150	4	49	317

[1] "top Box - Response CMS 1"

NotAlways	Always
186	1334

[1] "Top Box - Response CMS 2"

NotAlways	Always
335	1185

[1] "Top Box - Response CMS 3"

NotAlways	Always
370	1150

[1] "Survey Response - Composite Nurse Communication"

1	2	3	4	5	6	7	8	9
1	2	13	19	31	80	110	250	1014

[1] "Survey Items - Comparison Users, Non Users"

[1] "CMS Item 1-3 Responses with Bed App Users"
[1] "During this hospital stay, how often did nurses treat you with courtesy and respect? "
[1] "CMS 1 Cross Classifications with App Users"

	NotActivate	Activate	Sum
Always	1141	193	1334
Never	4	0	4
Sometimes	21	3	24
Usually	145	13	158
Sum	1311	209	1520

	NotActivate	Activate
Always	0.870327994	0.923444976
Never	0.003051106	0.000000000
Sometimes	0.016018307	0.014354067
Usually	0.110602593	0.062200957

Pearson's Chi-squared test

data: dat1491$Question.CMS_1 and dat1491$users.fact
X-squared = 5.3115, df = 3, p-value = 0.1504

[1] "CMS 2 Cross Classifications with Bed App Users"
[1] "During this hospital stay, how often did nurses listen carefully to you?"

	NotActivate	Activate	Sum
Always	1011	174	1185
Never	2	0	2
Sometimes	43	2	45
Usually	255	33	288
Sum	1311	209	1520

	NotActivate	Activate
Always	0.771167048	0.832535885
Never	0.001525553	0.000000000
Sometimes	0.032799390	0.009569378
Usually	0.194508009	0.157894737

Pearson's Chi-squared test

data: dat1491$Question.CMS_2 and dat1491$users.fact
X-squared = 5.7508, df = 3, p-value = 0.1244

[1] "CMS 3 Cross Classifications with Bed App Users"
[1] " During this hospital stay, how often did nurses explain things in a way you could understand?"

	NotActivate	Activate	Sum
Always	981	169	1150

```
Never             4       0    4
Sometimes        46       3   49
Usually         280      37  317
Sum            1311     209 1520

          NotActivate    Activate
Always    0.748283753 0.808612440
Never     0.003051106 0.000000000
Sometimes 0.035087719 0.014354067
Usually   0.213577422 0.177033493

          Pearson's Chi-squared test

data:  dat1491$Question.CMS_3 and dat1491$users.fact
X-squared = 5.063, df = 3, p-value = 0.1672



[1] "Top Box CMS 1 Cross Classifications with Bed App Users"

          NotActivate Activate  Sum
NotAlways        170       16  186
Always          1141      193 1334
Sum             1311      209 1520

          NotActivate   Activate
NotAlways  0.12967201 0.07655502
Always     0.87032799 0.92344498

          Pearson's Chi-squared test with Yates' continuity correction

data:  dat1491$q1al.fact and dat1491$users.fact
X-squared = 4.2541, df = 1, p-value = 0.03916



[1] "Top Box CMS 2 Cross Classifications with Bed App Users"

          NotActivate Activate  Sum
NotAlways        300       35  335
Always          1011      174 1185
Sum             1311      209 1520

          NotActivate  Activate
NotAlways   0.2288330 0.1674641
Always      0.7711670 0.8325359

          Pearson's Chi-squared test with Yates' continuity correction

data:  dat1491$q2al.fact and dat1491$users.fact
X-squared = 3.6021, df = 1, p-value = 0.05771
```

```
[1] "Top Box CMS 3 Cross Classifications with Bed App Users"

          NotActivate Activate  Sum
 NotAlways         330       40  370
 Always            981      169 1150
 Sum              1311      209 1520

          NotActivate  Activate
 NotAlways   0.2517162 0.1913876
 Always      0.7482838 0.8086124

          Pearson's Chi-squared test with Yates' continuity correction

data:  dat1491$q3al.fact and dat1491$users.fact
X-squared = 3.2423, df = 1, p-value = 0.07176




[1] "Associations with Composite Nurse Communication -  Univariate Linear model"
[1] "Nurse Communication - Age"
linear model

Call:
lm(formula = nurcom ~ age.num, data = dat1491)

Residuals:
   Min     1Q  Median     3Q    Max
-7.3285 -0.3182  0.6641  0.6848  0.7099

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  8.424709   0.157576  53.464   <2e-16 ***
age.num     -0.001480   0.002246  -0.659     0.51
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.235 on 1518 degrees of freedom
Multiple R-squared:  0.0002858,   Adjusted R-squared:  -0.0003728
F-statistic: 0.4339 on 1 and 1518 DF,  p-value: 0.5102

[1] "Nurse Communication - Gender Comparison"
$Female
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.000   8.000   9.000   8.336   9.000   9.000

$Male
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  2.000   8.000   9.000   8.309   9.000   9.000

[1] "Nurse Communication -standard deviation"
  Female     Male
1.215973 1.254362

linear model

Call:
lm(formula = nurcom ~ Gender, data = dat1491)

Residuals:
    Min      1Q  Median      3Q     Max
-7.3363 -0.3363  0.6637  0.6912  0.6912

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  8.33631    0.04407 189.170   <2e-16 ***
GenderMale  -0.02746    0.06337  -0.433    0.665
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.235 on 1518 degrees of freedom
Multiple R-squared:  0.0001237,   Adjusted R-squared:  -0.000535
F-statistic: 0.1878 on 1 and 1518 DF,  p-value: 0.6648




[1] "Nurse Communication - Race"
$NonWhite
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.000   8.000   9.000   8.341   9.000   9.000

$White
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  2.000   8.000   9.000   8.322   9.000   9.000

[1] "Nurse Communication -standard deviation"
NonWhite    White
1.408070 1.223007

linear model

Call:
lm(formula = nurcom ~ white.fact, data = dat1491)

Residuals:
    Min      1Q  Median      3Q     Max
-7.3407 -0.3219  0.6781  0.6781  0.6781
```

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)     8.34066    0.12944   64.44   <2e-16 ***
white.factWhite -0.01876    0.13349   -0.14    0.888
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.235 on 1518 degrees of freedom
Multiple R-squared:  1.3e-05,       Adjusted R-squared:  -0.0006457
F-statistic: 0.01974 on 1 and 1518 DF,  p-value: 0.8883

[1] "Nurse Communication - Nurse Station Comparison"

$`4K`
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  2.000   8.000   9.000   8.321   9.000   9.000

$`5K`
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  3.000   8.000   9.000   8.337   9.000   9.000

$`6K`
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  1.000   8.000   9.000   8.311   9.000   9.000

[1] "Nurse Communication -standard deviation"
     4K       5K       6K
1.193733 1.206940 1.309447

linear model

Call:
lm(formula = nurcom ~ Discharge.Nursing.Station, data = dat1491)

Residuals:
   Min      1Q  Median      3Q     Max
-7.3108 -0.3212  0.6633  0.6788  0.6892

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                8.32117    0.05276 157.712   <2e-16 ***
Discharge.Nursing.Station5K  0.01551    0.07643   0.203    0.839
Discharge.Nursing.Station6K -0.01039    0.07752  -0.134    0.893
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.235 on 1517 degrees of freedom
Multiple R-squared:  7.161e-05,   Adjusted R-squared:  -0.001247
F-statistic: 0.05432 on 2 and 1517 DF,  p-value: 0.9471
```

```
[1] "Nurse Communication - LOS Continuous"
linear model

Call:
lm(formula = nurcom ~ Length.of.Stay, data = dat1491)

Residuals:
   Min     1Q  Median     3Q    Max
-6.9503 -0.3494  0.6199  0.6813  1.5717

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)    8.44152    0.05240 161.113  < 2e-16 ***
Length.of.Stay -0.03070    0.01083  -2.835  0.00465 **
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.232 on 1518 degrees of freedom
Multiple R-squared:  0.005265,    Adjusted R-squared:  0.00461
F-statistic: 8.035 on 1 and 1518 DF,  p-value: 0.00465



[1] "Nurse Communication - Trend"
linear model

Call:
lm(formula = nurcom ~ yrs, data = dat1491)

Residuals:
   Min     1Q  Median     3Q    Max
-7.3358 -0.3114  0.6341  0.7027  0.7596

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  8.24037    0.05582 147.624   <2e-16 ***
yrs          0.06818    0.03794   1.797   0.0725 .
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.233 on 1518 degrees of freedom
Multiple R-squared:  0.002123,    Adjusted R-squared:  0.001466
F-statistic:  3.23 on 1 and 1518 DF,  p-value: 0.07248



[1] "Nurse Communication - User"
linear model
```

```
Call:
lm(formula = nurcom ~ users.fact, data = dat1491)

Residuals:
   Min     1Q  Median     3Q    Max
-7.2906 -0.2906  0.7094  0.7094  0.7094

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)      8.29062    0.03403 243.639   <2e-16 ***
users.factActivate  0.23570    0.09177   2.568   0.0103 *
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.232 on 1518 degrees of freedom
Multiple R-squared:  0.004327,    Adjusted R-squared:  0.003671
F-statistic: 6.597 on 1 and 1518 DF,  p-value: 0.01031
```

[1] "Associations with Composite Nurse Communication - Multivariate Linear model"

[1] "Nurse Communication - LOS, Trend, User"
linear model

```
Call:
lm(formula = nurcom ~ Length.of.Stay + yrs + users.fact, data = dat1491)

Residuals:
   Min     1Q  Median     3Q    Max
-6.9045 -0.3190  0.6154  0.7026  1.6090

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)      8.35651    0.06984 119.655  < 2e-16 ***
Length.of.Stay    -0.03257    0.01084  -3.006  0.00269 **
yrs               0.04948    0.03842   1.288  0.19797
users.factActivate  0.23456    0.09328   2.515  0.01202 *
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.228 on 1516 degrees of freedom
Multiple R-squared:  0.01143,      Adjusted R-squared:  0.009477
F-statistic: 5.844 on 3 and 1516 DF,  p-value: 0.0005743
```

[1] "Nurse Communication - age, User"
linear model

```
Call:
lm(formula = nurcom ~ age.num + users.fact, data = dat1491)

Residuals:
   Min     1Q  Median     3Q    Max
-7.2911 -0.2904  0.7079  0.7097  0.7115

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)       8.2977205  0.1654219  50.161   <2e-16 ***
age.num          -0.0001014  0.0023101  -0.044   0.9650
users.factActivate  0.2347004  0.0945711   2.482   0.0132 *
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.232 on 1517 degrees of freedom
Multiple R-squared:  0.004328,    Adjusted R-squared:  0.003016
F-statistic: 3.297 on 2 and 1517 DF,  p-value: 0.03725



[1] "Nurse Communication - trend,  User"
linear model

Call:
lm(formula = nurcom ~ yrs + users.fact, data = dat1491)

Residuals:
   Min     1Q  Median     3Q    Max
-7.3035 -0.2901  0.6413  0.7226  0.7697

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)       8.23018    0.05592 147.175   <2e-16 ***
yrs               0.05243    0.03851   1.362   0.1735
users.factActivate  0.21296    0.09325   2.284   0.0225 *
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.232 on 1517 degrees of freedom
Multiple R-squared:  0.005543,    Adjusted R-squared:  0.004231
F-statistic: 4.227 on 2 and 1517 DF,  p-value: 0.01476



[1] "Nurse Communication Interaction Model - LOS, User, Inter"
linear model

Call:
lm(formula = nurcom ~ Length.of.Stay * users.fact, data = dat1491)
```

```
Residuals:
   Min     1Q  Median     3Q    Max
-6.9383 -0.3129  0.6583  0.6871  1.5516

Coefficients:
                                  Estimate Std. Error t value Pr(>|t|)
(Intercept)                        8.39935    0.05626 149.283   <2e-16 ***
Length.of.Stay                    -0.02882    0.01189  -2.423   0.0155 *
users.factActivate                 0.36051    0.15426   2.337   0.0196 *
Length.of.Stay:users.factActivate -0.02430    0.02889  -0.841   0.4005
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.229 on 1516 degrees of freedom
Multiple R-squared:  0.01081,      Adjusted R-squared:  0.008855
F-statistic: 5.524 on 3 and 1516 DF,  p-value: 0.000901


[1] "Final Model - Nurse Communication - LOS, User"
linear model

Call:
lm(formula = nurcom ~ Length.of.Stay + users.fact, data = dat1491)

Residuals:
   Min     1Q  Median     3Q    Max
-6.8880 -0.3161  0.6510  0.6839  1.6719

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       8.41489    0.05314 158.350  < 2e-16 ***
Length.of.Stay   -0.03293    0.01084  -3.039  0.00242 **
users.factActivate  0.25624    0.09177   2.792  0.00530 **
---
Signif. codes:  0 ΓÇÿ***ΓÇÖ 0.001 ΓÇÿ**ΓÇÖ 0.01 ΓÇÿ*ΓÇÖ 0.05 ΓÇÿ.ΓÇÖ 0.1 ΓÇÿ ΓÇÖ 1

Residual standard error: 1.229 on 1517 degrees of freedom
Multiple R-squared:  0.01035,      Adjusted R-squared:  0.009046
F-statistic: 7.934 on 2 and 1517 DF,  p-value: 0.0003736
```