USE AND EFFECTS OF HEALTH INFORMATION TECHNOLOGIES IN SURGICAL PRACTICE

By

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CHAPTER I

Introduction

Research Motivation

Health information technology (HIT) has evolved rapidly and experienced increasing adoption by patients, healthcare providers, and researchers over the last two decades, owing to both consumer demand by patients for access to their health information as well as regulatory requirements such as the United States government's Meaningful Use program.[1, 2] HIT, including electronic health records (EHRs), computerized provider order entry (CPOE), and patient portals has transformed the way providers and patients interact with healthcare systems. HIT is widely adopted across clinical specialties and practice settings, including in outpatient, inpatient, medical, surgical, and specialty care. The last decade has shown a continued increase in the use of EHRs across the nation. In 2013, 78.4% of office-based physicians reported having an EHR, an increase of 21% between from 2012.[3] As of 2015, 94% of non-federal acute care hospitals had implemented a certified EHR.[4]

Growing HIT adoption has led to increased research on HIT implementation and use.[5] Key studies in this domain have investigated the effects of HIT on patients, providers, and healthcare systems. However, the overwhelming majority of research has been conducted in primary care and medical specialty settings, with little data on how the use of HIT affects surgeons and the care of surgical patients.[6-8]

This thesis describes three research projects, presented in three published manuscripts, that address important gaps in the scientific evidence on how HIT is used by surgeons and their patients. The first study is a systematic review that examines the current knowledge about the effects of HIT on surgical practice. This project summarized the known effects of HIT on surgical outcomes and identified important gaps in the evidence about the use of consumer HIT by surgical patients and providers. The second and third projects examined the use of one of the most popular consumer health technologies, patient portals, by surgical providers and patients.

Patient portals are web-based applications that enable patients to interact with their health information and healthcare systems. Patient portals are typically managed by healthcare organizations, and most portals allow users to have access to selected personal health information from the EHR, schedule appointments, and exchange secure messages with providers.[9] Patient portals are widely used in both the inpatient and outpatient settings across clinical specialties. In surgery, as in other specialties, patient portal messaging has become a frequent method of outpatient communication between patients and their providers. As in other areas of HIT, the majority of research about patient portals has been performed in the primary care or medical specialty settings.[6-8] Little data exists focusing on the implementation, use, or effects of patient portals on patients in acute care specialties, such as surgery, or acute care settings, such as the hospital.

An analysis of the My Health at Vanderbilt (MHAV) patient portal usage at Vanderbilt University Medical Center (VUMC) demonstrated that after broad deployment of a patient portal across clinical specialties, surgery was the clinical specialty with the second (to medicine) most frequent use of the patient-provider messaging function. In 2010 at VUMC, up to 15% of outpatient interactions (i.e., clinic visits and portal message threads) with surgical patients were conducted through portal messaging. At this time, it was also observed that approximately 600 to 1000 patients accessed the MHAV patient portal at VUMC while admitted to the hospital. The second research project presented in this thesis characterized the use of MHAV by hospitalized surgical patients and examined factors that were correlated with portal registration and use during hospitalizations.

Prior research has shown that interactions between providers and patients in patient portal messages may include patients communicating medical concerns and providers actively making decisions regarding the care of the patient.[10] This use represents medical care that is being provided with established patients, with many potential financial implications for healthcare institutions. With expanding integration of HIT into patient care, nonconventional forms of care must be identified and quantified to identify opportunities for payment model reform and reimbursement for care provided online. The third study presented in this thesis examined the semantic nature of the content of patient-

provider messages between surgeons and their patients, categorizing communications into informational, medical, logistical, social, and other communication categories. In medical communications, the level of complexity of provider medical decision-making was determined, as defined by standard coding schemes used for provider reimbursement. To our knowledge, this is the first study addressing the detailed nature of communications between surgical patients and their providers and to measure the potential for reimbursement for medical care provided through patient portals.

Specific Aims

This thesis addressed three specific aims, detailed below.

Specific Aim #1: Determine the Effects of Health Information Technologies on Surgical Patient Care

The first aim of this thesis was to determine the current state of the evidence about the effects of HIT in surgical practice. A comprehensive systematic review was conducted to assess the effects of EHRs, CPOE, patient portals, and Internet-based information resources on surgical outcomes and the care of surgical patients.

Specific Aim #2: Characterize the Use of Patient Portals by Hospitalized Surgical Patients and Factors Influencing Registration and Inpatient Use

Although the functions commonly offered by patient portals may meet important needs of hospitalized patients, most patient portals were designed for outpatient use. Many portals have policies that would discourage inpatient usage, such as specific delays for availability of test results or the expectation that it may take several business days prior to the answering of secure messages. Despite such barriers, inpatient adoption of patient portals had been observed. In this aim, we sought to characterize the adoption and use of the MHAV patient portal by patients admitted to surgical services at VUMC, a large academic medical center with an established and widely adopted patient portal.

Specific Aim #3: Evaluate the Nature of Communications and Complexity of Medical Decision-Making in Portal Messages Exchanged Between Patients and Surgeons

As patient portal and secure messaging adoption increases, understanding the nature of portal messaging interactions and considering their implications for provider workload and potential lost compensation become important. This final aim of this thesis was to classify the semantic nature of the MHAV portal message communications between surgical patients and providers into medical, informational, logistical, social, and other categorizes. All medical communications were further analyzed using the current outpatient billing model for in-person encounters by the Centers for Medicare and Medicaid Services (CMS) to determine the complexity of medical decision-making within each portal message thread. Utilization of HIT has been proposed as a central method of optimizing performance and reducing costs of the healthcare system; however, the potential loss in reimbursement secondary to medical care being provided online has not been thoroughly addressed.[9] As payment models evolve, nontraditional forms of care must be identified and quantified to support potential reimbursement strategies. We therefore sought to characterize the types of communications in secure messaging, the amount of medical care provided, and the complexity of medical decision-making in the care delivered through patient portal messaging by surgical providers to examine the potential for reimbursable care provided through portal messaging.

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CHAPTER II

Review of Information Technology for Surgical Patient Care

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Abstract

Introduction: Electronic health records (EHRs), computerized order entry (CPOE), and patient portals have experienced increased adoption by healthcare systems. The objective of this study was to review evidence regarding the impact of such health information technologies (HIT) on surgical practice.

Materials and Methods: A search of Medline, EMBASE, CINAHL, and the Cochrane Library was performed to identify data-driven, non-survey studies about the effects of HIT on surgical care. Domain experts were queried for relevant articles. Two authors independently reviewed abstracts for inclusion criteria and analyzed full-text of eligible articles.

Results: 2890 citations were identified. 32 observational studies and 2 RCTs met eligibility criteria. EHR or CPOE improved appropriate antibiotic administration for surgical procedures in 13 comparative observational studies. 5 comparative observational studies indicated electronically generated operative notes had increased accuracy, completeness, and availability in the medical record. The Internet as an information resource about surgical procedures was generally inadequate. Surgical patients and providers demonstrated rapid adoption of patient portals, with increasing proportions of online versus in-person outpatient surgical encounters.

Conclusion: The overall quality of evidence about the effects of HIT in surgical practice was low. Current data suggest an improvement in appropriate perioperative antibiotic administration and accuracy of operative reports from CPOE and EHR applications. Online consumer health educational resources and patient portals are popular among patients and families, but their impact has not been studied well in surgical populations. With increasing adoption of HIT, further research is needed to optimize the efficacy of such tools in surgical care.

Introduction

Health information technology (HIT) has experienced rapid evolution and adoption over the last several decades, and the use of HIT in the process of healthcare delivery poses new challenges for both patients and providers.[1-5] A global trend has shown a rise in consumer demand for HIT by patients.[6] Within the United States, specific legislation has dramatically affected the adoption and use of HIT by healthcare organizations. The Affordable Care Act of 2010 provided financial incentives to health care providers and organizations for demonstrating Meaningful Use of certified electronic health records (EHRs) and promoted widespread adoption of HIT by healthcare organizations. In 2015, financial penalties for failure to achieve Meaningful Use of EHRs began.[7, 8] The emergence of EHRs, computerized provider order entry (CPOE), and patient portals has transformed the way health information is stored, used, and communicated among healthcare providers, patients, and caregivers.

HIT has been widely adopted across clinical specialties and practice settings. In 2013, 78.4% of office-based physicians reported having an EHR, an increase of 21% between 2012 and 2013.[9] There is evidence that this rise continues. As of October 2015, over 85% of Regional Extension Centers enrolled Critical Access/Rural Hospitals and 8 out of 10 primary care providers are demonstrating Meaningful Use of certified EHR technology.[10] 94% of non-federal acute care hospitals have possession of a certified EHR and 59.4% have adopted a basic EHR system, up from 15.6% in 2010.[11]

This increase in the implementation and adoption of HIT has prompted substantial growth in research about such systems.[12] The overwhelming majority of research on the effects of HIT has been conducted in primary care and medical specialty settings, with a paucity of data on how the use of HIT affects surgeons and the care of surgical patients.[13-15] The objective of this study is to review comprehensively the available evidence on the impact of HIT on surgical practice. We aimed specifically to determine the effects of EHRs, CPOE, patient portals, and Internet-based information resources on the care of surgical patients.

Materials and Methods

Data Sources and Search Strategy

We performed a systematic search of Medline, EMBASE, CINAHL, and the Cochrane Library to identify published literature on the effects of EHRs, CPOE, patient portals, or online health information resources on surgeons and their patients from 1990 to July 2015. The search was focused specifically on studies performed exclusively in surgical patients or subsets. Medical Subject Heading (MeSH) terms and keywords used for the search included those pertaining to computerized health record systems, electronic health records, information technology, medical order entry systems, personal health record, computerized order entry, patient or web portals, access to information, patient participation, surgery, surgical procedures, or operative care.

The search query employed was: ("Medical Records Systems, Computerized"[MeSH Terms] OR "Electronic Health Records" [MeSH Terms] OR “personal health record”[Title/Abstract] OR “information technology”[Title/Abstract] OR “Medical Order Entry Systems"[MeSH Terms] OR “computerized order entry”[Title/Abstract] OR "patient portal" OR "web portal" OR "Access to Information"[MeSH Terms] OR "Patient Participation"[MeSH Terms] OR "Patient Access to Records"[MeSH Terms]) AND ("surgeons"[MeSH Terms] OR "surgical procedures, operative"[MeSH Terms] OR “surg*”[Title/Abstract]) AND ("1990"[PDAT] : "2015"[PDAT]).

In addition, we also queried surgeons with expertise in informatics or HIT and mined the bibliographies of all retrieved articles for citations of potentially relevant articles. Prior systematic reviews were utilized to identify original studies.

Study Selection

We selected for analysis all experimental, observational, randomized, or non-randomized studies published in scientific journals, peer-reviewed conference proceedings or sources identified by domain experts. Editorials, government reports, letters to the editor, conference abstracts, or non–data-driven studies were excluded. Articles not published in English and without full text availability were excluded.

We included only studies that examined the effects of HIT related specifically to surgical practice or contained a separate surgical subgroup analysis.

Two authors independently reviewed the abstracts of all retrieved articles to identify publications meeting inclusion criteria and then performed full text review of relevant articles. Disagreements were resolved with assessment by a third reviewer and discussion to achieve consensus.

Data Analysis and Grading Criteria

Study classification was performed in a similar manner as prior systematic reviews in health information technology.[12, 15-17] We classified articles into descriptive qualitative studies, descriptive quantitative studies, and hypothesis-testing studies. Articles were classified as "hypothesis-testing" if the investigators used statistical analysis to compare data between groups. Hypothesis-testing studies were further classified by study design (e.g., randomized, controlled trial (RCT) and retrospective or prospective observational studies).

The authors summarized the data available for each category of HIT, which allowed formulation of a general consensus and determination of what areas were lacking evidence. Due to the heterogeneity of the studies identified, a meta-analysis was not performed.

Results

The systematic database search retrieved 2909 potentially relevant publications. An additional 24 articles were identified from expert recommendations and bibliographies of retrieved articles. After removal of duplicate articles and abstract review, 201 potentially eligible articles underwent full-text review, of which 34 studies were retained for data analysis (Figure 2.1). The majority of articles were excluded based on the lack of data-driven evidence.

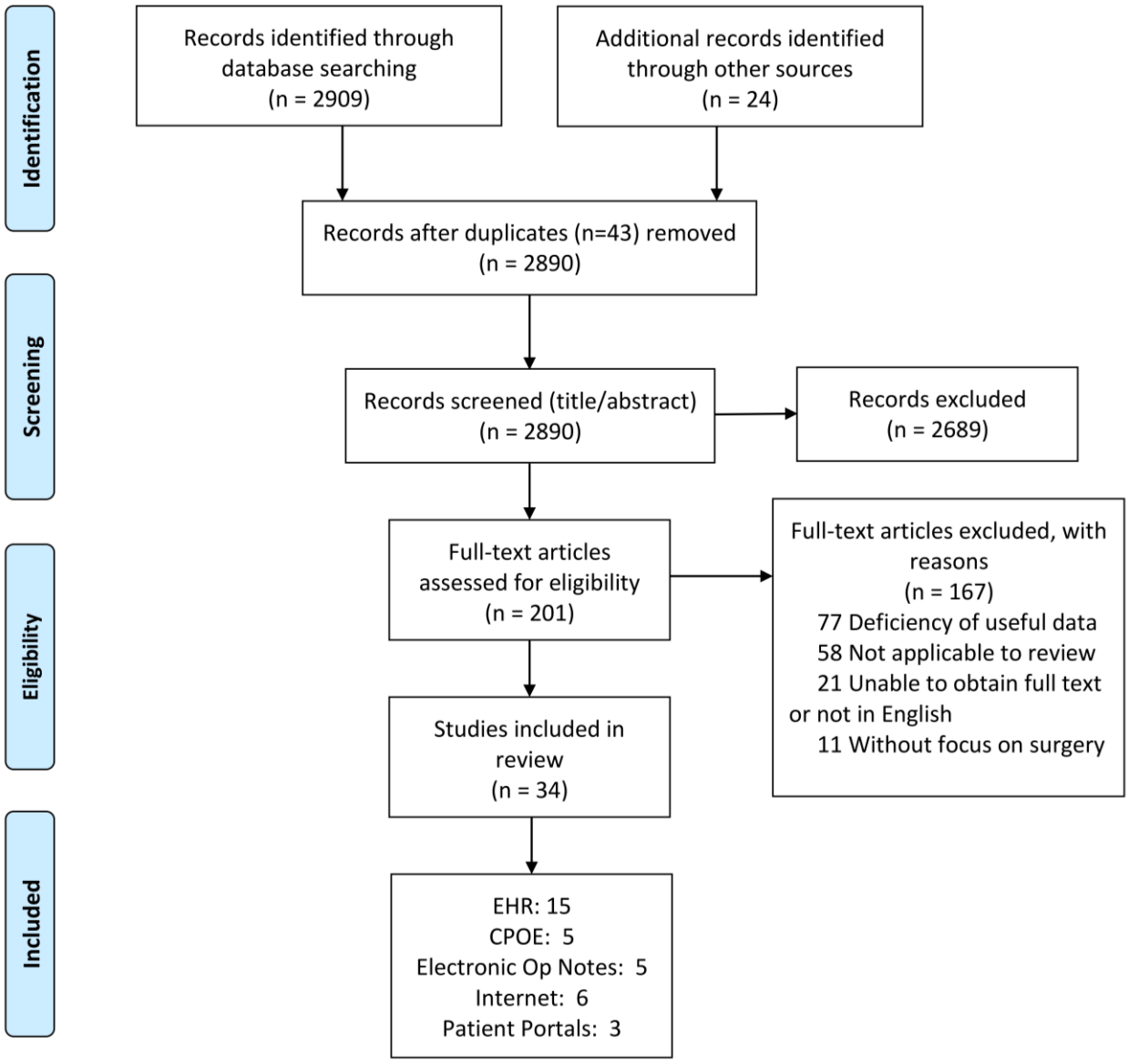

Figure 2.1. Outline of review of health information technology for surgical patient care

Systematic database search retrieved 2909 potentially relevant publications and an additional 24 articles were identified from expert recommendations and bibliographies of selected articles. After removal of duplicate articles and abstract review, 201 articles underwent full-text review. 34 studies were retained for data analysis, 15 examined the impact of electronic health records (EHRs); 5, computerized provider order entry (CPOE); 5 electronic operative notes; 6 online health information resources; and 3 patient portals.

Table 2.1 presents a summary of the evidence for the effects of HIT in surgical care. Of the 34 studies analyzed, 15 examined the impact of EHRs; 5, CPOE; 5, electronic operative notes; 6, online health information resources; and 3, patient portals. The vast majority of the evidence was low (9 studies) or very low (20 studies) in quality. Five research studies had moderate levels of evidence, and only one article reported high quality evidence. Four of the five articles with moderate levels of evidence evaluated EHRs, and one examined an online informational resource. All included studies on CPOE, electronic operative notes, and patient web portals in surgical care had low or very low levels of evidence.

The following paragraphs present the evidence for the effects of HIT on surgical patients and practice, organized by type of technology.

Table 2.1. Health Information Technology Research in Surgical Care

Comprehensive review of the literature identified 34 articles, summarized in this table. Articles are grouped based upon area of research, including electronic health records (EHRs), computerized provider order entry (CPOE), electronic operative notes, Internet resources, and patient portals. Articles are subsequently ordered based upon year. Key findings and limitations of each study are summarized.

Table 2.1: **Health Information Technology Research in Surgical Care**

Author	Study Name	Year	Type of Study	Cohort Size (Study/Control)	Institution	Finding/Addition to literature/Limitations	Result
ELECTRONIC HEALTH RECORDS							
Larsen et al.	Improved Perioperative Antibiotic Use and Reduced Surgical Wound Infections Through Use of Computer Decision Analysis	1989	Prospective Observational Study	1621/1830	LDS Hospital	Developed a computerized decision analysis tool to determine which patients qualified for receipt of pre-operative antibiotics. Found a decrease in surgical site infections in the patients stratified to the computerized decision analysis cohort; however, this was not statistically significant after adjusting for the larger quantity of clean cases in the cohort. Found an improvement in timing of prophylactic antibiotic administration, likely due to the impact of placing physician reminder stickers in patient charts.	Positive
Evans et al.	Reducing the Duration of Prophylactic Antibiotic Use Through Computer Monitoring of Surgical Patients	1990	Prospective Observational Study	3665/3991	LDS Hospital	The EHR was used for a clinical decision support system for identifying surgical patients who could have their antibiotics discontinued, followed by a clinical pharmacist who would place a stop-order. No decrease in the number of patients receiving antibiotics too long, but there was a decrease in the number of antibiotic doses for the patients identified as having no indication for antibiotics, from 19 to 13 days.	Positive
Durieux et al.	A Clinical Decision Support System for Prevention of Venous Thromboembolism	2000	Prospective Observational Study	1112/859	Lariboisiere Hospital	Implemented a clinical decision support system which determined based on patient characteristics the risk of a venous thromboembolism and recommendation for prophylaxis in an orthopedic surgery population. There was an improvement in compliance with guidelines from 82.8% in the control (no CDSS) to 94.9% in the intervention group.	Positive
Stengel et al.	Comparison of Handheld Computer-Assisted and Conventional Paper Chart Documentation of Medical Records	2004	Randomized Controlled Trial	36/36	Berlin Trauma Center	Compared traditional paper charting to coding software on a handheld computer for use at the bedside. The handheld device allowed automatically generated ICD codes related to complaints and clinical findings, resulting in significantly more coded diagnoses. There was a significant decrease in the time required for handheld documentation during the study period.	Positive
St. Jacques et al.	Improving Timely Surgical Antibiotic Prophylaxis Redosing Administration Using Computerized Record Prompts	2005	Retrospective Observational Study	148/139	Vanderbilt University Medical Center	Using a part of the computerized record system, the anesthesia computer charting software, computerized alerts notified providers of an approaching redose time 30 minutes prior to the specified time interval. On time antibiotic redosing increased after the implementation of the reminder system, from 20% to 57%.	Positive
O'Reilly et al.	An Anesthesia Information System Designed to Provide Physician-Specific Feedback Improves Timely Administration of Prophylactic Antibiotics.	2006	Prospective Observational Study	Unknown	University of Michigan Health System	Implemented a reminder system for antibiotic administration in an anesthesia information management system. The rate of antibiotic compliance increased from 69% to 92% during a 1-year study period.	Positive

Table 2.1: **Continued**

Author	Study Name	Year	Type of Study	Cohort Size Study/Control	Site	Finding/Addition to literature/Limitations	Result
ELECTRONIC HEALTH RECORDS							
Wax et al.	The Effect of an Interactive Visual Reminder in an Anesthesia Information Management System on Timeliness of Prophylactic Antibiotic Administration.	2007	Retrospective Observational Study	4987/9478	Mount Sinai	Retrospectively analyzed the effect of the addition of an event icon for antibiotic administration in the operating room. Compliance for administration of antibiotics increased from 82.4% to 89.1% before and after the even icon implementation.	Positive
Staes et al.	Computerized Alerts Improve Outpatient Laboratory Monitoring of Transplant Patients	2008	Prospective Observational Study	348/2123	LDS Hospital	Compared a traditional reporting system using clinic staff to track new laboratory results to a system with integrated computerized alerts in transplant patients. 34% of traditionally reported labs did not reach the office and although the results were available in the EHR, no alert notified physicians that the new result was present. 0.8% of computerized lab notifications were not reported. Nurses were able to review the results much quicker with the computerized notification (9.2 hours compared to 33.4 hours).	Positive
Haut et al.	Improved Prophylaxis and Decreased Rates of Preventable Harm with the Use of a Mandatory Computerized Clinical Decision Support Tool for Prophylaxis for Venous Thromboembolism in Trauma	2010	Retrospective Observational Study	399/1200	Johns Hopkins Hospital	Implemented a clinical decision support system (CDSS) which determined based on patient characteristics the risk of a venous thromboembolism (VTE) and recommendation for prophylaxis in adult trauma patients. The compliance rate for evidence-based VTE prophylaxis improved from 66.2% at baseline (no CDSS) to 84.4% and there was a decrease in preventable VTE rates after CDSS implementation.	Positive
Nair et al.	Feedback Mechanisms Including Real-Time Electronic Alerts to Achieve Near 100% Timely Prophylactic Antibiotic Administration in Surgical Cases	2010	Prospective Observational Study	3159/8550	University of Washington	Retrospective review of the paper anesthesia charting reports and prospective study on the implementation of an AIMS to determine antibiotic documentation rates. Real-time feedback and reminders to the anesthesia team to administer and document antibiotics made the largest improvement (9.3%).	Positive
Schwann et al.	Point-of-care Electronic Prompts: an Effective Means of Increasing Compliance, Demonstrating Quality, and Improving Outcome.	2011	Prospective Observational Study	9127/10617	Lehigh Valley Health Network	Prospectively analyzed the effect of point of care electronic prompts via an AIMS on the administration of prophylactic antibiotics and surgical-site infections. Compliance with antibiotic administration increased from 31% to 92% and the overall rate of SSI decreased from 1.1% to 0.7% for the 6-month period before and after prompts implementation.	Positive

Table 2.1: **Continued**

Author	Study Name	Year	Type of Study	Cohort Size (Study/Control)	Institution	Finding/Addition to literature/Limitations	Result
ELECTRONIC HEALTH RECORDS							
Yang et al.	The Effect of Electronic Medical record Application on the Length of Stay in a Chinese General Hospital: a Department- and Disease-focused Interrupted Time-series Study	2013	Retrospective Observational Study	31153/56022	Xijing Hospital	Compared the length of hospital stay(LOS) for patients before and after the implementation of an EHR. Orthopedic and cardiac surgery units with patients having the specific diagnoses of intervertebral disc disorders and ventricular septal defects had decreased LOS by an average of 2.3-2.8 days. Authors note that this may be due other factors which simultaneously underwent change related to LOS.	Positive
Choi et al.	Organizational Performance and Regulatory Compliance as Measured by Clinical Pertinence Indicators Before and After Implementation of Anesthesia Information Management Systems (AIMS)	2014	Retrospective Observational Study	3997/984	Maimonides Medical Center	Compared patients who had data documented in AIMS versus the traditional paper charts. One outcome was the completeness of the documentation which significantly increased with EHR charting ($p< 0.001$). They also analyzed each of the separate parameters and found that although there was an improvement in documentation of medication dosages, physiological status, mental status, and pain improved, there was not a significant improvement in compliance with antibiotic administration. Of note, their system did not have an interactive prompt as a reminder for antibiotic administration.	Positive
Pinto Thirukumaran et al.	The Impact of Electronic Health Record Implementation and Use on Performance of the Surgical Care Improvement Project Measures	2015	Retrospective Observational Study	1816	Strong Memorial Hospital/Highland Hospital	Compared SCIP measures pre-EHR to post-EHR. They found a decline in odds of urinary catheter removal and blood glucose control after surgery in the months immediately following EHR deployment. After 3 months of deployment, there was a statistically insignificant improvement in scores for these measures.	Negative
Flatow et al	Quality Outcomes in the Surgical Intensive Care Unit after Electronic Health Record Implementation	2015	Retrospective Observational Study	1274/1229	Mount Sinai	Analyzed quality indicators in a surgical ICU 2 years before and after the implementation of an EHR. There was no difference in LOS, C.diff colitis, readmission rate, and case mix indexes. Found an 85% decrease in central line associated blood stream infections per 1000 catheter days and a 28% decrease in mortality within the SICU. However, the study had a significant number of cofounders including the use of daily goals sheets for central line necessity, hiring of more physician extenders, and palliative care involvement for early patient transfers.	Positive

Table 2.1: **Continued**

Author	Study Name	Year	Type of Study	Cohort Size Study/Control	Site	Finding/Addition to literature/Limitations	Result
COMPUTERIZED PROVIDER ORDER ENTRY (CPOE)							
Webb et al.	Reducing Surgical Site Infections through a Multidisciplinary Computerized Process for Preoperative Prophylactic Antibiotic Administration	2006	Prospective Observational Study	unknown	Atlanta Veterans Administration Hospital	Implemented a computerized order entry option for preoperative antibiotics with practice improvement, improving appropriate and timely administration. Found a significant decrease in clean wound infection rates from 2.7% to 1.4% during the 1-year study period.	Positive
Liu et al.	Using Information Technology to Reduce the Inappropriate use of Surgical Prophylactic Antibiotic	2008	Prospective Observational Study	858	Taichun Veterans General Hospital	Implemented a physician education program and computerized reminder system to order post-operative antibiotics according to guidelines. There was no change in postoperative wound infection rates, but there was a decrease in the use of prophylactic antibiotics for clean cases and decreased duration of prophylactic antibiotics for clean contaminated cases.	Positive
Haynes et al.	Effectiveness of an Information Technology Intervention to Improve Prophylactic Antibacterial use in the Postoperative Period	2010	Prospective Observational Study	2608/2808	University of Pennsylvania	Studied the implementation of an order set preventing prophylactic antibiotics to be ordered for longer than a specified time period (20 hours or 44 hours after surgery in non-cardiac and cardiac surgery patients respectively). Timely discontinuation of antibiotics increased from 38.8% to 55.7%. This discontinuation was virtually only present in locations of the hospital where the electronic CPOE would trigger, suggesting it was not an educational improvement.	Positive
Appari et al.	Medication Administration Quality and Health Information Technology: a National Study of US Hospitals	2011	Retrospective Observational Study	Unknown	Dartmouth, The Health Information and Management Systems Society Analytics Database	Analyzed data from nationwide hospitals to determine if the use of EHR and/or CPOE had an effect on the administration of recommended medications. Found a small increase in the odds of receiving the appropriate preoperative antibiotics and VTE prophylaxis in hospitals with EHR and CPOE. Also found hospitals demonstrated better medication compliance with increased experience with EHR or CPOE.	Positive
Van Sise et al.	Improving the Selection of Recommended Prophylactic Antibiotics Using an Electronic Medical Record	2012	Retrospective Observational Study	934/938	Stony Brook Hospital	Retrospectively looked at the use of prophylactic antibiotics before and after the addition of computerized order sets for antibiotics. There was an increase in the use of recommended antibiotics from 43.4% to 58.1% after order set CPOE.	Positive

Table 2.1: **Continued**

Author	Study Name	Year	Type of Study	Cohort Size Study/Control	Site	Finding/Addition to literature/Limitations	Result
ELECTRONIC OPERATIVE NOTES							
Laflamme et al.	Efficiency, Comprehensiveness and cost effectiveness when comparing dictation and electronic templates for operative reports	2005	Prospective observational study	138/198	Wishard Memorial Hospital	Compared template electronic notes to traditional dictated notes. Time to verified completed document was 0.46 hours v 374 hours for the template group compared to dictation group. Estimated an average monthly saving of 650 dollars from not having to pay for dictation services. "Key elements" were present in 97% of template electronic reports and 85% of dictated reports. Mean time to produce the report was slightly longer in the template group (6.77 minutes compared to 5.96 minutes.	Positive
Cowan et al.	Electronic Templates versus Dictation for the Completion of Mohs Micrographic Surgery Operative Notes	2007	Retrospective Observational Study	58/52	Johns Hopkins Medical Center	Compared dictated operative notes using a template to electronic template operative notes. The dictated notes required more than a minute longer to complete than those complete by templates. Editing of notes for dictations was 201 seconds compared to 41.6 seconds for electronically generated notes. Template electronic notes took 0.115 days to sign versus 20.7 days to sign dictated notes. For dictated notes, 81 % had at least one error. 5.77 % of electronic template notes had one or more errors.	Positive
Park et al.	Electronic Synoptic Operative Reporting: Assessing the Reliability and Completeness of Synoptic Reports for Pancreatic Resection	2010	Prospective/Retrospective Observational Study	112/102	MSKCC	Electronic synoptic operative reports were developed for pancreatic resections and compared to prior dictated operative notes by the same surgeon for the same procedure. The operative reports were evaluated with a checklist. Electronic notes had significantly higher completeness checklist scores compared to dictated notes (88.8% versus 59.6%) and were available in median 0.5 days compared with 5.8 days for dictated operative notes. Notes were completed in an average of 4 minutes, which was not compared to dictation.	Positive
Hoffer et al.	Structured electronic operative reporting: Comparison with dictation in kidney cancer surgery	2011	Retrospective Observational Study	158/97	Princess Margaret Hospital and the Ontario Cancer Center	Creation of an electronic, online service for electronic operative note creation for urologists. Increased completion rate from 68% to 92% with structured notes compared to dictated notes. There was no difference between attending staff and trainees, and physicians chose which method they wanted to use. 30% of dictated notes were completed in over 5 days and the median time for electronic notes was 2 days.	Positive

Table 2.1: **Continued**

Author	Study Name	Year	Type of Study	Cohort Size Study/Control	Site	Finding/Addition to literature/Limitations	Result
ELECTRONIC OPERATIVE NOTES							
Ghani et al.	Smart electronic operation notes in surgery: An innovative way to improve patient care	2014	Retrospective Observational Study	50/50	Royal London Hospital	Audit of 50 operative notes before and after the implementation of electronic operative notes showed an improvement in operative note completeness. Prior to electronic note, 60% contained closure details, 69% included antibiotics at induction, and 66% had legible hand writing. After electronic operative notes, 100% included closure details, antibiotics, and were legible.	Positive
INTERNET							
Melloul et al.	Donor Information for Living Donor Liver Transplantation: where can Comprehensive Information Be Found?	2012	Qualitative Research	NA	Internet	Used the EQIP (Ensuring quality information for patients) instrument to analyze living donor liver transplantation information found through the first 100 websites identified through 3 search engines, resulting in 32 unique websites. A median number of 16 out of 36 criteria were met.	NA
Bruce-Brand et al.	Assessment of the Quality and Content of Information on Anterior Cruciate Ligament Reconstruction on the Internet	2013	Qualitative Research	NA	Internet	Used the JAMA benchmark, DISCERN criteria, and HONcode certification to analyze the content returned when ACL reconstruction was queried by analyzing the first 60 returned sites on 4 search engines. Websites with HONcode certification had significantly higher mean DISCERN scores. Academic institutions had higher DISCERN scores.	NA
Fast et al.	Evaluating the quality of Internet health resources in pediatric urology	2013	Qualitative Research	NA	Internet	Used DISCERN and HONcode to analyze 60 websites identified with Google for the terms circumcision, posterior urethral valves, and vesicoureteral reflux. 25-30% of the websites were HONcode certified. Out of the maximum score of 80, the average DISCERN Plus score was 60, 40, and 45 respectively.	NA
Sullivan et al.	Can Internet Information on Vertebroplasty be a Reliable Means of Patient Self-Education?	2014	Qualitative Research	NA	Internet	Used a rating system to determine if the first 35 articles on 3 search engines contain one indication, one risk and one benefit on vertebroplasty. 43% of sites were adequate with sites lacking most in risks and contraindications to procedures, especially in academic centers.	NA
Corcelles et al.	Assessment of the quality of Internet information on sleeve gastrectomy	2015	Qualitative Research	NA	Internet	Used the JAMA benchmark, DISCERN criteria, and HONcode certification to analyze the content in 50 sites for sleeve gastrectomy. Using the mean of three separate scorers, the average score 46.3 out of 80. Academic institutions had higher DISCERN scores.	NA

Table 2.1: **Continued**

Author	Study Name	Year	Type of Study	Cohort Size Study/Control	Site	Finding/Addition to literature/Limitations	Result
INTERNET							
Fortier et al.	Web-Based Tailored Intervention for Preparation of Parents and Children for Outpatient Surgery	2015	Randomized Controlled Trial	38/44	Children's Hospital of Orange County and Yale Children's	Implemented a web-based tailored pre-operative educational intervention for both parents and children. Found significantly decreased anxiety of children upon entrance to the OR and introduction of the mask as well as decreased parent anxiety in preoperative holding according to the Modified Yale Preoperative Scale and the State-Trait Anxiety Inventory, respectively.	Positive
PATIENT WEB PORTALS							
Burke et al.	Transforming Patient and Family Access to Medical Information	2010	Prospective Observational Study	252	Miami Children's Hospital	Developed a web-based patient accessible electronic health record that contained textual and image data. 252 of 270 (93%) of parents offered access became users of the system. Image data was accessed more frequently than textual data. The resource was used more frequently while patients were in the hospital (67% v 33% of total logins). No patients or families requested to see their paper charts during the study period.	Positive
Baucom et al.	Case Report: Patient Portal Versus Telephone Recruitment for a Surgical Research Study	2014	Prospective Observational Study	391/74	Vanderbilt University Medical Center	Study compares the recruitment of patients who have undergone a ventral hernia repair for a research study either through telephone call or patient web portal messaging. Patients recruited through the portal were slightly younger and more recently had undergone their operation compared to patients recruited via telephone. The portal was successful at recruiting 16% of the total study participants.	Positive
Shenson et al.	Rapid Growth in Surgeons' Use of Secure Messaging in a Patient Portal	2015	Retrospective Observational Study	20484	Vanderbilt University Medical Center	Analyzed three years of patient-initiated portal message threads and found that secure messages accounted for 11.5% of all surgical outpatient interactions during the study period. The use of portal messaging gradually increased over the three year period (5.4 % in 2008 to 15.3% in 2010).	Neutral

Electronic Health Records

Fifteen articles were identified containing data-driven studies on the impact of EHRs on the care of surgical patients.[18-32] These articles varied in their study design and outcomes.

Four studies examined the impact of EHRs on the care of post-surgical patients. Pinto Thirukumaran and colleagues conducted a historical comparison study, which found that Surgical Care Improvement Project (SCIP) measures of quality such as early Foley catheter removal and adequate blood glucose control declined significantly in the first 3 months after EHR implementation but leveled off after 3 months.[31] Another study, analyzing a 4.5 year period before and after the implementation of an EHR at Xijing Hospital in China, found that the length of hospital stay significantly decreased in surgical patients admitted to cardiovascular and orthopedic surgical specialties for the specific diagnoses of intervertebral disc disorders and ventricular septal defects by an average of 2.3-2.8 days.[29] Flatow and colleagues found an 85% decrease in central line associated blood stream infections per 1000 catheter days and a 28% decline in mortality within a surgical intensive care unit after the institution of an EHR; however, there were many associated confounders.[32]

Stengel and colleagues conducted a RCT that randomized 80 patients to charting with either traditional paper-based methods or using hand-held devices on an orthopedic surgery inpatient unit.[21] This study showed a significant improvement in the daily documentation with the handheld device as measured by the generation of International Classification of Disease (ICD) diagnosis codes, with an increase in the median number of diagnoses per patients from 4 to 9. In addition, the investigators reported a significant decrease in the time required for handheld documentation (from 10-15 minutes to 2-3 minutes) as the study period progressed, but they did not compare the time for completion of the hand-written notes to the electronic notes.

Six articles were focused on the effects of computerized alerts to notify providers of critical information, such as laboratory results or the need for prophylactic antibiotic dosing, another major SCIP initiative.[22-27] Staes and colleagues performed a prospective observational study focused on outpatient

laboratory monitoring of liver transplant patients at the LDS Hospital in Salt Lake City, Utah. The investigators compared laboratory reporting by traditional methods such as fax and postal mail with a computerized alerting system in an EHR. They found a significant improvement in the review of laboratory results in transplant patients using a computerized alerting system.[25] With the traditional reporting process, 34% of laboratory results did not reach the office and although the results were available in the EHR, no alert notified physicians that the new result was present. Using electronic reporting, 0.8% of computerized lab notifications were not reported to an appropriate clinician. Nurses were able to review the results much quicker with the computerized notification (9.2 hours compared to 33.4 hours).

The remaining studies on computerized alerts were centered on anesthesia information management systems (AIMS), integrated electronic record systems for anesthesia providers. Although surgeons themselves may not interact with the AIMS directly, these systems have direct impact on surgical patients. AIMS can provide structured data entry fields and point-of-care electronic alerts, preventing providers from continuing documentation until certain fields are complete. In a recent retrospective observational study, Choi and colleagues reviewed anesthesia documentation during a 3-year period before and 1-year period after the institution of AIMS, and evaluated documentation quality based on three metrics, clinical pertinence indicators from SCIP, elements of performance (EP) from The Joint Commission (TJC), and guidelines from the Centers for Medicare and Medicaid Services (CMS). They found a significant improvement in adequate documentation including medication dosages, physiological status, mental status, and pain scales, attributable to data entry fields that required completion prior to advancing.[30] They did not find improvement in compliance of antibiotic administration, noting that the AIMS could have been optimized by inclusion of a computerized alert as a reminder to administer the antibiotics within 60 minutes of incision. Schwann and colleagues prospectively analyzed a 6-month period before and after implementation of medical record point-of-care electronic alerts for prophylactic antibiotic administration and found a significant increase in antibiotic compliance, from 31% to 92%, and decrease in overall surgical site infections, from 1.1% to 0.7%.[27]

Other researchers also found electronic alerts in the AIMS to increase appropriate and timely antibiotic administration, but the existence of other confounding factors could not be excluded, such as continuing education or changing practice patterns. The improvement was greater in studies starting out with poor compliance. For example, appropriate perioperative antibiotic administration rates increased from 20% to 57% in 2005 at Vanderbilt University Medical Center and from 69% to 92% in 2006 at University of Michigan Health Center.[22, 23] More recent studies with baseline antibiotic compliance rates over 80% showed a less than 10% improvement.[24, 26]

Four large-scale observational studies evaluated clinical decision support systems (CDSSs) specific for surgical patients.[18-20, 28] CDSSs include software designed to make recommendations and directly aid clinicians in appropriate decision-making.[33] In 1989, Larsen and colleagues assessed infection rates before and after implementing a computerized decision analysis tool for determining if surgical patients should receive pre-operative antibiotics.[18] Although they reported a decrease in surgical site infections (SSIs) after deploying the computerized decision support (1.8% to 0.9%), this effect was not statistically significant after adjusting for the larger quantity of clean cases in the cohort with decision support. They did have an 18% improvement in timing of prophylactic antibiotic administration, likely due to the impact of placing physician reminder stickers in the patient charts of those undergoing procedures deemed to benefit from antibiotic use. In two studies, a CDSS used patient characteristics to risk stratify the need for venous thromboembolism (VTE) prophylaxis. In 2000, Durieux and colleagues showed an improvement in compliance with VTE prophylaxis guidelines from 82.8% in the control (i.e., no CDSS) to 94.9% in the intervention group among orthopedic surgery patients in an alternating time-series designed study, with three 10-week intervention periods, four 10-week control periods, and a 4-week washout between each period.[20] In 2010, Haut and colleagues conducted a historical comparison study on a similar CDSS for adult trauma patients and found compliance improved from 66.2% in a 1-year baseline period (no CDSS) to 84.4% in a 3-year period after CDSS implementation.[28] They also found a significant decrease in preventable VTE events, from 4 events in the 1-year control period to 4 events in the 3-year intervention period.

Computerized Provider Order Entry

The review identified five articles highlighting the use of CPOE in surgical practice.[34-38] Four observational studies showed an improvement in appropriate prophylactic antibiotic administration with the use of CPOE or electronic pre-operative order sets.[34-36, 38] Webb and colleagues reported a decrease in the incidence of clean wound SSIs from 2.7% to 1.4% during a 1-year study period with the implementation of CPOE along with educational practice improvement initiatives.[34]

Prophylactic antibiotics may not be indicated for all cases, and inappropriate perioperative antibiotic administration is not without risk. One study at a Veteran's Hospital in Taiwan showed that a physician education program in conjunction with computerized reminders decreased the ordering of prophylactic antibiotics in clean cases in otolaryngology.[35] Although prophylactic antibiotics are often indicated, multiple repeated doses of antibiotics in the postoperative setting without infection are not, and may increase hospital antibacterial resistance.[39, 40] Haynes and colleagues implemented a CPOE system that restricted the ability of providers to order antibiotics specified as prophylactic beyond a recommended time point.[36] The computerized decision support in conjunction with CPOE determined the appropriate duration of antibiotic therapy, improving timely discontinuation of antibiotics from 38.8% to 55.7% over an 8-month period.

Appari and colleagues used nationwide databases to determine if the use of EHR and/or CPOE has an effect on the administration of recommended medications.[37] They performed a comparison of the Health Information and Management Systems Society (HIMSS) Analytics Database, which surveys 5281 non-federal acute-care hospitals in the United States for hospital characteristics and operational status of HIT applications, and CMS Hospital Compare Database, which provides medication-related process quality measures for more than 3470 non-federal acute-care hospitals. In hospitals with EHR and CPOE, they found 13% and 29% increases in the odds of receiving preoperative antibiotics and appropriate VTE prophylaxis, respectively. Interestingly, the effect was more prominent in institutions where EHR or CPOE had been in place for a longer period of time and each additional 2 years of technology use was associated with 6-15% higher odds of compliance. This study was conducted prior to

the Affordable Care Act and limited by a lack of data about dates of HIT implementation for many hospitals.

Electronic Operative Notes

This review found 5 studies evaluating the use of electronic operative notes in surgical care.[41-45] Each article reported either a retrospective or prospective observational study consisting of sample sizes with less than 200 notes in each arm. All studies showed greatly improved inclusion of crucial information, such as closure details, anesthesia, and antibiotics in electronically generated notes.

Ghani and colleagues compared 50 electronic and 50 handwritten operative notes for emergency orthopedic trauma surgery, finding that all electronically generated notes were legible in comparison to 66% of hand-written operative notes.[45] Four of the studies reported a significant decrease in the time to finalization of electronic notes, with electronic notes being completed in 0.1-0.5 days compared to 5.8-20.7 days for dictated notes.[41-44] Most studies compared non-templated hand-written or dictated notes to templated electronic notes and included operative reports from different surgeons. Creation of the note took slightly longer (mean 6.77 versus 5.96 minutes; $p = 0.036$) for electronic notes compared with dictated notes in a 2005 study of reports for common obstetrical and gynecologic procedures performed at the Wishard Memorial Hospital, a county hospital in Indianapolis, Indiana.[41]

Cowan and colleagues showed that for a specific operation, Mohs micrographic surgery, editing of the notes was much shorter for electronic notes than for dictation (41.6 seconds versus 201.1 seconds).[42] They compared dictated notes based on an outline of the procedure to electronic notes based on a template using a system designed at Johns Hopkins Medical Center.[42] Even though both notes were generated based on a template, significantly more of the dictated notes contained an error (81.03%) compared to electronic notes (5.77%).

Park and colleagues conducted a historical case controlled comparison of electronic notes to previously dictated notes by the same surgeon performing the same procedure of pancreatic resections.[43] Electronic notes had significantly higher completeness checklist scores compared to

dictated notes (88.8% versus 59.6%) and were available in median 0.5 days compared with 5.8 days for dictated operative notes. Electronic notes were completed in an average of 4 minutes.

Surgical Consumer Health Information on the Internet

A total of 6 articles studied Internet resources for surgical patients and disease processes. Five of the articles analyzed the quality of information available on the Internet for a particular disease or procedure, including resources about living donor liver transplantation, anterior cruciate ligament reconstruction, circumcision, posterior urethral valves, vesicoureteral reflux, vertebroplasty, and sleeve gastrectomy.[46-50] These studies used popular search engines to determine the quality of websites returned in response to health related terms. Three of these studies used the DISCERN criteria and presence or absence of the HONcode seal to determine the quality of information.[47, 48, 50] One article used author-generated criteria to grade the websites and another used the Ensuring Quality Information for Patients (EQIP) tool.[46, 49]

DISCERN is a reliable instrument designed to judge the quality of written consumer health information regarding treatment choices.[51] The DISCERN score ranges from 0-80 based upon publication reliability, the quality of information on different treatment choices, and the overall rating.[50] The Health On the Net (HON) Foundation is a nonprofit, nongovernmental organization, accredited for establishing ethical standards for health-related information on the Internet.[52, 53] Obtaining HONcode certification requires individual websites to apply for evaluation. The HONcode seal accredits websites based on the transparency and quality of the information provided.[50] The EQIP instrument is a checklist applicable to all information types for evaluation of quality, readability, and design aspects of written information. It has been expanded for use in evaluation of health-related information.

Regardless of the scoring criteria utilized, all studies reported that the quality of health information on the Internet about these specific surgical procedures was poor.[46-49] Mean DISCERN criteria scores ranged from 40 – 60 (out of 80) and only 4-30% of the websites bore the HONcode seal.

Websites with HONcode certification had significantly higher mean DISCERN scores (58.0 v 39.8).[47] Two studies found that academic institutions had improved quality of websites based upon DISCERN scores (approximate 10-point improvement) compared to average quality of all websites combined (including physicians, academic, commercial, social network, non-physicians, and unspecified websites).[47, 50] These studies were limited in that they typically analyzed one surgical procedure or problem.

Fortier and colleagues conducted a small-scale RCT in 2015 which evaluated a tailored web-based intervention for surgical patients.[54] Children undergoing elective outpatient surgery and their parents were randomized to the use of an Internet-based intervention preoperatively or standard of care (no intervention). Anxiety levels for both children and parents on the day of surgery were decreased with the intervention according to the Modified Yale Preoperative Scale and the State-Trait Anxiety Inventory, respectively. The study consisted of a small sample size of approximately 40 patients in each arm, and participation was limited to children without developmental delays and parents with available Internet access.

Patient Web Portals

The review identified three articles that studied the effects of patient web portals on surgical care.[55-57] All of these studies were observational and involved web-based applications allowing patients and their family members to view portions of the EHR or interact with healthcare systems through messaging. In one study, parents of patients undergoing congenital cardiac surgery at Miami Children's Hospital from 2006 to 2009 were offered access to a system that allowed users to view admission notes, discharge summaries, discharge instructions, operative images, and daily bedside images of the patient. During the study period, 252 of 270 of parents (93%) offered access became users of the system. Users accessed the system more often while the patients were in hospital than after discharge (67% v 33% of total logins). Imaging data were viewed significantly more frequently than textual data.[55] At Vanderbilt University Medical Center, a comprehensive patient portal was shown to be a

useful resource in the recruitment of participants for a study of outcomes after ventral hernia repair, with 44% of study participants having a registered portal account and 16% of the participants recruited through portal messaging.[56] Shenson and colleagues examined the growth in adoption of patient-provider secure messaging through the same portal relative to outpatient clinic visits at Vanderbilt University Medical Center in the 3-year period after portal implementation. This study demonstrated that in surgical specialties, portal messaging accounted for 11.5% of all outpatient interactions (i.e., message exchanges and clinic visits) in surgical practice. Furthermore, portal message exchanges between surgical patients and providers continued to increase over time, with messaging accounting for 5.4 % of outpatient interactions in 2008 and 15.3% in 2010.[57] The exact nature of patient and provider interactions conducted through messaging was not explored.

Discussion

This comprehensive review reveals a paucity of research about the effects of HIT in surgical practice and an overall poor quality of available evidence. Our review identified 34 studies evaluating HIT effects on the care of surgical patients, and the grade of evidence was predominately low. The Affordable Care Act has stimulated rapid implementation and adoption of EHRs and CPOE. Increasing access to and use of the Internet by patients has prompted the emergence of consumer HIT. Although these technologies are becoming ubiquitous in healthcare as organizations respond to regulatory requirements and consumer demands, they are not new. Computer-based health records were implemented as early as the late 1950s using punch card technologies, and patients have been seeking health information on the Internet for decades. Many of the pioneering researchers in the fields of health informatics were primary care or medical specialty providers. Therefore, research about the development and evaluation of HIT for surgical providers and patients has been limited.[58, 59]

Available evidence about the use of a variety of HIT tools by surgical providers does however demonstrate three consistent trends in the effects of these technologies: enhanced quality of surgical documentation, increased adherence to guidelines for medication administration sometimes with

associated better clinical outcomes, and improvements in patient care with tools for alerting providers. Improved documentation quality was an early goal for EHR systems and has been demonstrated in non-surgical settings.[60, 61] With regard to surgical documentation, one small randomized trial of EHRs for hospitalized orthopedic surgery patients and several non-randomized comparative studies of templated electronic operative reports for a variety of surgical procedures and specialties have shown significant improvements in inclusion of diagnoses and critical elements for documentation of operative procedures, respectively. Few of these studies examined the time required for completion of documentation, although electronic operative reports were available in the medical record significantly earlier than dictated procedure notes. The content of narrative dictated operative reports is often inconsistent and incomplete.[62] Electronic operative reports have several additional advantages as data from discrete fields can be employed for research and determination of outcomes.[63] Thus, the improvements in documentation quality and benefits of data reuse are likely to outweigh the increased time for report generation in the long term, although further research is needed to prove this hypothesis.

Appropriate perioperative antibiotic administration and VTE prophylaxis have been the focus of surgical quality initiatives over the last several decades, and this review provides some evidence that HIT can improve this aspect of surgical practice. Several non-randomized comparative studies revealed that adjuncts to the EHR and CPOE, such as clinical decision support and computerized alerts could improve quality measure documentation and receipt of the appropriate medication for the appropriate length of time. Few studies, however, translate these process measures into improvements in clinical outcomes. A small, but statistically significant, decrease in the incidence of SSI and incidence of VTE was found in two studies.[28, 34]

Our review provides good evidence that computerized alerting systems within EHRs can improve surgical patient care. Reminders improved laboratory monitoring of transplant patients and prophylactic antibiotic dosing in the operating room, and CPOE effectively prohibited physicians from ordering inappropriate post-operative “prophylactic” antibiotics beyond the recommended time frame.[36] We believe computerized reminder systems could support a wide range of quality-improvement activities for

surgical care. The widespread implementation of EHR and CPOE systems are an appropriate framework for the integration of further CDSS in various surgical specialties and practice settings. However, for these systems to be accepted and improve patient care, they will need to be well incorporated into clinical workflows, which have not been well studied in surgery.

Consumer health informatics is an emerging area of research. Evidence about the use of consumer-oriented HIT in surgical practice is too limited to offer strong recommendations, but this review did identify several important areas for future research. In 2004, patient access to electronic health records became a federal mandate, leading to the emergence of technologies such as patient portals.[55] Patient portals are web-based applications that provide a means for patients and families to interact with health care systems and access health information.[56] Our review identified two studies that demonstrated rapid adoption of patient portals by surgical providers and patients. However, the effects of these interactive and engagement technologies are unknown and should be the subject of future research.

Several studies showed that Internet-based health information resources for specific surgical problems and procedures are often incomplete and sometimes misleading, based on criteria developed by clinical or web experts. With the increasing use of Internet resources by both providers and patients, there are growing concerns about the quality and validity of the available information.[47, 64] Prior reviews have identified hundreds of invalidated instruments for measuring the quality of health information on the Internet.[65, 66] Consumer health information needs are poorly understood and understudied, and the value of a particular resource to a patient or caregiver may not be best measured by such criteria. This review identified one RCT that showed a decrease in the anxiety of the parents of children undergoing outpatient surgery after using a web-based educational intervention.[54] Future studies of consumer HIT should employ both high quality designs and consumer-focused outcomes to measure effectively the impact of such resources and tools in a specific context.

Our study has several limitations. First, our review only included literature available in the English language, and it is likely that relevant studies published in other languages were missed. Our research team is seeking collaborators to assist with inclusion of such studies in future work. Second, we

did not define an explicit question to be answered by this review, as the quantity and nature of the available literature in the domain of surgery was not known. This review serves as one of the first comprehensive summaries of HIT applied to the domain of surgery in the information age and defines important gaps in knowledge and areas for future research. Finally, the paucity of data and heterogeneity of studies precluded a formal meta-analysis. As this field evolves and additional evidence becomes available, future reviews should address very specific effects and combine findings when appropriate.

Conclusions

In all areas of health care, including surgery, there has been rapid implementation and adoption of HIT by providers and patients. Existing large cross-sectional studies about the effects of HIT are confounded by variations in patient populations and practice patterns across clinical specialties. There is a paucity of data and overall low quality of evidence regarding HIT in surgical practice. We identified three consistent trends in the effects of these technologies in surgery including an improvement in the quality of surgical documentation, increased adherence to guidelines for medication administration, and improvements in patient care with provider alerts. Further research is needed to optimize the incorporation of electronic documentation, CPOE, and CDSS into surgical workflow and to evaluate the effects of HIT on surgical outcomes. In addition, more and better quality studies with consumer-focused outcomes are needed to evaluate the effects of web-based patient educational and engagement technologies to determine the impact of such resources on surgical patients.

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CHAPTER III

Use of a Patient Portal During Hospital Admissions to Surgical Services

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Abstract

Patient portal research has focused on medical outpatient settings, with little known about portal use during hospitalizations or by surgical patients. We measured portal adoption among patients admitted to surgical services over two years. Surgical services managed 37,025 admissions of 31,310 unique patients. One-fourth of admissions (9,362, 25.3%) involved patients registered for the portal. Registration rates were highest for admissions to laparoscopic/gastrointestinal (55%) and oncology/endocrine (50%) services. Portal use occurred during 1,486 surgical admissions, 4% of all and 16% of those registered at admission. Inpatient portal use was associated with patients who were white, male, and had longer lengths of stay ($p < 0.01$). Viewing health record data and secure messaging were the most commonly used functions, accessed in 4,836 (72.9%) and 1,626 (24.5%) user sessions. Without specific encouragement, hospitalized surgical patients are using our patient portal. The surgical inpatient setting may provide opportunities for patient engagement using patient portals.

Introduction

Patient portals are web-based applications that enable patients to view portions of their electronic health record (EHR) and interact with their healthcare providers.[1-3] The United States government defines a patient portal as "a secure online website that gives patients convenient 24-hour access to personal health information from anywhere with an Internet connection."[2] The data within a portal is typically managed by a healthcare institution and allows patients to have access to personal health information, including recent doctor visits, discharge summaries, medications, immunizations, allergies, and laboratory results. More advanced portals enable patients to schedule appointments, message their providers[4], and sometimes maintain personal health records.[5] Increasingly, health care systems offer portals to their patients, and consumers adopt them quickly.[6, 7] Hospitals are motivated to provide patient portals by financial incentives created by the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 and Meaningful Use criteria.[8, 9] Consumers are also demanding such technology and transparency from their health care providers.[10]

The majority of research about patient portals has been performed in the primary care or medical specialty settings with a paucity of research focusing on acute care specialties, such as surgery, or acute care settings, such as the hospital.[11-15] Two recent systematic reviews of over 100 studies on the effectiveness of patient portals revealed only three studies exploring portal use outside of primary care or medical specialties.[16, 17] Our prior research demonstrated that after broad deployment of a patient portal across clinical specialties, surgeons were the second most frequent specialty to use patient-provider messaging.[18] Further, messaging adoption by surgical patients and providers grew rapidly across surgical subspecialties.[6] As healthcare organizations increasingly deploy patient portals across clinical specialties to meet Meaningful Use objectives, we anticipate the use of patient portals by the understudied acute care population to continue to grow.

Many trials investigating patient portals involve outpatient management of chronic diseases, but very little is known regarding patient use of patient portals while in the hospital for an acute illness or after surgery.[18, 19] Masterson et al have described their development of a personalized inpatient portal

to improve patient engagement while in the hospital, but results are not yet reported.[11] Very small studies have assessed the efficacy of providing patients with tablet computers for specific encouragement of portal use during inpatient stay, showing patients utilized and appreciated the ability to view their health information.[20, 21] At Brigham and Women's Hospital, a web-based patient-centered tool kit offering many common patient portal functions was implemented and evaluated in the medical intensive care unit and oncology unit settings.[22] Studies of this system have shown encouraging trends for the adoption and sustained usage of such technologies in the acute care setting.[23] Although the functions commonly offered by patient portals meet important needs of hospitalized patients[24, 25], there has been a reluctance to encourage portal usage by hospitalized patients. Many patient portals have policies that would discourage inpatient usage, such as specific delays for availability of test results or several business day expectations for answering of secure messages.[26] Nonetheless, healthcare consumers often find innovative ways to use health information technologies. To address existing gaps in the literature about the use of patient portals by surgical patients in acute care settings, we sought to characterize the adoption and use of a patient portal by patients admitted to surgical services at a large academic medical center.

Methods

Study Setting

This study was conducted at Vanderbilt University Medical Center (VUMC), a private, non-profit, academic institution in Nashville, Tennessee, which provides primary and regional referral care to adults and children. VUMC encompasses Vanderbilt University Hospital (VUH) and Vanderbilt Children's Hospital (VCH), with over 900 inpatient beds and 50,000 inpatient admissions per year.

Patient Portal

VUMC launched the My Health At Vanderbilt (MHAV) patient portal in 2005, with implementation across the clinical enterprise completed in 2007. After initial implementation, a physician champion introduced MHAV to providers, and technical support staff was available to patients,

physicians, and staff as the portal was introduced in individual clinical units. MHAV was promoted to patients through flyers posted in outpatient clinics. This process was repeated, beginning in adult primary care, and then extending to adult and pediatric specialties. Programs did not promote MHAV use in the inpatient setting until 2014, when a link to the MHAV was made available through interactive television in the hospital rooms of VUH.

All patients who receive medical care at VUMC may register for access to MHAV. MHAV users may authorize another individual, termed a *delegate*, to access their MHAV account on their behalf. Our policies for MHAV accounts for pediatric patients are similar to those developed for other major children's hospitals.[5] For patients under 13 years of age, parents or guardians (called *surrogates*) may access MHAV account on behalf of their child. Adolescents 13 years of age and older may have their own, parent-controlled MHAV accounts.[26] MHAV provides access to selected portions of the medical record, appointment scheduling, account and bill management, targeted health education materials, and secure messaging with healthcare providers.[26, 27] MHAV is now a well-established patient portal, with over 327,000 registered users and over 300,000 logins per month by 50,000 unique users. MHAV is directly linked to the VUMC EHR, StarPanel, and thus, content is continually updated. MHAV allows access to selected health information from the EHR, including clinical visit summaries, laboratory results, and medication lists. Some information is immediately available and other sensitive content is only viewable after short delays to allow for physician review and management. MHAV messages are managed by clinical groups based on provider preferences. Some providers directly answer all patient-initiated messages, and others have messages triaged by administrative and clinical staff members, any of whom may respond. Tailored educational materials are available within MHAV based on patient problems and medication lists. Specific policies and procedures developed to enhance patient and provider adoption are published elsewhere.[26]

Study Population

We examined all admissions to surgical services at VUMC and all use of the MHAV patient portal by patients admitted by a surgical service or their delegates or surrogates between January 1, 2012 and December 31, 2013. This time period was chosen after a rise in anecdotal reporting of inpatient MHAV usage and prior to the promotion of portal registration and usage through interactive television in the hospital. We sought to examine inpatient portal access in the absence of specific programs to promote such usage.

Measures

For each admission during the study period, we recorded patient age, sex, and race, as well as admitting service, International Classification of Disease (ICD-9) admission diagnosis code, and length of stay. We categorized admitting services using 21 surgical specialties reflecting the departmental organization at VUMC: cardiac, thoracic, otolaryngology, emergency general, general, gastrointestinal/laparoscopic, liver transplant, neurosurgery, oncology/endocrinology, oral/maxillofacial, orthopedic, pediatric, pediatric trauma, pediatric urology, plastic, renal transplant, spinal, trauma, burn, urology, and vascular. MHAV users include VUMC patients who have registered for MHAV, delegates, and surrogates. For each admission, we considered the patient registered with MHAV if they had a portal account by the time of discharge. MHAV use during a hospital admission was defined as any MHAV activity through the admitted patient's or any affiliated delegate/surrogate accounts occurring between the date/time of admission and the date/time of discharge. We determined the total number of inpatient MHAV user sessions across user types. For each session, we classified the type of portal function utilized as account management, appointments, education materials, laboratory test results, messaging, or other.

Analysis

We calculated the total number of inpatient admissions to each surgical service, as well as the number of these surgical patients who were registered for MHAV either before or during their admission.

We also calculated the number of these patients who specifically registered for MHAV during inpatient stay. We constructed descriptive distributions and summary statistics of MHAV registration and use status across patient demographics and admission characteristics. Continuous variables were summarized with medians and inter-quartile ranges. Categorical variables were summarized as counts and frequencies. We modeled inpatient use among admissions of registered patients using a logistic model controlling for month of admission, race, sex, age at admission, length of stay, and admitting service. Standard errors were adjusted to account for correlation among multiple admissions for the same patient. All analyses were conducted in R version 3.0.1.[28]

Results

During the study period, VUMC surgical services managed 37,025 admissions of 31,310 unique patients. Demographics of the unique patients admitted to a surgical service listed in Table 3.1.

MHAV Registration Status

Of the 37,025 admissions during the study period, 9,362 (25.3%) involved patients registered for MHAV and 7,549 (24.1%) unique patients were registered for MHAV during at least one admission in the study period. In 194 admissions, the patient registered for MHAV during an inpatient stay rather than enrolling in MHAV prior to the admission. The MHAV registration rate was higher at VUH than VCH, with 27.0% of unique patients admitted to VUH having a portal account compared to 8.8% among unique patients admitted to VCH.

Table 3.1. Demographic and clinical characteristics of unique patients admitted to a surgical service at VUMC 2012-2013. Counts and percentages or median and IQR.

Characteristic	All	%	VCH	%	VUH	%
Total	31,310		5,002		26,308	
Race						
White	26,380	84.3	3,845	76.9	22,535	85.7
Black	3,497	11.2	715	14.3	2,782	10.6
Unknown	975	3.1	298	6	677	2.6
Asian/Pacific Islander	355	1.1	123	2.5	232	0.9
Native American/Alaskan	103	0.3	21	0.4	82	0.3
Sex						
Male	17,939	57.3	2,875	57.5	15,064	57.3
Female	13,371	42.7	2,127	42.5	11,244	42.7
Age at first admission (years)	49 (IQR 26-63)		6 (IQR 2-13)		54 (IQR 39-65)	
Age categories (decades in years)						
<10	3,175	10.1	3,152	63	23	0.1
10-19	2,694	8.6	1,792	35.8	902	3.4
20-29	2,863	9.1	39	0.8	2,824	10.7
30-39	3,099	9.9	8	0.2	3,091	11.7
40-49	4,040	12.9	4	0.1	4,036	15.3
50-59	5,457	17.4	4	0.1	5,453	20.7
60-69	5,609	17.9	3	0.1	5,606	21.3
70-79	3,218	10.3	0	0	3,218	12.2
80-89	1,035	3.3	0	0	1,035	3.9
90 or older	120	0.4	0	0	120	0.5
Age categories (pediatric)						
0-1yr	1156	3.7	1145	22.9	11	0
2-5yrs	1,142	3.6	1,132	22.6	10	0
6-10yrs	1,072	3.4	1,070	21.4	2	0
11-15yrs	1,231	3.9	1,208	24.2	23	0.1
16-18yrs	928	3	364	7.3	564	2.1
over 18yrs	25,781	82.3	83	1.7	25,698	97.7

Table 3.2 presents the demographics for all patients admitted to a surgical service compared to those registered for MHAV. Patients registered for MHAV differed from the entire patient cohort on each demographic characteristic, both overall and within each hospital ($p < 0.01$) with the exception of sex among patients admitted to VCH ($p = 0.29$). White and Asian/Pacific Islander patients were more likely to have a MHAV account than were Black, Native American/Alaskan, and other/unreported race patients. Overall, patients in their 50s and 60s were most likely to be registered for MHAV. Among patients admitted to VUH, female patients were more likely to be registered for MHAV compared to male patients (33.3% vs. 22.3%, respectively).

Table 3.2. Demographic and clinical characteristics of unique patients admitted to a surgical service at VUMC 2012-2013 by MHAV registration status. Counts and percentages or median and IQR.

Characteristic	All (n)	Registered (n)	Registered (% of total)
Race			
White	26,380	6,812	25.8
Asian/Pacific Islander	355	88	24.8
Native American/Alaskan	103	18	17.5
Black	3,497	545	15.6
Unknown	975	86	8.8
Sex			
Female	13,371	3,941	29.5
Male	17,939	3,608	20.1
Age at first admission (years)	49 (IQR 26-73)	54 (IQR 41-64)	
Age categories (decades)			
< 10	3,175	277	8.7
10-19	2,694	202	7.5
20-29	2,863	452	15.8
30-39	3,099	834	26.9
40-49	4,040	1,193	29.5
50-59	5,457	1,768	32.4
60-69	5,609	1,821	32.5
70-79	3,218	801	24.9
80-89	1,035	186	18
90 or older	120	15	12.5
Age categories (pediatric)			
< 6 months	542	34	6.3
6-12 months	248	33	13.3
12-24 months	366	50	13.7
2-5yrs	1,142	96	8.4
6-10yrs	1,072	75	7.0
11-15yrs	1,231	91	7.4
16-18yrs	928	69	7.4
over 18yrs	25,781	7,101	27.5

The number and proportion of patients registered for MHAV by surgical admitting service are presented in Table 3.3. At the adult hospital, VUH, 8,851 of 31,448 (28.1%) admissions to surgical services involved patients registered for MHAV compared to 511 of 5,577 surgical admissions (9.2%) at VCH. The surgical services with the highest rate of MHAV registration were adult gastrointestinal/laparoscopic (54.5%) and adult oncology/endocrinology (49.6%). The surgical services with the lowest rates of MHAV registration were pediatric trauma (1.2%) and burn (1.8%).

Table 3.3. Surgical admitting service and MHAV registration among 2012-2013 VUMC admissions, categorized into Vanderbilt Children's Hospital (VCH) and Vanderbilt University Hospital (VUH). (Reg = Registered)

Surgical Admitting Service	All	Reg	Reg	All	Reg(n) (VCH)	Reg(%) (VCH)	All	Reg(n) (VUH)	Reg(%) (VUH)
Total	37,025	9,362	25.3	5,577	511	9.2	31,448	8,851	28.1
Year of admission									
2012	18,270	4,471	24.5	2,655	215	8.1	15,615	4,256	27.3
2013	18,755	4,891	26.1	2,922	296	10.1	15,833	4,595	29
GI/Laparoscopic	1,574	858	54.5	1	1	100	1,573	857	54.5
Oncology/Endocrine	1,206	598	49.6	0	0	0	1,206	598	49.6
Spinal	27	13	48.1	0	0	0	27	13	48.1
Thoracic	1,068	481	45	1	1	100	1,067	480	45
General	2,006	855	42.6	23	1	4.3	1,983	854	43.1
Renal Transplant	504	205	40.7	4	0	0	500	205	41
Liver Transplant	534	207	38.8	3	1	33.3	531	206	38.8
Neurological	4,239	1,461	34.5	391	84	21.5	3,848	1,377	35.8
Urology	2,658	805	30.3	50	4	8	2,608	801	30.7
Cardiac	957	279	29.2	9	0	0	948	279	29.4
Emergency General	1,444	385	26.7	1	0	0	1,443	385	26.7
Otolaryngology	2,030	521	25.7	574	75	13.1	1,456	446	30.6
Orthopedic/Rehab	6,602	1,672	25.3	1,011	84	8.3	5,591	1,588	28.4
Vascular	525	121	23	1	0	0	524	121	23.1
Plastic	1,435	283	19.7	451	53	11.8	984	230	23.4
Oral/Maxillofacial	286	44	15.4	49	2	4.1	237	42	17.7
Pediatric Urology	269	25	9.3	269	25	9.3	0	0	0
Pediatric	2,292	175	7.6	2,287	175	7.7	5	0	0
Trauma	6,032	352	5.8	10	0	0	6,022	352	5.8
Burn	1,083	19	1.8	191	2	1	892	17	1.9
Pediatric Trauma	254	3	1.2	251	3	1.2	3	0	0

Inpatient Use of MHAV

Portal usage occurred during 1,486 surgical admissions (4% of all admissions and 16% of registered user admissions) involving 1,270 unique patients. 6,634 portal user sessions occurred during surgical inpatient admissions. For admissions during which MHAV was accessed, the median number of MHAV sessions was 2 (IQR 1-4); however, during some admissions, patients accessed MHAV more than 20 times, with a few users accessing MHAV over 80 times during admission. Normalizing by length of stay, the median number of MHAV sessions per inpatient day was 2.0 (IQR 1.0-3.1) among admissions with MHAV use.

In unadjusted tests among admissions involving MHAV registered patients, admissions with inpatient portal use differed from those without portal use in terms of length of stay, race, sex, and admitting service ($p < 0.01$), but did not differ on patient age. These findings were observed overall and within VUH admissions only. Among admissions to VCH, admissions with portal use were longer than admissions without use (median LOS 5 vs. 3 days; $p < 0.01$).

Adjusting for patient demographics and admission characteristics, white race, male sex, increased length of hospital stay, and admitting service were associated with inpatient portal use ($p < 0.01$). Figure 3.1 demonstrates the odds ratios (OR) for inpatient portal use based on demographics and admission service. Black patients were significantly less likely than white patients to use the portal or have MHAV accessed on their behalf during hospitalization (OR 0.53, 95% CI 0.39-0.71). Male patients were more likely to use the portal or have MHAV accessed on their behalf during hospitalization than female patients (OR 1.33, 95% CI 1.17-1.52). Compared to general surgery admissions, admissions to the liver transplant service were at 76% higher odds of portal use (OR 1.76, 95% CI 1.19-2.62). Admissions to the liver transplant service were also more likely to use the portal than those to neurological, plastic, gastrointestinal/laparoscopic, otolaryngology, and orthopedic surgery services. Otolaryngology (OR 0.69, 95% CI 0.48-0.98), gastrointestinal/laparoscopic (OR 0.57, 95% CI 0.41-0.80), and orthopedic surgery (OR 0.73, 95% CI 0.56-0.94) admissions showed a decreased likelihood of portal use compared to general surgery admissions.

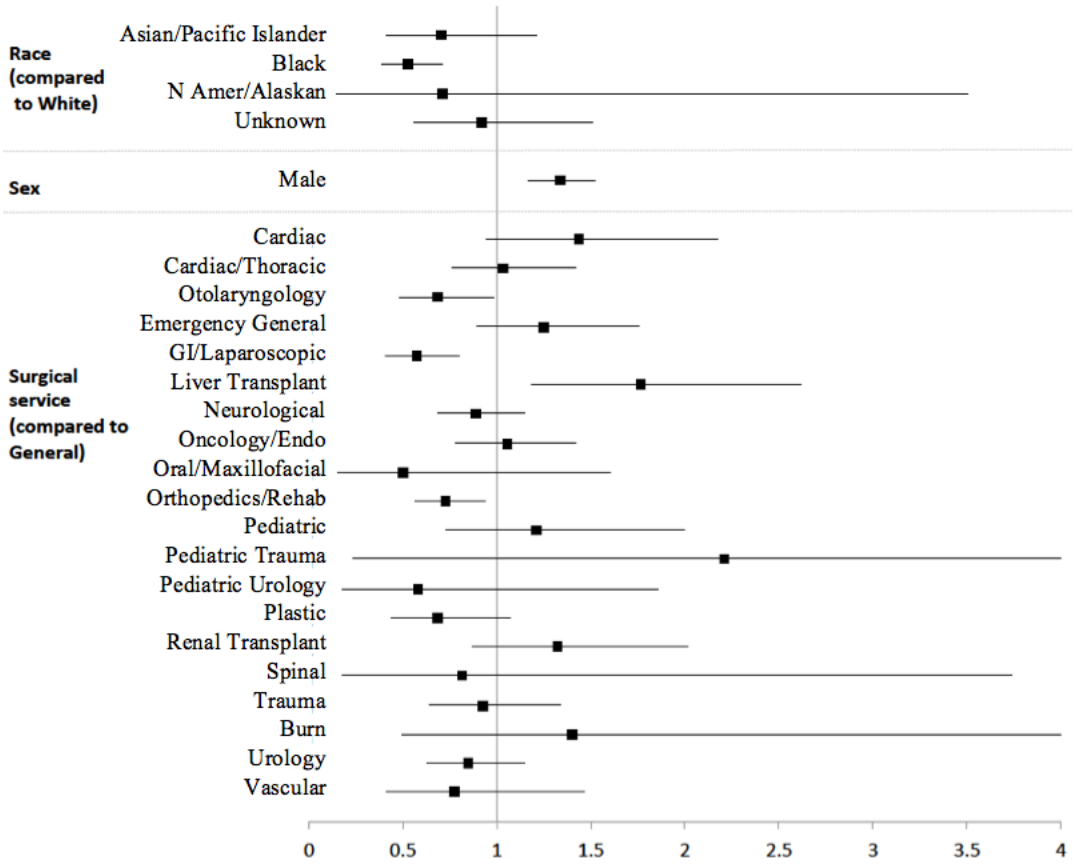

Figure 3.1. Odds ratios for inpatient MHAV use among registered admissions

Among admissions with inpatient use of MHAV, the portal was accessed through the patient's account in 92.7% of admissions, through a delegate account in 2.6% of admissions, and through a surrogate account in 5.5% of admissions (see Table 3.4). Although patients utilized a variety of portal functions, viewing health record data (i.e. laboratory results, medication lists, or clinical documents) and secure patient-provider messaging were the most common, accessed in 4,836 (72.9%) and 1,626 (24.5%) of total inpatient user sessions, respectively (see Table 3.4).

Table 3.4. Number of inpatient user sessions accessing each MHAV function, overall and by user role.

	Any user (n)	Patient (n)	Delegate (n)	Surrogate (n)
Total sessions	6,634	6,243	127	264
Viewing health record	4,836	4,563	77	196
Messaging	1,626	1,489	54	83
Educational materials	521	521	0	0
Appointments	495	462	10	23
Account management	72	67	2	3
Other	120	112	1	7

Tables 3.5 and 3.6 describe the most prevalent ICD-9 diagnosis codes for all admissions and admissions with inpatient use of the patient portal to VUH (adults) and VCH (pediatrics), respectively. The three most frequent diagnoses among adult patients who utilized the portal while hospitalized were postoperative infection, morbid obesity, and intestinal obstruction. In contrast, the 3 most frequent diagnoses among pediatric patients who used the portal while inpatient were scoliosis and kyphoscoliosis, esophageal reflux, and hypertrophy of tonsils with adenoids.

T**able 3.5. Top 10 most prevalent ICD9 diagnosis codes of patients at VUH (adults; n = # of admissions)**

All admissions to VCH		Admissions to VUH with inpatient MHAV use	
ICD-9	**n**	**ICD-9**	**n**
185 - Mal neoplasm prostate	771	998.59 - Other postop infection	34
278.01 - Morbid obesity	759	278.01 - Morbid obesity	25
998.59 - Other postop infection	610	560.9 - Intestinal obstruction	21
189.0 - Mal neoplasm kidney	464	189.0 - Mal neoplasm kidney	21
715.36 - Osteoarthrosis lower leg	433	403.9 - Hypertensive chronic kidney disease	20
715.35 - Osteoarthrosis pelvis	254	198.3 - Secondary mal neoplasm brain/spinal	19
560.9 - Intestinal obstruction	242	V55.2 - Attention to ileostomy	17
733.82 - Nonunion of fracture	223	715.36 - Osteoarthrosis lower leg	17
403.91 - Hypertensive chronic kidney disease	221	562.11 - Diverticulitis of colon	14
414.01 - Coronary Atherosclerosis	194	997.49 - Other digestive sys complications	13

Table 3.6. Top 10 most prevalent ICD9 diagnosis codes of patients at VCH (children; n = # of admissions)

All admissions to VCH		Admissions to VUH with inpatient MHAV use	
ICD-9	**n**	**ICD-9**	**n**
750.5 - Hypertrophic pyloric stenosis	233	737.30 - Scoliosis and kyphoscoliosis	5
540.9 - Acute appendicitis w/o peritonitis	224	530.81 - Esophageal reflux	4
474.10 - Hypertrophy of tonsil w/ adenoids	145	474.10 - Hypertrophy of tonsil w/ adenoids	4
737.30 - Scoliosis and kyphoscoliosis	134	276.51 - Dehydration	4
540.0 - Acute appendicitis w/ peritonitis	126	996.63 - Complication nervous sys implant	3
812.41 - Supracondylar fracture humerus	109	787.22 - Dysphagia oropharyngeal phase	3
998.11 - Hemorrhage complicating procedure	89	560.81 - Peritoneal adhesions w/ obstruction	3
756.0 - Congenital anomalies of skull/face	86	556.9 - Ulcerative colitis unspecified	3
996.2 - Complication nervous sys implant	85	756.19 - Other congenital anomalies spine	2
540.1 - Acute appendicitis w/ abscess	84	742.59 - Other cong anomalies spinal cord	2

Discussion

This study documents modest and somewhat unexpected usage of a patient portal by hospitalized surgical patients; it is one of the first studies to report inpatient portal adoption outside of a specific program or technology designed for the hospital setting. Without promotion for use in the inpatient setting, 4% of all admitted surgical patients and 16% of patients registered for the portal utilized the portal while in the hospital. With a known lack of research about technologies to engage patients in the inpatient setting[29], this study suggests that existing technologies such as patient portals may have a role in meeting the needs of hospitalized patients and their families.

Our study showed that patient portals were more likely to be used during hospitalization for patients who were white, male, and had extended lengths of stay. Outpatient studies of patient portals have shown similar disparities with decreased use by minorities, especially African Americans.[30-32] In contrast to our findings, prior studies suggest that portal use is fairly similar between women and men, with most studies demonstrating slightly higher registration rates and usage by women.[31] Of note, we cannot determine from usage logs whether the portal was actually used personally by the patient, or rather another individual using the patient's login information.

In our study, the services with the most registered portal users included those with significant pre-operative relationships, including gastrointestinal and laparoscopic (including a large majority of bariatric surgery patients) and oncology and endocrine surgery. ICD-9 diagnosis codes for adults registered for the portal aligned with the service designations, with the most common diagnoses being prostate cancer and morbid obesity. Interestingly, the most frequent ICD-9 code of adult patients using the portal while inpatient was post-operative infection, suggesting patients with a complication may be more likely to utilize the portal to view personal health information and contact providers. The only service that showed portal usage increased over that of general surgery in hospitalized patients was liver transplantation, potentially due to frequent laboratory monitoring and clinical complexity of patients.

Prior research has shown encouraging adoption of similar technologies during hospitalization, but usually in the context of a specific research program in which registration was encouraged and usage was supported by training. Wilcox and colleagues piloted a customized inpatient personal health record in cardiothoracic surgery patients and found medication tracking tools to be an effective means to increase inpatient engagement.[33] Burke reported enthusiastic adoption of a web-based multimedia EHR for patients with congenital cardiac disease and their parents with a 93% adoption rate and 67% of use occurring during hospitalization.[34] Notably, this study was conducted in families with children undergoing surgical repair of congenital cardiac abnormalities, who likely have long-standing relationships with their surgeons. O'Leary and colleagues showed that patient use of a portal designed specifically with inpatient information including team members, medication lists, and daily agendas on tablet computers within a general medical service unit could improve the ability of patients to identify physicians and roles by over 25%.[35] In contrast to prior work focused on technologies developed for inpatient setting, our study demonstrated substantial use of a patient portal designed for the outpatient setting, by patients who were hospitalized and their caregivers, without specific encouragement or training, and in the presence of policies that might discourage inpatient use.

There are many potential benefits to using a patient portal during inpatient admissions. First and foremost, even minor surgeries are considered major life events for most patients and families, and they

offer “teachable moments” when otherwise unengaged individuals might consider making important healthcare changes.[36] Introducing patient portals during hospitalizations may provide tools for patients and families to learn about health problems and engage in their care. Furthermore, hospital team members, including physicians, residents, and nursing staff are highly dynamic,[37] and many hospitalized patients are unable to identify their physicians.[38, 39] Hospitalized patients frequently have multiple active conditions, tests, and procedures, with acute illness and its associated stress making it difficult for patients and families to retain information provided on daily rounds or at discharge.[35, 40-42] Others have shown that patients and caregivers desire access to the daily plan of care and team member roles, often not present in patient portals.[43, 44] Patient portals can allow patients to review their health data, schedule and view post-operative appointments, and communicate with providers. In the inpatient setting, hospital staff can provide training and support to assist patients and their families with registration and navigation of portal functions, giving them the knowledge and experience needed to promote ongoing engagement.[45] Use and familiarity with the portal prior to discharge may increase the portal usage on an outpatient basis. For example, patients may feel more comfortable communicating problems or concerns post-operatively through secure messaging after using it as an inpatient.

Such changes could have a significant impact on surgical workflow. Some patients who undergo certain operations may not require a face-to-face follow up, and provider-patient messaging could be utilized to ensure the patient is recovering as expected post-operatively. A pilot study at our institution has shown that over three–fourths of patients undergoing elective general surgery procedures were satisfied with online follow up, and post-operative complications were not missed by online visits.[46] Portal follow-up can potentially prevent patients from travelling long distances or missing work or school for unnecessary face-to-face clinic visits. This approach also benefits providers as follow-up appointments are typically included within the global payment period.

This study has important limitations. The design is retrospective, and the research was done at single large academic medical center with a locally-developed patient portal. The findings may not apply to other clinical settings or portal implementations, and therefore may not be generalizable to all

hospitals. However, our portal functions and many of the MHAV procedures and policies are similar to those reported by others.[7] One main difference is that MHAV was broadly deployed across clinical specialties soon after implementation, and our findings represent those of an established portal in use across the clinical enterprise for over 5 years. We have not assessed factors that may contribute to adoption and usage of the portal, such as encouragement by specific providers or teams. Further, we do not know the platform on which the portal was used by patients, the clinical context in which the portal was accessed, or other measures of usability or satisfaction, which would further inform the interpretation of our usage data. These questions are the subject of our ongoing research projects.

Conclusions

This study demonstrates modest use of a patient portal by hospitalized surgical patients without specific encouragement. Disparities in portal adoption among minority patients may occur in the inpatient setting. Although designed for the outpatient setting, patient portals may have a role in meeting consumer health information needs and engaging surgical patients both during and after hospitalizations. The perioperative period may offer a uniquely teachable time in which to engage patients and families in their care, and using a portal during hospitalization could support online postoperative follow up, which can benefit both patients and providers. Additional research is needed to determine the best ways to leverage patient portals during inpatient admissions to improve care.

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CHAPTER IV

Complexity of Medical Decision-Making in Care Provided by Surgeons Through Patient Portals

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Abstract

Introduction: Patient portals are online applications that allow patients to interact with healthcare organizations and information. Portal messages exchanged between patients and providers contain diverse types of communications, including delivery of medical care. The types of communications and complexity of medical decision-making in portal messages sent to surgeons has not been studied.

Materials and Methods: We obtained all message threads initiated by patients and exchanged with surgical providers through the Vanderbilt University Medical Center patient portal from June 1 to December 31, 2014. Five hundred randomly selected messages were manually analyzed by two research team members to determine the types of communication (i.e., informational, medical, logistical, or social), whether medical care was delivered, and complexity of medical decision-making as defined for outpatient billing in each message thread.

Results: 9,408 message threads were sent to 401 surgical providers during the study period. In the 500 threads selected for detailed analysis, 1,293 distinct issues were communicated, with an average of 2.6 issues per thread. Medical needs were communicated in 453 message threads (90.6%). Further, 339 (67.8%) of message threads contained medical decision-making. Overall complexity of medical decision-making was straightforward in 210 messages (62%), low in 102 messages (30%), and moderate in 27 messages (8%). No highly complex decisions were made over portal messaging.

Conclusions: Through patient portal messages, surgeons deliver substantial medical care with varied levels of medical complexity. Models for compensation of online care must be developed as consumer and surgeon adoption of these technologies increases.

KEYWORDS: patient portal, health information technology, consumer health informatics, evaluation and management billing

Introduction

Patient portals are online applications that enable patients and their caregivers to interact with healthcare providers and view health information.[1-3] The United States government defines a patient portal as "a secure online website that gives patients convenient 24-hour access to personal health information from anywhere with an Internet connection."[1] Implementation of patient portals by healthcare systems is increasing in response to consumer demand and government incentives such as the Meaningful Use criteria created by the Health Information Technology for Economic and Clinical Health (HITECH) Act.[4-8] Patient portals are typically managed by a healthcare institution and allow patients to have access to personal health information, including recent doctor visits, discharge summaries, medications, immunizations, allergies, and laboratory results. Most advanced portals enable patients to exchange secure messages with their providers, and secure messaging is one of the most popular functions of patient portals.[5]

Little research has focused on the classification or description of secure messaging through patient portals, and most prior work has been performed in primary care or medical specialty settings.[9] North and colleagues manually classified 323 messages in the primary care setting at a large academic medical center, demonstrating that 91% of messages were related to the direct medical care of the patient, including medication, symptom, or test-related content.[9, 10] Another study of 1207 patient portal messages sent to an adult multi-specialty neurology clinic revealed that 45% contained clinical questions, 35% consisted of administrative questions, and the remainder addressed refill requests or non-clinical issues.[11] A small mixed-methods study of veterans' experiences using secure messaging in the My Health*e*Vet patient portal characterized 66 messages sent by 18 unique participants into four user-selected categories (i.e., general, appointment, medication, and test). Ninety-four percent of messages contained content from at least one of these categories, but patient-chosen categories were found to be inconsistent.[10] One study of 3253 patient portal messages from a large academic medical center including all clinical specialties found that 72% involved medical needs or communications.[12, 13] It is

unknown if these findings are representative of secure messaging content in acute care or surgical specialty settings.

Prior research has demonstrated that after broad deployment of a patient portal across clinical specialties, surgeons were the second most frequent specialty to participate in patient-provider messaging.[14] Further, messaging adoption by surgical patients and providers grew rapidly across surgical subspecialties.[15] Although providers conduct growing numbers of online encounters by exchanging messages with patients through such portals, the nature of such communications has not been analyzed for surgery.[15, 16]

Utilization of technologies has been proposed as a central method of optimizing performance and reducing costs of the healthcare system.[4, 17] Although the HITECH Act encouraged healthcare organizations to implement health information technologies such as patient portals, models for characterizing the utilization and evaluating the effectiveness of patient portals are lacking. As patient portal and secure messaging adoption increases, understanding the nature of portal messaging interactions and their implications for provider workload becomes important. With expanding integration of health technology into patient care and as payment models evolve, nonconventional forms of care must be identified and quantified to support potential reimbursement strategies. We therefore sought to characterize the types of communications in secure messaging, amount of medical care provided, and complexity of medical decision-making in the care delivered through patient portal messaging by surgical providers at an academic medical center to examine the potential for reimbursable care provided through portal messaging.

Materials and Methods

Setting

The study was performed at Vanderbilt University Medical Center (VUMC), a private, non-profit institution that provides primary and regional referral care to over 500,000 patients annually with over 900 inpatient beds and more than 1 million outpatient visits per year. VUMC consists of both Vanderbilt

University Hospital (VUH), which cares for primarily adults, and Monroe Carell Jr. Children's Hospital at Vanderbilt (MCJCHV).

In 2005, VUMC launched a patient portal, My Health at Vanderbilt (MHAV), for adult patients and deployed the portal widely across all clinical specialties.[16] In 2007, accounts for pediatric patients and their parents or guardians were made available. MHAV provides a collection of common patient portal functions including access to selected portions of the electronic medical record, appointment scheduling, secure messaging with healthcare providers, account and bill management, and delivery of personalized health information.[18] Meaningful Use financial incentives have increased the national implementation of patient portals. Although many institutions have adopted patient portals to meet Meaningful Use criteria, MHAV was developed well prior to the American Recovery and Reinvestment Act of 2009, which created Meaningful Use, and has been promoted as a means of patient engagement since development. Secure messaging was a core function of MHAV present at release and has been avidly adopted by MHAV users without any specific promotion related to Meaningful Use. MHAV has had stable overall patient adoption of 25-30% since 2010.

Secure messaging is one of the most utilized functions of MHAV, with patients sending over 32,000 new messages to VUMC providers each month.[19] Within MHAV, messages are directed to inboxes called *message baskets*, which may serve individual providers, specialty groups, or other clinical entities. These message baskets are typically managed by clinical care teams, which may include physicians, nurses, and allied health professionals within the same division, department, or other clinical unit. Each clinical unit routes incoming messages with a process tailored to align with specialty workflow and provider preferences. While some clinicians answer their own messages, others utilize support staff such as medical assistants or nursing personnel to triage messages and respond. The flexibility allowed in the management of portal secure messages was designed to encourage provider adoption and maximize the incorporation of the technology in varying medical settings.

Study Population

We examined all patient-initiated message threads sent to surgical providers at VUMC between June 1 and December 31, 2014. *Message threads* are collections of messages exchanged between MHAV users and VUMC healthcare providers (i.e., the initial message and all replies). *MHAV users* consist of VUMC patients who have registered for MHAV; individuals whom a patient designates to access MHAV on their behalf, termed *delegates*; and, parents or guardians who have access to their children's health information through MHAV, called *surrogates*. This study was approved by the VUMC Institutional Review Board.

Measures

For all message threads during the study period, we collected the initial message date, patient demographics (i.e., age, sex, and race), role of the message sender (i.e., self, delegate, or surrogate), receiving VUMC provider, and specialty of the recipient provider. The clinical specialty for each thread was determined by the specialty of the recipient. Surgical specialties reflected the departmental organization at VUMC and included 12 surgery specialties: general, vascular, oral, plastic, dermatology, cardiothoracic, urology, ophthalmology, otolaryngology, orthopedic, neurological, and all pediatric surgery. Each specialty consisted of all relevant subspecialty divisions. For example, general surgery included colorectal, trauma, hepatobiliary, kidney transplant, and surgical oncology. The research team assigned each MHAV message basket to one of the 12 surgical specialty categories enumerated above. Multidisciplinary and administrative VUMC message baskets that could not be assigned to a single specialty were excluded.

Analysis

We calculated the total number of message threads, patients using messaging, and recipient message baskets for each month of the study period. We constructed descriptive distributions and summary statistics of the demographics of the patients about whom messages were sent. Continuous

variables were summarized with medians and inter-quartile ranges. Categorical variables were summarized as counts and frequencies. We explored differences in messaging usage by surgical specialty. We determined differences in both the frequency of messages received between surgical subspecialties with and without accounting for the number of providers receiving messages within the specialty. This was performed in attempt to control for the number of providers per specialty, as some specialties are larger than others. All analyses were conducted in R version 3.0.1.[20]

Of the messages during the time period, 500 were randomly selected for detailed content analysis. Message content was classified using a validated consumer health taxonomy developed by the research team and is shown in Figure 4.1. This taxonomy has been employed to categorize questions from patient journals and patient portal messages, and it has been validated with inter-rater reliability of its application.[12, 21] The taxonomy can be applied to describe both consumer health questions (i.e., needs) and the answers to those questions (i.e., communications). The taxonomy provides a comprehensive model of the semantic types of consumer health information needs and communications and divides interactions into five main categories: informational, medical, logistical, social, and other. *Informational* needs are questions that require clinical knowledge, such as information about the side effect of a drug or the prognosis for a disease. *Medical* needs are requests for delivery of medical care, such as the expression of a new symptom requiring management or an inquiry about a test result. *Logistical* needs are requests for pragmatic information, such as the location of a clinic or the copy of a medical record. The *social* category includes personal communications such as an expression of gratitude or a complaint. The *other* category covers communications that are incomplete or unintelligible.

Portal messages can contain more than one type of need or communication. For each message thread, at least two members of the research team independently assigned all applicable categories. Discrepancies were discussed, and consensus was achieved.

I. Informational Needs or Communications

A. Normal Anatomy and Physiology

B. Problems (Diseases or Observations)
1. Definition
2. Epidemiology
3. Risk factors
4. Etiology
5. Pathogenesis/natural history
6. Clinical presentation
7. Differential diagnosis
8. Related diagnoses
9. Prognosis

C. Management
1. Goals/strategy
2. Tests
3. Interventions
4. Sequence/timing
5. Personnel/setting

D. Tests
1. Definition
2. Goals
3. Physiologic basis
4. Efficacy
5. Indications/contraindications
6. Preparation
7. Technique/administration
8. Interpretation
9. Post-test care
10. Advantages/benefits
11. Costs /disadvantages
12. Adverse effects

D. Interventions
1. Definition
2. Goals
3. Mechanism of action
4. Efficacy
5. Indications/contraindications
6. Preparation
7. Technique/administration
8. Monitoring
9. Post-intervention care
10. Advantages/benefits
11. Costs/disadvantages
12. Adverse effects

II. Medical Needs or Communications

A. Appointments/scheduling
B. Medical equipment
C. Personnel/referrals
D. Prescriptions
E. Problems
F. Follow-up
G. Management
H. Tests
I. Interventions

III. Logistical Needs or Communications

A. Contact information/communication
B. Facility/policies
C. Insurance/billing
D. Medical records
E. Personal documentation
F. Health information technologies
G. Tests
H. Interventions
I. Transportation

IV. Social Needs or Communications

A. Acknowledgment
B. Complaints
C. Emotional need or expression
D. Relationship communication
E. Miscellaneous

V. Other

Figure 4.1. Taxonomy of consumer health needs and communications

The taxonomy is used to categorize consumer health needs and communications within the portal messages into 5 categories, including informational, medical, logistical, social, or other.

Complexity of Medical Decision-Making Analysis

Within each thread, we determined the complexity of medical decision-making, one of the three defined elements of outpatient billing, according to the Center for Medicare and Medicaid Services (CMS) Evaluation and Management (E/M) guidelines (Table 4.1a).[22, 23] Complexity of medical decision-making is based upon three factors, including diagnoses, amount of data reviewed, and risk of complications (Table 4.1b). Each message thread was classified based upon these three criteria to determine the overall medical complexity. There is a point system to establish the level of diagnoses or

management, with new problems or multiple ongoing established diagnoses receiving higher point values. Similarly, CMS has a point system for measuring the amount of reviewed data, with higher points for increasing complexity of data ordered or reviewed. Level of medical risk is determined by the highest level of risk in one of three categories: presenting problems, diagnostic procedures ordered, or management options.[23, 24] Calculation of the overall complexity of medical decision-making was performed by scoring each of the three categories separately (type and number of diagnoses, complexity of data elements, and medical risk). At least 2 of the 3 criteria must be met to qualify for a certain level of medical decision-making (Table 4.1b). Discrepancies in category assignments between coders were discussed to reach consensus.

Table 4.1a. Components of an established patient visit

	History	**Exam**	**Medical Decision Making**
Level 1	Not required	Not required	Not required
Level 2	Problem-focused	Problem-focused	Straightforward
Level 3	Expanded problem-focused	Expanded problem-focused	Low
Level 4	Detailed	Detailed	Moderate
Level 5	Comprehensive	Comprehensive	High

*Only two of the three components (history, exam, medical decision making) are required for established patient visit outpatient compensation

Table 4.1b. Elements of medical decision-making

Diagnoses or Management Options	Amount and Complexity of Data	Level of Risk of Complications	**Complexity of Medical Decision-Making***
Minimal	Minimal or None	Minimal	**Straightforward**
Limited	Limited	Low	**Low**
Multiple	Moderate	Moderate	**Moderate**
Extensive	Extensive	High	**High**

*The complexity of medical decision-making is based on 3 categories: diagnoses or management options, amount and complexity of data, and level of risk. To meet a certain level of complexity, at least 2 of the 3 categories must be met.

Results

During the study period, 9,408 message threads about 9,259 unique patients were sent to 401 surgical providers. Patients about whom messages were sent were more likely to be female (5,319, 57%) and white (8,455, 90%) with mean age of 52.8 years (range: newborn to 98 years) as in Table 4.2. The distribution of ages of the patients is in Figure 4.2.

Table 4.2. Demographics of patients for whom portal messages were sent to surgical providers

	Number of patients (%)
Sex	
Female	5319 (57%)
Male	4088 (43%)
Race	
White	8455 (90%)
Black	678 (7%)
Other	189 (2%)
Unknown	86 (1%)
Ethnicity	
Non-Hispanic	9046 (96%)
Hispanic	146 (2%)
Unknown	216 (2%)
Age (mean, SD)	52.8, 16.1

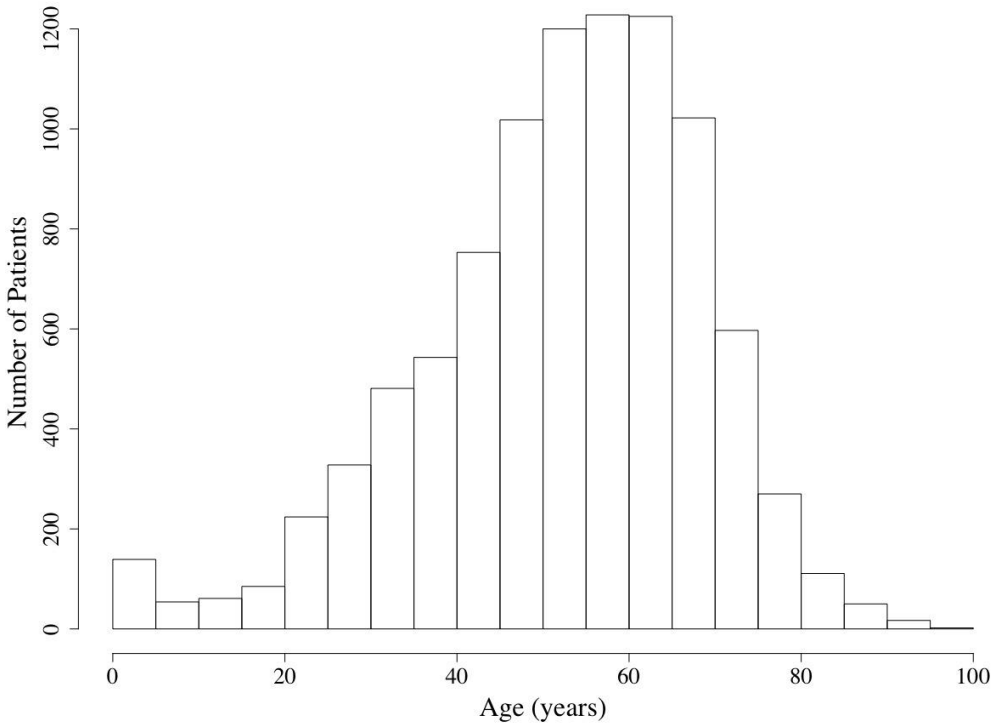


Figure 4.2. Age distribution of patients who initiated portal messages to surgical providers

The majority of the patients who initiate messages to surgical providers through the patient portal are middle age, with a median of 55 years (IQR 43-64 years).

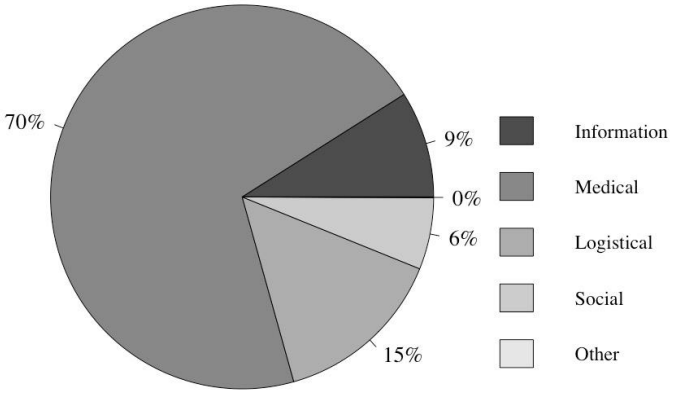
Individual surgical providers received a wide range of portal messages, from 0.2 to 135.1 threads/provider/month, with an average of 3.4 threads/provider/month. The breakdown of message threads per surgical specialty is in Table 4.3. Specialties receiving the most threads were general surgery (3,134), neurosurgery (1,601), and orthopedics (1,577). Specialties with the most threads/provider/month were neurosurgery (5.1), ophthalmology (4.7), and general surgery (4.4). Specialties with the fewest threads/provider/month were pediatric surgery (1.0), plastic surgery (1.0), and oral surgery (1.1).

Table 4.3. Patient-initiated message threads per surgery specialty

Surgical Specialty	# Message Threads (n = 9408)	% of Total Messages	# Recipient Providers (n = 401)	# Threads/Provider/ Month
General Surgery	3152	33.50	102	4.4
Neurosurgery	1601	17.02	45	5.1
Orthopedic Surgery	1577	16.76	55	4.1
Otolaryngology	954	10.14	43	3.2
Ophthalmology	656	6.97	29	4.7
Urology	413	4.39	18	3.2
Pediatric-ALL specialties	376	4.00	54	1.0
Cardiothoracic Surgery	347	3.69	26	1.9
Dermatology	189	2.01	10	2.7
Plastic Surgery	72	.77	10	1.0
Oral Surgery	71	.75	9	1.1

Of the 500 randomly selected message threads, 1,293 distinct issues were communicated, with an average of 2.6 issues per thread. The overall categorization of the issues according to the consumer health taxonomy is displayed in Figure 4.3a. The majority of the issues communicated were medical concerns (70%). Although 70% of the needs communicated were medical, multiple needs could be communicated per message. Therefore, of the 500 message threads, medical needs were expressed in 453 message threads (90.6%). The types of medical care are described in Table 4.4 with 32.6% of patient-initiated messages (18% of all medical needs communicated) conveying new or worsening medical concerns. The most frequently expressed medical needs consisted of the need to schedule appointments (212 threads; 42.4%), communicate new or worsening problems (163 threads; 32.6%), and need for prescriptions (139 threads; 27.8%) The breakdown of all medical needs expressed within message threads is visualized in Figure 4.3b. Logistical needs, such as contact information or insurance questions, were reported in 150 threads (30.0%); informational needs, referring to knowledge often available in a reference textbook (e.g., what a medical diagnosis is), in 77 threads (15.4%); and social communications, such as complaints or emotional needs (e.g., expressing gratitude or complaints) in 62 threads (12.4%).

A.



B.

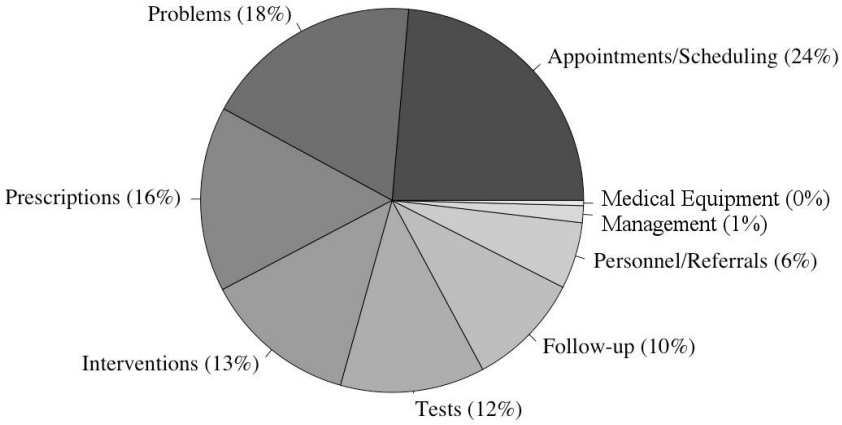


Figure 4.3.

A. Types of needs in portal messages to surgical providers

The majority (70%) of needs or communications within messages sent via the patient portal to surgical providers were related to medical needs of the patients.

B. Types of medical needs in portal messages to surgical providers

The types of medical needs or communications in messages sent to surgical providers were most commonly regarding the need for scheduling of appointments (24%), medical problems (18%), and the need for prescriptions (16%).

Table 4.4. Types of medical needs expressed by surgical patients in patient-initiated message threads

Types of Medical Care Needs	# Message Threads (n = 500)	% of Total Messages
Appointments/Scheduling	212	42.4
New or worsening problems	163	32.6
Prescriptions ordered	139	27.8
Tests or Interventions	182	36.4
Referrals	51	10.2

In the 500 message threads selected for content analysis, 339 (67.8%) contained medical decision-making, and the level of risk was minimal in 35 (10.3%), low in 171 (50.4%) moderate in 132 (38.9%), and high in 1 (0.03%). The overall complexity of medical decision-making, as determined by the level of risk as well as presenting diagnoses and data reviewed, was straightforward in 62% (210 messages), low in 30% (102 messages), and moderate in 8% (27 messages). Straightforward medical decisions included refilling or adjusting prescriptions and formulating plans based upon laboratory or radiology results with established patients. For example, one patient messaged her provider post-operatively from a thyroidectomy to discuss recent calcium levels. The provider reviewed the laboratory results, diagnosed the patient with mild hypercalcemia, and communicated to the patient to decrease her calcium dosage. Medical decision-making of low complexity included the medical care of acute problems, along with the decision to order and review laboratory tests or consultations. In one portal message thread, a patient reported new and increasing abdominal pain and constipation, for which the provider ordered and scheduled a gastroenterology appointment. Moderately complex medical decision-making included communications regarding undiagnosed new problems and the decision to review clinical tests and perform procedures. One such moderately complex portal message interaction involved the patient communicating with his provider after receiving a laboratory result in the portal of an elevated prostate specific antigen (PSA) level and the provider subsequently choosing to schedule a prostate biopsy. Another included a patient messaging his provider with new-onset, shooting right leg pain with a history of left hip degenerative changes. The provider reviewed previously ordered plain films and

ordered lumber spine magnetic resonance imaging (MRI). No highly complex decisions (e.g., scheduling major surgery with risk factors) were made over portal messaging.

Discussion

This research study is one of the first to conduct a detailed analysis of the types of communications and medical care delivered by surgical providers through patient portal messages and is the first study to associate the types of care with elements required for outpatient billing. We found that over 90% of message threads between surgical providers and patients involved the delivery of medical care, such as the management of new findings, ordering of tests, prescription of new medications, and referrals to specialists. A prior study of a random sample of 3253 MHAV messages found that approximately 72% involved medical needs or communications, but this study only analyzed individual patient-initiated messages, not the entire threads, and involved all clinical specialties, not just those messages sent to surgeons.[12, 13] We know that the majority of patient-initiated MHAV messages are received by primary care or medicine specialty providers [16], so it is not clear whether the higher percentage involving medical care found in this study was due to differences in portal messaging use across specialties or the richness of the full message threads. However, in both studies, a critical finding was that substantial medical care was being delivered through patient portal messages.

To further characterize the nature of the care being delivered, we analyzed each message thread for the level of risk and complexity of the medical decision-making performed by providers. We found that most portal-based decision-making had low or moderate levels of risk with overall straightforward or low levels of complexity, although high levels of risk and moderate level of complexity were seen in some message threads. Messaging is not currently recognized as a billable form of outpatient interaction, and thus, these portal message threads represent a significant volume of uncompensated care provided by surgeons and their staff. The complexity of medical decision-making is only one component of the CMS E/M guidelines for coding outpatient encounters, which also include history and physical examination components (Table 4.2). Although these components were not assessed in this study, MHAV only allows

users to send messages to providers with whom they have an established relationship. Thus, portal message encounters would involve return patients, and only two of the three key components must be met in order to charge for an established patient encounter, which in these messages would include history and medical decision making (Table 4.1a).[25] Portal message encounters do not involve a physical examination, but most message threads provided a rich history and detailed plan, and thus, the final encounter code would predominately rely on the level of risk and complexity of medical decision-making within each interaction. If physicians could bill for the care they provide through patient portal message threads as outpatient encounters, this study provides some insights into the levels of outpatient encounters that are being delivered through patient portals by surgeons.

This study also confirmed that surgeons continue to receive substantial numbers of messages from patients through patient portals and deliver care using this emerging technology. Earlier research has shown rapid growth in the use of MHAV portal messaging amongst surgeons in the initial years of after patient portal deployment with significant variation across all clinical specialties and surgical subspecialties.[15, 16] This study corroborates the persistent variability in the use of messaging across surgical specialties and demonstrates shifts in the utilization of messaging beyond the early adoption phase of patient portals. Our study shows that most surgical specialties frequently received portal messages from patients, and many surgical providers often interact with patients through the portal, yet some specialties, such as pediatric surgery and trauma rarely, if at all, utilize patient-provider messaging in the portal. Our study is limited in that only patient-initiated message threads were examined, and thus, may underestimate total messaging use. However, this approach was used to ensure the message threads involved interaction with a patient. Portal utilization has changed from the early phases of MHAV adoption in which the specialties receiving the most messages from patients were orthopedic surgery, otolaryngology, and urology. This study shows that general surgery and neurosurgery were the specialties managing the most message threads in more recent years. In both studies, pediatric surgical providers received the fewest portal messages. Reasons for the limited use of portal messaging in the pediatric surgery group include additional privacy procedures for access to pediatric patient information, including

the need for the parent or caregiver to also have a separate MHAV account, as well as reduced provider adoption in the pediatric surgical specialties.

Although most payers do not currently reimburse for patient portal encounters, there are many prospective benefits of caring for patients online. With rising costs of medical care in the United States, some office visits could be avoided by managing lower complexity issues online, potentially lowering operating costs for low level visits. This shift could enhance efficiency and productivity by increasing the complexity of care provided during in-person visits.[26] In 2004, a survey of primary care physicians found that more than two-thirds would be willing to increase email communication with patients if they were offered reimbursement for this service.[27] The American College of Physicians stated in 2003 that Medicare's system for reimbursing physicians has failed to keep pace with the rising use of computers and time spent communicating and monitoring patients over the Internet.[26] Our study provides evidence that portal messages deliver care with predominantly straightforward and low risk, with occasional moderate risk decision-making. Handling these concerns online can benefit both patients, saving travel and office waiting time, and providers, by making available in-person clinic visits for the high complexity medical care that might be best done face to face.

Anecdotally, many surgeons who frequently utilize the MHAV portal report the ability to manage low-acuity concerns through portal messages. When such concerns are addressed within a global period after surgery, both patient and provider benefit. The patient saves time and money associated with travel, and the provider can potentially replace an uncompensated postoperative visit with a compensated new patient evaluation. If care is delivered through portal messaging outside of the global pay period, the opportunity for a compensated office visit is lost. Our study did not determine whether portal messages were sent within a global pay period, and thus, we were not able to measure potential benefits and losses. What is evident from our study is that surgeons deliver substantial volumes of care of varied complexity through portal messages, and currently, these surgical provider efforts are unaccounted for or compensated. This study is the first to analyze the care delivered through portal messages using

traditional elements of billing in the hope that recognition might prompt development of appropriate models for compensation.

Meaningful Use requirements and financial incentives, have increased the national implementation of patient portals.[28] Providers who frequently utilize the portal may potentially be reducing office visit reimbursement by caring for patients electronically. However, in the current model, there is no method to account for this lost compensation and obtain reimbursement for the care provided. One of the criteria needed to achieve Stage 2 Meaningful Use during 2017 is that a secure message must be sent (i.e., either an initial message or reply to a patient message) to over 5 percent of unique patients seen by the provider during a year.[3, 29] It is unclear if these Meaningful Use financial incentives are currently adequate to balance the potential losses in compensation from care provided online rather than in-person. However, the Meaningful Use financial incentives are for a limited time period, whereas volume of uncompensated online care is likely to continue to rise with increasing utilization of patient portals.

Our research did not examine whether portal messaging between surgeons and their patients influenced clinical outcomes. Only a limited number of studies have analyzed the effects of portal usage on clinical outcomes, and nearly all involved the management of chronic diseases such as diabetes, hypertension, and depression. Use of patient portals has been shown to improve satisfaction, enhance communication, and improve clinical outcomes in primary care or medical specialty settings.[30-39] Only one study by Broman et al has investigated the effects of online care in surgery. In this study, online care was delivered by sending patients MHAV messages with web links to post-operative surveys using REDCap (Research Electronic Data Capture).[40] Any concerns discovered through the surveys were discussed between the patient and provider over portal messaging. This study compared the online versus in-person post-operative follow-up in 50 patients after ventral hernia repair and showed that online follow-up recognized all potential complications that were confirmed in the in-person clinic visits.[41] Further, three-quarters of patients reported that they would be satisfied with follow-up performed solely online. Analyzing the effects of portal message on clinical outcomes is a focus of ongoing research for

our group. As the volume of care delivered through portal messages increased, it will be crucial for our surgical community to determine both its clinical and economic effects.

Similar to barriers facing telehealth adoption, reimbursement for the care provided during portal message interactions and time necessary to deliver that care is lagging behind resource utilization.[42] Implementation of patient portals by healthcare systems will continue to increase in response to consumer demand and regulatory pressures such as Meaningful Use. Models for compensation of online care should be developed to alleviate the burden on providers and promote widespread adoption these technologies by surgeons.

Conclusions

Surgical providers use secure messaging through patient portals to meet a wide variety of needs for their patients, and actual medical care with varying levels of risk and complexity is delivered in over 90% of patient portal message threads exchanged with surgeons. These portal messages represent a large volume of rich outpatient encounters for which surgeons are not reimbursed and an increasing proportion of the outpatient care provided by surgeons. Models for compensation for such online care should be developed.

Disclosures

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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CHAPTER V

SUMMARY

In all areas of health care, including surgery, there has been increasing adoption of HIT by providers and patients. The majority of research about the adoption and effects of HIT has been conducted in primary care or medical specialty settings. This thesis focused on and expanded the knowledge about the use of HIT in surgical practice and its effects.

A systematic review revealed three consistent, positive trends in the effects of HIT in surgery, including an improvement in the quality of surgical documentation, increased adherence to guidelines for medication administration such as perioperative antibiotics and venous thromboembolism prophylaxis, and improvements in patient care with provider alerts. There was overall a paucity of data and low quality of evidence regarding HIT in surgical practice.

The area of research with the least evidence was the use of consumer HIT. This thesis made two contributions to the use of patient portals by surgical providers and patients to address this gap. We first demonstrated use of a patient portal designed for specifically for the outpatient setting by hospitalized surgical patients; four percent of all admitted surgical patients and approximately 16% of those registered for the portal accessed the portal during their hospitalizations. This inpatient portal usage occurred without a specific program to encourage such use and suggests that hospitalized surgical patients are willing utilize patient portals to meet health-related needs in the inpatient setting. Importantly, the perioperative period may offer a uniquely teachable time in which to engage patients and families in their care. Inpatient use of a patient portal might not only assist in meeting the needs of patients and their caregivers, but it also could support patient and family engagement by encouraging continued interaction with health information and healthcare providers after discharge. Further, use of the portal while hospitalized may allow patients and caregivers to be more comfortable with online postoperative follow

up for selected individuals, reducing costs to the healthcare system and improving patient satisfaction by reducing travel time and lost work.

An analysis of the content of patient portal messages exchanged between surgeons and their patients demonstrated a substantial volume of medical care delivered by surgeons through messaging in patient portals. Portal messages contained a wide variety of communication types, and actual medical care with varying levels of risk and complexity was delivered in over 90% of patient portal message threads exchanged with surgeons. These portal messages represent a large volume of rich outpatient encounters for which surgeons are not reimbursed.

This thesis is limited in that it does not evaluate all influences of HIT in surgical care or patient care outcomes. In particular, except for the effects of EHR and CPOE implemnetation on peri-operative antibiotics and venous thromboembolism prophylaxis, there is little known on how EHRs and CPOE can affect surgical care as a whole. The majority of studies, including the ones within this thesis, are focused on describing the current use of HIT with respect to adherence to specific guidelines for medication administration. Most surgical research is focused on the improvement of postoperative outcomes and mortality. While the use of HIT, including EHRs, CPOE, and patient portals have the potential to affect these factors, little research has actually focused on these outcomes that are most important to both surgical patients and providers.

The surgical perspective has been underrepresented in the design, implementation, evaluation, and regulation of HIT. This thesis provides insights into the use and effects of HIT on surgical practice. As the field of HIT continues to evolve, the unique perspectives of surgical providers and patients should be considered and studied. Use and implementation of HIT is increasing, and a significant amount of medical care is now provided online. Therefore, frameworks for compensation of this online care should be developed, and the effects and outcomes of HIT use should be studied in a wide variety of clinical settings.