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Securing Your Radiology Practice: Evidence-Based Strategies for Radiologists Compiled From 10 Years of Cyberattacks and HIPAA Breaches Involving Medical Imaging

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Abstract

While there is significant literature discussing physical and cybersecurity risks around health information technology in general, the number of publications that specifically address medical imaging is much smaller, and many of these focus on the technical security requirements for the exchange of medical images over public networks rather than practical guidelines for radiologists and technicians. This study examines the US Department of Health and Human Services database of reported breaches involving medical imaging from 2010-2020, identifies the most common contributing factors to those breaches, and offers recommendations for radiology practices to prevent each, based on the National Institute of Standards and Technology (NIST) guidelines as well as measures proposed in the literature on health information technology.

Keywords: cybersecurity, picture archiving and communications system (PACS), digital imaging and communications in medicine (DICOM), Health Insurance Portability and Accountability Act (HIPAA)

Introduction

In August 2021, the US Department of Health and Human Services sent a warning to health systems that vulnerabilities in medical imaging servers, namely picture archiving and communication systems (PACS), were responsible for over 275 million unsecured images across 130 health systems.[1] This report is the latest example highlighting not only the increasing cybersecurity risks within the healthcare industry—which saw a 55 percent increase in breaches between 2019 and 2020—but also radiology departments in

particular.[2] Healthcare data breaches have quickly become the costliest of attacks across all economic sectors, and radiology groups and imaging centers have been increasingly affected in the form of ransomware, denial of service attacks, and lawsuits brought by affected patients.[3]

Interestingly, the vast majority of cyberattacks and breaches could be prevented if basic physical and information security practices were followed, many of which occur at the level of the clinician rather than the information technology or cybersecurity professionals employed by health systems. Despite this, little focus is placed on the role of physicians, technicians, and other healthcare providers in preventing the unauthorized exposure of medical imaging. While large hospital chains and academic medical centers are more likely to have advanced automated protections in place, independent radiologists and imaging centers must do more to involve clinicians in securing complex networks and devices.[4] As this review of breaches involving medical imaging in the US from 2010-2020 shows, basic human error continues to be the most prevalent cause of healthcare breaches and can be prevented through simple, yet often-neglected, measures.

Methods

Specific instances of breaches or unintentional disclosures of medical images between the years 2010 and 2020 were identified in the US Department of Health and Human Services database of reported breaches[5] using the search terms “radiology,” “imaging,” “PACS,” or “DICOM.” Of 3,366 recorded breaches, 45 cases included these terms, and nine were excluded because no information was available on the type or outcome of the breach. Thirty-six cases involving the theft or illegal disclosure of medical images of 4,835,967 patients were identified and included in this study. These cases were categorized by the type of vulnerability leading to the breach (e.g., lack of physical security, unsecured PACS server, use of unencrypted networks, etc.) and recommendations for radiologists and imaging technicians to prevent similar breaches were proposed based on a careful review of the cybersecurity literature and the National Institute for Standards and Technology (NIST) recommendations for radiology departments.[6]

Results

Thirty-six breaches from 2010-2020 were organized into nine categories, based on how personal health information (PHI) was accessed, and the number of patients affected (Table 1).

The categories “physical theft of PHI,” “loss of hard copy records,” “loss of unencrypted hard drives,” and “unauthorized access and unintentional disclosure of records” can all be considered failures of physical and information security practices. Together, these categories included 24 breaches from 2010-2020 affecting some 4.68 million patients. Three breaches involved the theft of unencrypted computers left in unsecured offices or taken home by employees and subsequently stolen. Another breach involved a former employee removing electronic protected health information (ePHI) from a practice. Five breaches involved PHI mistakenly mailed to the wrong physicians or patients who

requested imaging records, billing statements, or annual reminders for mammograms. One breach involved clerical staff emailing ePHI to their personal email accounts to work at home. Server and software vulnerabilities resulted in three cyberattacks affecting the medical images of 65,516 patients, and two unintentional exposures of images on unsecured servers affected 65,911. One attack involved the business associate of a radiology practice, and two involved the internet-facing servers of radiology practices. Three programming errors affecting servers or billing software led to unauthorized users accessing ePHI. Three phishing attacks and one ransomware attack compromised the data of 7,500 and 10,700 patients, respectively.

The categories of breaches were also examined by the year they were reported to the US Department of Health and Human Services, and no discernible trends in the frequency of varies categories was noted (Figure 1). There were an average of 3.2 breaches per year between 2010 and 2020.

Discussion

Basic Physical and Information Security Measures

The types of breaches identified in this report match the conclusions of previous authors: namely, that data breaches of PHI in the US most often involve accessing electronic media from laptop computers or portable electronic devices, which are typically obtained through theft.[7] Many of the measures to prevent breaches of this nature will seem obvious but will still require effort for an effective implementation. These include the use of strong passwords, multifactor authentication, encryption of devices, and physical security measures like securing laptop computers not in use, the use of logbooks for issuing laptops and portal electronic devices, and ensuring network access is suspended and ID badges deactivated for former employees.

Wunsch and colleagues also recommend healthcare workers “learn their environments” to best guard against theft and unauthorized access of information.[8] Users in the radiology department should know where servers are located and where portable laptops and other devices are stored. Access to this equipment should be physically secure and available to a limited number of people.

Additionally, any exposed network plugs should be physically secured so that they cannot be pulled out and plugged into a different device. Networking equipment such as switches and routers should only be in secured rooms with limited access, and switches should be configured so that only pre-approved devices and computers are permitted to connect. Furthermore, unused network ports should be switched off until they are needed. Wireless networks should be operated in a secure configuration, which needs to be reviewed and updated at regular intervals.[9] Any wireless “guest” devices like personal cellphones or computers should be segmented and not allowed to interface with the primary healthcare network.

Server and Software Vulnerabilities

In 2020, the US Cybersecurity and Infrastructure Security Agency (CISA) identified security loopholes in the software of over 100 types of devices, including radiography, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound (US), mammography, positron emission tomography (PET), fluoroscopy, and others.[10] Of these loopholes, unsecured servers represent one of the greatest security risks to radiology departments. Studies conducted using internet scanning tools have identified thousands of unprotected servers in the United States. In radiology departments, the unprotected servers are most commonly PACS, containing medical imaging studies and other sensitive ePHI.[11,12] In most instances, these vulnerabilities never result in breaches, but they present an enormous risk to radiology departments and can be prevented with the implementation of simple IT security measures.

Many software loopholes and vulnerabilities can be mitigated by using basic cyber hygiene, such as limiting the use of administrative privileges. It is not uncommon for end users to have administrative privileges allowed on their user accounts for convenience and flexibility. However, the United States Center for Internet Security (CIS) has reported that the misuse of administrative privileges is a "primary method" for attackers.[13]

An essential step that radiologists and technicians can take to mitigate these risks is to ensure their IT department utilizes what is known as a continuous vulnerability and patch management system that regularly updates operating systems, applications, and firmware to adhere to medical device advisory released by CISA. Any legacy systems that can no longer be updated should be replaced.[14] Other examples of vulnerabilities identified by CISA include older versions of DICOM servers, which transmit messages in unprotected, clear-text format that can be exploited if an attacker has access to the network[15] and methods of hiding malware within DICOM files.[16] DICOM servers that are connected to the internet should be protected by a firewall and require a VPN connection and password to be accessed via the internet.[17]

Targeted Phishing and Malware Attacks

The most probable and oftentimes most damaging attack directed at health systems is ransomware, which is a form of malware that encrypts files on the infected computer and its shared networks and then displays a message demanding the payment of a ransom. A particularly concerning subset of ransomware is known as killware. Killware is a type of malware that causes substantial physical harm or death.[18] When ransomware incapacitates medical equipment or medical records, diagnoses may may be delayed or missed and people's lives and well-being can be put at serious risk. In these scenarios, ransomware may be considered killware. Rials suggests that ransomware attacks will continue to be a top cybersecurity threat, and variants will evolve to become more technically advanced.[19] Most ransomware variants involve human interaction for the malware to be activated and spread throughout the network.[20] A common injection method for ransomware is phishing, a form of social engineering that can be used to gain access to a network and then disrupt health services, steal ePHI, or target individual patients.

Another route for the delivery of malware and for data theft is via portable storage media such as universal serial bus (USB) memory sticks. Sittig and colleagues recommend that "at the local device level, organizations should consider disabling USB ports to prevent malicious software delivery."[21]

If feasible, healthcare institutions should use application whitelisting on servers, desktops, and laptops so ransomware and other unauthorized executables cannot be run. This requires organizations to develop a "whitelist" of specified programs that are allowed to run. This should be relatively simple in the PACS context where only a limited number of applications will be used (e.g., on a diagnostic workstation), whereas this might be a rather complex task on general-purpose office PCs.[22] Anti-malware software should be regularly updated on all endpoints throughout the network.

While backups do not prevent cyber incidents from occurring, they do aid in incident response. Unfortunately, cyber incidents have become a ubiquitous facet of life, and some attacks will inevitably succeed, making strong incident response, including backups, necessary.[23] Strong cybersecurity plans should be focused on fast and efficient response to cyber incidents as well as prevention methods. Accessing secure and air-gapped backups is one of the first steps when responding to cyber incidents. Sittig et al. also recommends that backups "should be made frequently (i.e., at least daily, and a continuous or real-time backup is ideal)."[24] Organizations should use the 3-2-1 backup rule: Maintain at least three copies of your data, keep two copies in separate locations, and store at least one copy off-site.

Detection-based tools can give protection to a certain extent but are becoming less effective because advanced threats are not easily detectable in the first place and hundreds to thousands of new advanced malwares are being developed every day by cyber criminals, making it simply impractical and impossible to detect them.[25]

One of the fist steps in improving your cybersecurity posture is to perform a cyber risk assessment to discover any vulnerabilities. Once the weaknesses are identified, tools like gap analysis can be used in order to create remediation plans for any identified risks. When discussing cybersecurity, gap analysis refers to the process of reviewing an organization's existing security controls and determining whether these need to be strengthened, or if new controls need to be added, in order for the company to attain its preferred level of security.[26] Therefore, organizations should continually work toward addressing items in the cyber gap analysis to improve overall cybersecurity posture.

A summary of the most pertinent recommendations according to the categories of breaches discussed is included in Table 2.

Limitations

There were several limitations of the present study. Most notably, the US Department of Health and Human Services database provided very narrow descriptions on the circumstances leading to each breach, which presented a challenge in making detailed recommendations to mitigate specific server or software vulnerabilities that radiology

practices may be facing. Additionally, while each breach discussed in the report was independently identified after being located using search terms, the reliance on common keywords associated with imaging like “PACS” or “DICOM” likely resulted in breaches that were missed during the review of the database.

Conclusion

From 2010-2020, the US Department of Health and Human Services reported the loss of 4,833,667 patient records involving medical imaging. As examined in this study, many of these losses of PHI and ePHI occurred because of human error on the clinician level. Even the most advanced security solutions can be bypassed when the end users of software and devices or hard copy records fail to take adequate precautions to protect them.

However, such losses can be prevented if radiologists and imaging technicians take simple yet frequently overlooked steps to improve their cyber hygiene. These include preventing physical loss of PHI by restricting access to devices, servers, networking equipment, and physical files. Likewise, server and software vulnerabilities can be prevented by regularly updating software and replacing legacy systems. Clinicians can also prevent phishing and malware attacks by disabling USB ports at the device level, utilizing application whitelisting, regularly updating anti-malware software, and by backing up data. Taken together, such steps can prevent devastating losses of PHI, severe business disruptions, and costly lawsuits from patients.

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Notes

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Procedure Code Utilization for Vascular Access Device Placement in the Inpatient Setting: A Retrospective Analysis

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Abstract

Vascular access (VA) is essential to inpatient care, and the documentation/coding practices for vascular access device (VAD) placement procedures remain unexplored. Accurate documentation may present benefits for patients, providers, and researchers. A retrospective analysis was performed in adult inpatients (2015 to 2020) using Cerner Real World Data™ to evaluate the utilization of CPT codes for VAD placement/replacement procedures. A total of 14,253,584 patient encounters were analyzed, 0.111 percent (n=15,833) of which received at least one VAD procedure code. Non-tunneled CVC procedures had the highest code rate (0.067 percent), while PIV/midline procedures were the least likely to be coded (0.004 percent). The annual proportion of code utilization increased from 10.9 percent in 2015 to 19.7 percent in 2020 (p<0.0001). Despite widespread use of VADs in the inpatient setting, the procedure coding rate was found to be remarkably low. Appropriate coding/documentation practices may ensure proper care by capturing VA-related patient history, and improve research quality and resource/staff allocation.

Keywords: clinical coding, current procedural terminology, documentation, vascular access devices, data accuracy

Introduction

Approximately 90 percent of all hospitalized patients require vascular access (VA).[1] Millions of vascular access devices (VADs) are placed in the US annually[2,3] for the administration of medications, hydration fluids, and blood products as well as blood sampling and hemodynamic monitoring.[4,5]

Proper medical coding and documentation are crucial for multiple stakeholders, including patients, providers, and payers. Adequate coding enables collaboration and coordination among providers, which may lead to better patient care during subsequent visits.[6,7] Current Procedural Terminology (CPT) codes allow documenting and accurate billing for medical procedures and professional services.[8] Furthermore, CPT code data can be utilized for retrospective research since it constitutes a reliable and inexpensive resource for researchers.[9,10]

Despite the importance of appropriate coding, error rates in medical coding are substantial, and improper CPT code documentation is common.[11] Belanger et al. evaluated the utilization patterns of new CPT codes for advance care planning (ACP) visits and reported low code utilization by hospice and palliative medicine specialists, two-thirds of which did not use the relevant codes despite treating patients most likely needing ACP.[12]

VADs are both vital and common in clinical settings, thus the importance of capturing data on their placement procedures for improving patient care, clinical practice, and research. However, medical coding and documentation practices for VA procedures remain unexplored. This retrospective study aims to evaluate the utilization of CPT codes for VAD placement procedures in the inpatient setting.

Methods

Data Source

We conducted this retrospective, observational study using Cerner Real World Data™ (Cerner Corporation, Kansas City, Missouri), a de-identified, HIPPA-compliant, US database of electronic health records (EHR) from 101 clinical facilities and hospital systems. Our analysis of de-identified data was determined to be exempt from local institutional review board (IRB) review in advance by Western IRB (Puyallup, Washington).

Study Population

The study included adult patients who had a documented inpatient encounter between January 1, 2015, and December 31, 2020.

Outcomes and Analyses

We calculated the counts and proportions of inpatient encounters with at least one CPT code corresponding to placement or replacement of a VAD: non-tunneled central venous catheter (CVC; 36556, 36580); peripherally inserted central catheter (PICC; 36573, 36569, 37799, 36586); or midline or peripheral intravenous catheter (PIV; 36410).

Chi-squared and Wilcoxon-Mann-Whitney tests were used to characterize variations in hospital characteristics (academic versus non-academic institutions and bed size comparisons), patient demographics (age, sex, ethnicity, and census region), and Charlson Comorbidity Index (CCI) score. CCI was chosen as a method to capture patient comorbidities based on the diagnosis codes found in the dataset. To capture all relevant

patient comorbidities, a longitudinal lookback that contained all diagnosis codes for the study encounters as well as all previous encounters was used to calculate the CCI score. All other characteristics were evaluated only for the study encounters. The Cochran-Armitage test for trends was performed to evaluate six-year trends in VAD procedure code use between 2015 and 2020. All statistical analyses were executed using PySpark 2.4.4. through the Cerner® HealtheDataLab platform/tool and SAS version 9.4 (SAS Institute Inc., Cary, North Carolina) with a significance level set $\alpha = 0.05$.

Results

Patient Characteristics

A total of 14,253,584 unique patient encounters met the study inclusion criteria. Detailed demographic characteristics are provided in Table 1. Patients who received at least one CPT code for VAD placement/replacement were more likely to be older (62.7 versus 56.5 years, $p<0.001$), male (49.9 percent versus 42.9 percent, $p<0.001$), and to have a higher CCI score (3.7 versus 1.9, $p<0.001$). Most encounters with VAD procedure codes occurred in the Northeast (56.5 percent) US census region, while the South region had the lowest rate (3.9 percent).

VAD Procedure Code Utilization

The counts and proportions of inpatient encounters with at least one VAD procedure code by device type are presented in Table 2. Of the total 14,253,584 patient encounters, only 0.111 percent (n=15,833) received at least one VAD procedure code. Non-tunneled CVC procedures were the most likely to be coded (0.067 percent), while PIV/midline procedures had the lowest code rate (0.004 percent).

Code Utilization Trends 2015–2020

VAD procedure code utilization trend between 2015 and 2020 is illustrated in Figure 1. The annual proportion of encounters with VAD procedure codes consistently increased from 10.9 percent (2015) to 19.7 percent (2020), except for a minor drop to 18.8 percent in 2019. Overall, the number of reported encounters with VAD procedure codes increased by 80.6 percent between 2015 (n=1,724) and 2020 (n=3,114). The upward trend in VAD code utilization from 2015-2020 was statistically significant based on a Cochran-Armitage trend test ($p<0.001$).

Discussion

This analysis has shown a remarkably low utilization of VAD procedure codes since only 0.111 percent of encounters included at least one relevant code despite the prevalent use of VADs in inpatient care. To our knowledge, this is the first study to explore the coding practices regarding VAD procedures. Our results are consistent with previous studies that evaluated CPT code use in other procedures/services and demonstrated low utilization levels.[13,14] Several potential reasons may be considered regarding the underutilization of VA-related CPT codes. VAD placement/replacement procedures are commonly performed by nurses,[15] and a professional fee is not reimbursed when the nurses complete these

procedures, which may lead to a lack of incentive for documentation. Moreover, the process of assigning CPT codes is complex and labor-intensive, necessitating various resources, including specialized coding personnel.[16] Nurses face a high burden of documentation workload and spend around 25-50 percent of their shifts documenting patient care.[17] Considering the extended work hours, staff shortages, and demanding work conditions experienced by nurses,[18] streamlined and simplified documentation processes should be implemented. This can partially be achieved by eliminating the need of documenting the same procedure multiple times (e.g., patient charts, electronic health records, reimbursement) in the absence of a unified platform.

Despite the high prevalence of peripheral access in inpatient care, CPT codes for PIV/midline placement had the lowest utilization rate. In the US, around 300 million PIVs are placed annually,[19,20] and based on their common occurrence, peripheral catheter placements may be considered minor procedures, which could partially explain poor documentation practices. On the other hand, the relatively higher utilization of central line procedure codes may be due to their use for longer-term therapies, which provide ample time and opportunities for documentation. Furthermore, virtually all CVCs are inserted by physicians, who are eligible for professional fees and likely have more incentive to utilize corresponding CPT codes.

Our study demonstrated a significant increase in VAD procedure code utilization from 2015 to 2020, suggesting improved awareness in VA-related medical coding among clinicians. This increase was most notable from 2015 to 2018. The slight decrease in code utilization in 2019 coincides with the American Medical Association revision and issuance of new guidance for the CPT codes for multiple VADs (e.g., PICCS, midlines),[21] which may have temporarily affected coding practices.

Our research also revealed significant variability among patient/institutional characteristics and their association with code utilization. While some of these differences were straightforward (e.g., higher code use in sicker patients or academic institutions), others point to more complex factors. It is not surprising that patients with multiple comorbidities (higher CCI score) were more likely to receive a VAD procedure code. Sicker patients often stay hospitalized for extended periods and may be more likely to receive attention/care from healthcare providers, which could lead to more accurate reporting. We also identified differences in age, sex, and ethnicity regarding VAD code utilization. Previous studies suggested that patient care might differ based on demographic factors and demonstrated such disparities based on gender.[22] Our findings showed that younger or female inpatients were less likely to receive a VAD procedure code. Furthermore, while the proportion of black patients who received a VAD code (21 percent) was higher than those without codes (8.7 percent), the direction of data was the opposite for other patients of color (8.7 percent; 14.8 percent). These differences might stem from disparities in quality of care, which was documented in the literature.[23,24] While the underlying reasons for these differences should not be overlooked, our study was not designed to capture the related root causes.

Accurate medical coding and documentation are critical to coordinate patient care and foster collaboration among healthcare providers, which may improve patient care during

subsequent encounters.[25,26] VA is an essential part of patient care, and VA-related procedures are associated with complications such as phlebitis, thrombosis, and infection.[27,28] Therefore, it is valuable for clinicians to be aware of the patients' VA-related medical history, especially for optimal VAD selection when treating patients with difficult intravenous access since multiple insertion attempts may result in diminished clinical and economic outcomes as well as poor patient experience.[29] Moreover, proper medical coding is essential to produce accurate data for high-quality retrospective research.[30] Finally, appropriate documentation could inform unit-specific resource and personnel needs and may lead to improvements in inventory management and medical staff allocation.[31]

Limitations

This study presents several limitations, including intrinsic limitations of any retrospective research reporting descriptive analyses. Our study evaluated data from 101 US hospitals, and its findings may not be generalizable. Further research is necessary to understand the impact of low CPT code utilization on patient care and outcomes. Additional research may also be conducted to evaluate other forms of documentation (e.g., patient charts, clinician notes), which was not within the scope of our study. Worth noting, even if different forms of documentation are available, coding is an essential component of appropriate and complete documentation[32,33] considering its wide range of uses, including reporting, increased accuracy/efficiency, claims processing, guideline development, communication among providers, and retrospective research.[34,35]

Conclusion

Despite the widespread use of VADs, our study revealed a strikingly low use of VAD procedure codes in the inpatient setting. Accurate coding of VA procedures is particularly important to capture VA-related history and to ensure high-quality research and accurate resource/staff allocation. Simplified/streamlined coding processes should be considered, and more research is needed to evaluate the impacts of low code utilization.

Data Availability Statement

Cerner Real-World Data™ is a national, de-identified, person-centric data set that can be acquired from Cerner Corporation.

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Precepting HIM Students: A Multi-Case Study Exploring the Challenges of HIM Hospital-Based Professional Practice Experience

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Abstract

Introduction

Experiential learning supervised by a qualified preceptor has been an enduring requirement for accredited allied health academic programs.[1] Data show that students benefit from participating in experiential learning activities, such as an internship.[2] Further, studies show organizations are eager to hire new graduates who took part in some type of external hands-on experience.[3]

Health information management (HIM) programs accredited by the Commission on Accreditation for Health Informatics and Information Management Education (CAHIIM) require students to complete a supervised professional practice experience (PPE) before graduation to show proficiency of the curriculum requirements.[4]

This study explored the challenges and barriers of professional practice experience for placing local and online baccalaureate students in hospital-based HIM departments from the preceptors' viewpoint. This study focused on the hospital setting for several reasons: gaining site approval is complicated, the centralized HIM department poses unique problems for hosting students, and to narrow the research focus to a setting commonly used among HIM academic programs.

Literature Review

The PPE problems with placing and precepting students have been a long-standing concern in HIM education;[5] however, there was limited literature available directly related to this problem of practice. An extensive literature search was conducted that yielded only

a few research-based articles that provided limited information about the problem. Therefore, the literature review included related works from other allied health disciplines with similar issues with experiential learning.

The overarching findings for allied health academic programs centered on issues at the healthcare organizational level, including legal concerns, cost, time, and productivity.[6] Geographic location was yet another issue that prevented student placement. Additional concerns focused on lack of student or preceptor preparation for the experience.[7]

Methods

This was a qualitative multi-case study conducted in 2021. A total of six cases, or participants, took part in this study. Participants completed a pre-interview survey to obtain demographic information before conducting semi-structured interviews online with health information management preceptors. The survey data were compiled and analyzed to inform the interviews.

Results

The study results indicate that HIM preceptors are challenged with placing and precepting students at their hospitals. Lack of support from senior leadership is a contributing factor. Additional issues center on planning and preparation. Keeping students engaged with the learning experience was another key finding. Lastly, this research uncovered an anecdotal finding about the lack of preceptor training provided to HIM professionals.

Conclusion

A variety of issues contribute to the problem of placing and precepting students at the organizational level. Despite these challenges, the participants in this study expressed dedication to serving in the preceptor role. Further, this study identified plausible solutions for improving the PPE by incorporating creative ways to deliver learning activities. Finally, this study was carried out during the pandemic at a time when preceptors had to employ innovative strategies for precepting HIM students.

Keywords: allied health, experiential learning, health information management, preceptor, professional practice experience

Introduction

Professional practice experience (PPE) is the cornerstone of health information management education.[8] While these experiences are highly beneficial to students and health information management practitioners, academic programs are challenged with securing sites for students to complete the experience.

Experiential learning has been a long-standing requirement for academic health information management (HIM) programs accredited by the Commission on Health Informatics and Information Management Education (CAHIIM).[9] Students enrolled in

CAHIIM-accredited programs must complete a PPE before graduation.[10] The PPE provides opportunities for students to apply theory learned in class to real-world work in HIM. During the PPE, health information management students are supervised by a preceptor with content knowledge. Even though PPE preceptors have intrinsic and extrinsic motivation to serve this role, HIM programs struggle to place students with a site.

Methods

This study used a qualitative multi-case study design to answer two research questions. The research questions centered on preceptors' experiences on the challenges and barriers of placing and precepting student interns. A pilot study was conducted with two volunteers to test the efficacy of the pre-interview survey and interview guide. Purposive sampling techniques were carried out, and six participants were included in this study.

The study setting occurred with hospital-based health information management departments located throughout the United States. The study population included health information management professionals with recent precepting experience. Each study participant serves as a preceptor for different HIM programs throughout the country. After obtaining approval from the institutional review board, participants were recruited using the researcher's list of professional contacts. Each participant signed an informed consent form before any data were collected. Once consent forms were obtained, participants completed a pre-interview survey that included basic professional demographic information. Participants provided their job title, years of precepting experience, healthcare setting, and work location. Also, participants indicated the number of students that can be accommodated at one time, and their ability to precept students virtually.

Kolb's Experiential Learning Theory (ELT) served as the theoretical structure for this study.[11] ELT comprises elements of human learning and development theories and emphasizes that learning is an interactive process built by experiences. Experiential learning may be designed as an internship, study abroad, or various other fieldwork opportunities.

Before collecting any data, the study prospectus was carefully reviewed by the Institutional Review Board. All collected data were de-identified and stored on a secure password-protected computer. Data were collected using pre-interview surveys and interviews. The surveys collected participant demographic data to provide context for the interviews. The interviews focused on open-ended questions so that participants could expound on their experiences. Data analysis was carried out using The Framework Method, a seven-step methodical process.[12] First, the interviews were recorded, transcribed, and reviewed for accuracy by participants and this researcher. Then, the data were coded and grouped into themes. From there, a cross-case analysis was conducted. Next, the data were categorized and charted on a matrix. At this point, the nuances of the data were compared and contrasted to note similarities and differences, along with unanticipated findings. Data were triangulated to ensure the trustworthiness of this study. Detailed descriptions of the data were described to assure transferability to other contexts.

Results

Six HIM professionals participated in this study. All participants were female and have a bachelor's degree in health information management along with the registered health information administrator (RHIA) credential. Two of the participants hold a master's degree. Four out of the six have more than 10 years of experience in health information management. These four participants have been hosting students for more than 10 years. All of the participants currently work in acute care, and four of them work remotely. Two of the participants work on-site, one in a suburban area and the other in a rural location. Five of the participants indicated they could host more than one student at a time, including virtually. Each participant's direct quotes were assigned a number representing the participant [for example: Participant One = P1].

Theme One: Organizational Roadblocks

Preceptors indicated that their organizations impeded their ability to work with students. The participants noted that their organizations were concerned about potential privacy violations. For this reason, preceptors reported that it is challenging to secure signed affiliation agreements and gain student access to health information systems. Participants added that their organizations voiced concerns about hosting students' impact on productivity. One participant described her experience working with the executive leadership team:

> "I basically had to figure it out on my own. I didn't have help at the facilities I had worked for in the past; we didn't have a support system. I had defined all of those resources. I had to connect with the right people, and then I had to repeatedly explain why this was so important." (P6)

Theme Two: Planning and Preparation

Preceptors described the importance of planning for the student experience. Preceptors need adequate time to secure signatures, prepare tasks and projects, and schedule meetings with other staff and departments to ensure students gain a robust experience. Most preceptors described receiving a PPE guide or handbook to assist with hosting students. However, some preceptors shared that they would appreciate more information, particularly suggestions for projects that students could complete. One participated strongly recommended planning a few months in advance:

> "We received the packet from the college so far in advance, so I reached out and started to make the schedule so that everybody knew. So, if there was going to be any variation to the schedule like somebody needed to decline or reschedule, that was all ironed out before the students started. And then, once they started, it was typically a smooth process." (P2)

Theme Three: Student Engagement

Ensuring students were engaged with the PPE was a common concern among preceptors. As such, preceptors reported concerns about creating a schedule of interesting activities

to increase student engagement. The participants agreed that keeping students busy was key to avoiding conduct issues, such as disrupting staff. Some preceptors noted that hosting small groups of students at a time increased the level of engagement. One of the participants expressed the importance of keeping students busy to ensure they remained engaged:

> "Ensuring that I had every minute allocated to an activity or something for the student to do. Otherwise, I felt that they weren't engaged in what they were doing. So, ensuring that the instructions were given out, that the project that I gave, or the assignment, that they were complete and properly timed." (P3)

Theme 4: Solutions

The findings concluded with participants suggesting solutions for placing and precepting HIM students. The primary solutions identified this study were providing a virtual experience, hosting small groups of students instead of one at a time, timely communication, and planning structured time for the students. Interestingly, most preceptors favored hosting students virtually, a shift from the traditional PPE format. However, as more HIM departments move to work remotely, the virtual PPE is a plausible solution. Some preceptors advocated for hosting students in small groups as a solution and fostering engagement among the students. Another participant explained how a remote centralized health information management department could be an advantage for hosting student interns:

> "We did a centralized release of information, medical identity theft, a lot of those functions that were actually at the facilities, even less now centralized. So, there was a virtual experience where before it was face-to-face to capitalize on those efficiencies." (P4)

The participants noted that early communication from the HIM program is vital. By receiving requests to host students in advance, preceptors can be better prepared for the student's arrival, and thus provide a more meaningful experience. According to several participants, being asked to serve a preceptor a few weeks in advance is helpful, while some participants stated more time is needed to prepare.

Lastly, the participants observed that structure and time are crucial for ensuring students receive a quality experience. Planning a daily schedule that includes allotted time for each task is a strategy that one preceptor identified. She stated, "Because I always made sure that I was working on something that a student could participate in, and then I would use our data, use what we were working on" (P6), and that ensuring students stayed focused and on task improved engagement and minimized potential conduct issues.

Discussion

While HIM professionals agree about students' importance in professional practice experiences, challenges remain with placing and precepting HIM students. This current study indicates that problems with placing students at PPE sites centered on

organizational and preparation issues. First, all of the preceptors reported having organizational roadblocks with placing students at their hospitals. The organizational barriers centered on the lack of support from executive leadership, who have a different perspective to consider in keeping the hospital protected from potential liability. The leadership concerns focused on students' ability to protect private patient information and potential impacts on staff productivity. Additionally, the centralized organizational structure of health information management departments is problematic for hosting students on-site. Lastly, participants reported that promptly obtaining the affiliation agreement between the hospital and college is a significant barrier.

Participants in this study also reported encountering problems with supervising student interns. The preceptors in this study expressed concerns about their ability to provide a valuable learning experience for student interns. These concerns stemmed from the challenges of acquiring student access to health information systems. Due to privacy concerns, hospitals may not be willing to allow students access, which makes it difficult for students to learn functions and tasks in an automated HIM department. For this reason, preceptors are challenged with keeping students engaged in the work and learning experience. Participants also noted that a lack of time to prepare for the student's arrival and experience adequately is challenging. Finally, preceptors expressed difficulties with underprepared students, which takes more time to supervise.

This research study uncovered alarming anecdotal information. Surprisingly, none of the study participants received training before precepting their first student. Some preceptors reported receiving a written guidebook to assist them but no formal training or preparation. As a result, these preceptors did not feel prepared for their preceptor role.

While problems exist with placing and precepting students in hospital-based HIM departments, the participants in this study identified many plausible solutions. When it comes to placing students, HIM academic programs can plan out PPEs in advance and collaborate with one another to determine needs and work with preceptors that might be able to host small groups from different programs simultaneously. HIM departments could host students virtually and create pre-recorded sessions that can be delivered electronically and used repeatedly. To improve the precepting experience, academic programs should review expectations with students and provide a PPE guide with instructions, policies, and expectations, including conduct on-site. Additionally, academic programs should provide an orientation and training program for new preceptors, including the students' needs and PPE expectations with the preceptors. While preceptors noted receiving a handbook prior to precepting students, they would feel more prepared with an orientation to the PPE that includes training on preparing, overseeing, and engaging students with relevant activities. Having clear-cut guidelines leads to an optimal experience for all stakeholders.

Limitations

The study was limited by the perspectives of HIM preceptors in hospital-based HIM departments and did not include viewpoints from health information management faculty

or students. Also, the study was limited to health information professionals currently working in the field with recent precepting experience. Lastly, the study was limited by the small sample size and time limitations were set for this study to ensure completion by the end of the summer term.

Conclusions

While PPEs serve as a valuable high-impact learning experience for HIM education, challenges and barriers exist with placing and precepting these students. Even so, HIM preceptors genuinely enjoy the precepting process and the ability to give back to their profession. Employing creative solutions to this study problem has been successful with some HIM departments.

Recommendations

In light of this study, this researcher recommends future research on factors that motivate HIM professionals to serve in the preceptor role. Additionally, a study to evaluate preceptor satisfaction rates could shed light on the problem. Lastly, a study about the ability of virtual PPEs to meet CAHIIM curriculum standards could highlight a viable solution to this problem of practice.

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The Evolution and Typology of Learning Health System Hospitals and other Health Information Interested Hospitals in the US

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Abstract

This study identifies the type, distribution, and interactions of US hospitals that identify as electronic-data-driven, patient-centric, and learning-focused. Such facilities, termed Health Information Interested (HII) hospitals in this study, meet the defining criteria for one or more of the following designations: learning health systems (LHS), Health Information Technology for Economic and Clinical Health (HITECH) meaningful use stage three compliant (MU3), Patient-Centered Outcomes Research Institute (PCORI) funded, or medical home/safety net (MH/SN) hospital. The American Hospital Association (AHA) IT supplemental survey and other supporting data spanning 2013 to 2018 were used to identify HII hospitals. HII hospitals increased from 19.9 percent to 62.4 percent of AHA reporting hospitals from 2013 to 2018. HII subcategories in 2018 such as the full LHS (37.2 percent) and MU3 (46.9 percent) were dominant, with 33.2 percent having both designations. This indicates increased interest in patient-centric, learning-focused care using electronic health data. This information can enable health information management (HIM) professionals to be aware of programs or approaches that can facilitate learning-focused, patient-centric care using electronic health data within health systems.

Keywords: health information interested hospitals, learning health systems, electronic data driven, patient-centric care, learning focused, mHealth, health IT, medical home/safety nets, PCORI, meaningful use stage three

Introduction

As US healthcare organizations are increasingly incentivized to improve care processes, they are also becoming more invested in the capture and use of electronic health data, including patient generated health data.[1,2] Patients are also calling for the increased use of electronic health data to inform their care processes and decisions.[3] Payors and patients alike pressure the healthcare system to improve quality, manage multifaceted individual and population health needs, curb costs, and reduce inefficiencies, some of which have been attributed to care fragmentation from a lack of systemic and patient-centric approach to care.[4-6]

Expanding electronic health data collection and use is one strategy to address these challenges. However, this requires that new initiatives and programs be created and older ones adapted. One means to healthcare organization improvement is adopting a learning health system (LHS) approach. The LHS supports technology and electronic data-driven strategies that have the potential to mitigate care fragmentation and facilitate patient-centered care. The LHS facilitates commitment to patient outcome measures, which support continuous improvement in care processes.[7]

Other approaches to health system improvement through expanded use of technology and electronic data include federal incentive programs, such as the Health Information Technology Economic and Clinical Health (HITECH) Act. HITECH's meaningful use stage three (MU3)[8] incentivizes hospitals to utilize electronic data capture and patient-centric measures, including patient generated health data.[9,10] Other programs that support or incentivize electronic data capture and patient-focused approaches include the Patient-Centered Outcomes Research Institute (PCORI) initiative, and the medical home/safety net (MH/SN) designation.[11-14] Awareness of these approaches among health information management (HIM) professionals can facilitate an understanding of potential programs that can be adopted to facilitate electronic data-driven, patient-centric care in their organizations.

The Institute of Medicine (IOM) and the National Academy of Engineering have advocated for the use of electronic health data in continuous improvement efforts.[15] Other research suggests that hospitals that have engaged with the aforementioned programs are more likely to demonstrate patient-centric and learning-focused approaches to care, and to use electronic health data to achieve their care and continuous improvement targets.[16-22] The common health information technology (IT) related features that characterize LHS, MU3, PCORI, and MH/SN programs suggests that participating facilities can also be grouped together. Based on their participation in one or more of these initiatives, this study defines hospitals that are committed to electronic data-driven, patient-centric, and learning-focused continuous improvement processes using electronic health data as Health Information Interested (HII). However, to date there has not been a comprehensive inventory and assessment of hospitals participating in these initiatives and their interactions. This study assesses hospital participation in these initiatives and programs, considers how widespread they are, the rate at which hospitals are choosing to participate in one or more, and summarizes their patterns of participation.

Background

Senge (1990), in his book *The Fifth Discipline*, detailed his account of the "learning organization." He defined learning organizations as "where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together."[23] According to Senge, learning organizations can quickly adapt to changes and can secure more competitive advantages due to their focus on learning and systems thinking.[24,25] The HII definition in this study was based on Senge's learning organization theory. The criteria for HII hospitals included those with demonstrable interest in learning from electronically collected data to inform patient-centric care and continuous improvement in care processes. A review of the literature showed that the aforementioned four HII hospital types in this study are similar in their use of electronic health data to enable learning, continuous improvement in care and patient-centric approaches to care.[26-30]

HII Hospitals

The LHS was designed to address health systems' needs for continuous improvement in care processes and is derived from the systemic approach described in Senge's learning organization model.[31] The LHS

addresses some of the needs of healthcare organizations that seek to become learning organizations through the development of technology and data-driven learning infrastructure. As defined by the IOM, the LHS is an integrated health system " ... in which progress in science, informatics, and care-culture align to generate new knowledge as an ongoing, natural by-product of the care experience, and seamlessly refine and deliver best practices for continuous improvement in health and healthcare."[32,33]

LHS's three core foundational components include an infrastructure for health related data capture, care improvement targets, and a supportive policy environment (Mullins et al., 2018). Ten core LHS values have also been identified as important for incorporating LHS tenets into population health improvements, and these include adaptability, scientific integrity, person-centeredness, inclusiveness, value, accessibility, governance, privacy, transparency, and cooperative and participatory leadership.[34,35] Based on the LHS definition, core foundational components, and values, four key LHS principles were derived in this study: 1) capacity to collect and use electronic health data; 2) commitment to evidence/data-driven decision support; 3) patient-centered/data-driven quality improvement measures; and 4) the use of safe and certified electronic health data platforms (Table 1.1).[36-38]

In addition to the LHS, this study posits that PCORI-funded, MH/SN, and MU3-compliant hospitals can be described as HII hospitals and as learning organizations. As earlier stated, HII hospitals are patient-centric, electronic health data-driven, and learning-focused. These facilities have designed health IT, electronic health data-driven and technology infrastructure that enable them to adapt to changes and secure more competitive advantages by learning from patient-focused data for their care improvement targets, consistent with Senge's learning organization theory. These hospital types can be described as HII hospitals because their daily operations include continuous improvement in care processes, patient-focused care, a systemic approach to care, and reflect the principles of Senge's learning organization theory.

Methods

This study evaluated three years of hospital health IT data to describe the distribution of HII hospitals generally, across time periods, and among the four HII subtypes. Data from the American Hospital Association's (AHA) 2013, 2016, and 2018 IT supplemental survey was used to identify LHS and MU3 hospitals.[39-41] These data sets are made up of the responses of the 3,283; 3,656; and 3,540 US hospitals that participated in 2013, 2016, and 2018 AHA IT supplemental surveys, respectively. Other supporting data sets included the CMS innovation award funding list and the PCORI funded projects web list, which were used to identify MH/SN and PCORI-funded hospitals, respectively.[42-45] MH/SN hospitals were initiated in 2013 to use innovative health IT tools to improve patient-centered care and care coordination.[46] PCORI was established to fund US healthcare organizations to conduct research related to patient-related outcomes based on information systems and technology in order to contribute complementary data to clinician-derived metrics traditionally used to inform healthcare decision-making.[47]

LHS principles developed in this study were used to create the LHS criteria, and a measure of the degree of LHS practice per year of data was developed by identifying questions in the AHA IT supplemental survey that aligned with Friedman et al.'s conceptualization of LHS development.[48] Table 1.2 provides the questions used from each year of the AHA IT supplemental survey to identify stages of LHS development. Only hospitals that met LHS stage three development, termed full LHS hospitals, were categorized as HII. Hospitals within the data that met the MU3 criteria; those that secured funding through PCORI to facilitate patient-centered, electronic data-driven, and learning-focused care or those

that obtained the CMS innovation funds to become MH/SN between 2013 and 2018 were categorized as HII and included in the study. The prevalence of LHS hospitals across the three stages, their change over the study period, the prevalence of the other HII hospitals, and the key subcategory interactions observed through cross-tabulations are presented as part of study results.

Results

Learning Health Systems Practicing Hospitals

LHS hospitals in total and at any stage increased progressively across the study period (Table 1.3). Among hospitals that responded to the AHA IT supplemental survey in 2013, 38.4 percent met any LHS criteria, increasing to 64.3 percent in 2016 and to 74.2 percent in 2018. A similar progression was seen across stages two and three. Hospitals meeting stage two LHS criteria increased from 15.8 percent in 2013 to 20.9 percent in 2016, and to 25 percent in 2018. Most notably, stage three LHS hospitals, defined as HII in this study, increased from 11.9 percent in 2013, to 30.3 percent in 2016, and to 37.2 percent of all respondent hospitals in 2018. These results suggest that a large proportion of hospitals are moving toward full LHS capability (LHS stage three).

HII Prevalence Overall and by Subcategories

Among hospitals that were MU3 compliant, 9 percent met HII criteria in 2013, increasing to 42.2 percent in 2016, and to 46.9 percent in 2018 (Table 1.4). The prevalence of HII hospitals based on the other two HII subcategorical defining criteria was relatively less definitive than for the AHA IT supplemental subcategories (the LHS and MU3). Among PCORI-funded hospitals, 2 percent met HII criteria in 2013, 1.5 percent in 2016, and 2.9 percent in 2018. MH/SN hospitals were the least represented in HII criteria, accounting for 0.7 percent in 2013 and 2016, and just 0.4 percent in 2018. HII hospitals defined by MU3 or consistency with full LHS criteria were the most prevalent across the three time periods, while hospitals in the PCORI-funded category accounted for 1-3 percent, and those in the MH/SN category accounted for less than 1 percent of all HII-defined hospitals across the study periods.

HII Subcategory Interactions

Hospitals in the four HII subcategories were cross-tabulated with each other per year of data to understand how they interacted. Results indicate that hospitals that met the full LHS criteria were more likely to also meet the criteria to be PCORI, MU3, or MH/SN subcategories (Table 1.5). MU3 subcategory hospitals were often in combination with hospitals that met full LHS criteria when compared to those that were not fully consistent with LHS criteria (e.g., stage one or two) across all three data points (23.3 percent versus 7.1 percent (2013), 75.5 percent versus 27.6 percent (2016), and 59.8 percent versus 39.3 percent (2018); (chi-sq = 110.2, $p < 0.01$ (2013); 719, $p < 0.01$; 139.6 (2016); $p < 0.01$ (2018)).

Similarly, hospitals in the PCORI-funded subcategory were more likely to be in combination with those that were fully consistent with the full LHS criteria when compared with those that were not PCORI funded (21.9 percent versus 11.7 percent (2013), 54.7 percent versus 29.9 percent (2016), and 67.3 percent versus 36.3 percent (2018)); (chi-sq = 6.1, $p < 0.05$ (2013); chi-sq = 15.3, $p < 0.01$ (2016); chi–sq = 40.3; $p < 0.01$ (2018)). Hospitals in the MH/SN subcategory were also more likely to be in combination with those that met the full LHS criteria when compared with hospitals that were not MH/SN (22.7 percent versus 11.9 percent (2013); 91.7 percent versus 29.8 percent (2016); and 92.9 percent versus 37 percent (2018); (chi-sq = 43.2; $p < 0.01$ (2016)); (chi-sq = 18.6; $p < 0.01$ (2018)).

MU3 subcategory hospitals were more in combination with hospitals that were PCORI funded when compared to hospitals that were not PCORI funded (20 percent versus 9 percent (2013); 76 percent

versus 42 percent (2016); and 60 percent versus 47 percent (chi-sq = 24.4, p < 0.01 (2016); (chi-sq = 7.6, p < 0.01 (2018)). MU3-compliant hospitals were also more likely to be in combination with hospitals that were MH/SN when compared with those that were not MH/SN (13.6 percent versus 9 percent (2013); 83.3 percent versus 42 percent (2016); and 71.4 percent versus 48.6 percent (chi–sq = 1, p = 0.444 (2013); chi-sq = 16.7, p < 0.01(2016); (chi-sq = 3.4, p < 0.05 (2018). Finally, hospitals that met the criteria to be MH/SN were more likely to be in combination with those that were PCORI funded when compared with those that were non-MH/SN (13.6 percent versus 1.9 percent (2013); 4.2 percent versus 1.4 percent (2016); and 21.4 percent versus 2.8 percent (2018) (chi-sq = 15.8, p < 0.001) (2013); chi-sq = 1.2, p = 0.264 (2016) chi-sq = 17.5, p < 0.001) (2018)).

Key Hospital Subcategories and Interactions Across the Study Period

The full LHS subcategory, the MU3-compliant subcategory, or their combination were dominant across the study period (Table 1.6). By 2018, the PCORI-funded subcategory made up less than 1 percent of all HII hospitals, and no stand-alone MH/SN hospitals were observed. Less than 1 percent (0.1 percent) of hospitals met the criteria for inclusion in all four subcategories in 2018, and no hospital met the criteria for inclusion in all four subcategories in 2013 and 2016.

Discussion

In this study, HII hospitals more than tripled (19.9 percent to 62.4 percent) over the five-year study period. Among the HII hospitals, about 60 percent were consistently full LHS hospitals. Overall, full LHS and all other hospitals that met the criteria for HII hospitals grew at the same rate across the five-year period. Hospitals that met any of the LHS criteria also increased progressively, with emerging LHS hospitals increasing across the study period. By 2018, nearly three quarters (74 percent) of the hospitals evaluated met any LHS criteria (LHS stages one to three). In 2016, the meaningful use stage three law that was released in 2015 resulted in an increase in adoption, and this category became the most common among the HII subcategories (84.6 percent) (Table 1.4), and by 2018 nearly half (46.9 percent) of the hospitals evaluated had made this transition. This shows that across the study period, more hospitals met the study's definition of HII hospitals through compliance with the HITECH Act's MU3 criteria.

MH/SN- and PCORI-funded hospitals were generally fewer than other designations across the study period, with the proportion of hospitals meeting either set of criteria decreasing across the period. MH/SN hospitals decreased by more than one-third (36.4 percent) between 2013 and 2018, coinciding with the end of financial incentives. Among hospitals that were included in multiple categories, those that met the full LHS criteria and were also MU3 compliant were the most dominant across the study period. In 2016 and 2018, at least half of PCORI-funded or MH/SN hospitals were in combination with either hospitals that met the full LHS criteria or those that were MU3 compliant. MH/SN hospitals were, however, less likely to be in combination with PCORI-funded hospitals.

Overall, across the study period, more hospitals became HII or acquired additional HII subcategories by becoming full LHS or MU3 compliant. There were multiple drivers for this observed trend in any given hospital, all incentivizing or facilitating more capture and use of electronic health data and thus driving increases in most HII subcategories. Some of this increase might have been due to efforts to improve quality and efficiency, which led more hospitals to participate in programs such as the LHS and the potential loss of revenue due to penalties for MU3 noncompliance. Also, supplemental funding targeted toward developing patient-centric measures that are facilitated by health IT tools such as in the PCORI funded and the MH/SN subcategories might have contributed to this shift. However, when incentives for

specific, narrowly focused programs such as the MH/SN end, that metric also falls, but even so, may have contributed in more lasting ways to other HII strategies.

Limitations

Study limitations include the identification, definition, and operationalization of variables, and selection of measurements and statistical tests. Adaptation of the AHA IT survey and data to create HII criteria might have led to study design and measurement errors. Also, the study evaluated MU3 compliance in 2013, although the final rule was not officially published until 2015. Given the exploratory nature of this study, there also might be other means of defining HII subcategories that were not identified.

Conclusions and Implications for Practice, Policy, and Further Research

This exploratory study showed the types, distribution, and interactions of hospitals that are more likely to be interested in improving their health IT capabilities to facilitate continuous improvement in care processes, improved patient care, and engagement using electronic health data. The adoption of LHS principles, MU3 compliance, and the availability of PCORI and CMS funds for health IT innovation have facilitated the development of health-IT driven, patient-centric hospitals. Knowledge of how widespread participation in these initiatives and programs is can help HIM professionals to understand the differential uptake of these initiatives among different HII hospitals, and this can signal the potential for synergistic approaches in health IT adoption through their combination. Identifying differences in the uptake of these initiatives and programs can also help to bridge access gaps. For example, the reduction in the MH/SN subcategory across the study period indicate that this initiative might need to be extended to achieve its health-IT-related objectives. The prevalence of the full LHS and MU3 subcategories indicate that these initiatives are spreading and are increasing the overall number of HII hospitals across the US.

Awareness of the various hospital types described in this study by HIM professionals can help to identify programs, approaches, and policies that are expanding (such as the LHS and MU3) and can enable the development of patient-centric and learning-focused HIM systems and facilitate continuous improvement processes using electronic health data. An understanding of these hospital types and their interactions can also contribute to improvements in systemic learning competencies as it relates to healthcare organizations among HIM professionals and create more avenues to be engaged in HIM decision-making within health systems. Future studies can use the developed measures of LHS practice in this study to evaluate LHS uptake in aspiring learning hospitals. Future studies can also evaluate the relationship of these HII hospitals with specific health IT indicators such as patient-generated health data capture and use.

Conflicts of Interest and Support

We have no conflicts of interest or financial support to report.

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Design and Evaluation of an Electronic Information Exchange System Connecting Laboratories and Physicians' Offices

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Abstract

Laboratory services are a crucial part of medical care and contribute to physicians' treatment-related decision-making. However, paper-based information exchanges between physicians' offices and laboratories waste physicians' time and prevent them from using outpatient test results in a timely and effective manner. To solve this problem, improve the safety and quality of patient care, and save patients' time and energy, the present study developed a web-based system for electronic information exchange between laboratories and offices in Microsoft Visual Studio with the ASP.net technology and the Microsoft SQL Server database.

The developed web-based software met the needs of the users and stakeholders (physicians, laboratory personnel, and patients) in the laboratory service cycle. To evaluate the software, user satisfaction was assessed in terms of user interface, operational functionality, and system performance, indicating the acceptability of all the criteria from the viewpoint of the stakeholders.

The developed web-based software enables electronic communication between offices and laboratories (two important healthcare bases), establishes information exchange (sending requests and receiving laboratory results) between these two bases, and also notifies the patients. The software gained the overall satisfaction of the users, and this highlights the need for electronic communications in the healthcare domain.

Keywords: information systems, interoperability, physicians' offices, laboratories, health information exchanges

Introduction

Laboratory services play a pivotal role in directing treatment-related activities in physicians' offices. In these offices, laboratory services can continue care by the continuation of laboratory tests on patients with chronic diseases and by notifying healthcare providers (HCPs) about increased risk conditions and potential gaps in healthcare.[1]

The laboratory service cycle or process consists of different phases (pre-preanalytical, pre-analytical, analytical, post-analytical, and post-postanalytical),[2] and any error or inefficiency in each phase can disrupt the entire process and lead to ineffective patient management.[3,4] The majority of "laboratory errors" occur outside the laboratories, not in the analytical stage but in pre- and post-analytical stages.[5-8]

Information exchange between laboratories and offices, particularly in developing countries, is still paper-based, which can lead to errors in the laboratory service cycle, especially in the pre- and post-analytical phases. In developing countries, most primary healthcare centers do not have electronic medical records, and outpatient healthcare centers are rarely connected electronically to their reference laboratories.[9-13] Even developed countries, which are pioneers in this domain, have not fully addressed the challenges related to interoperability.[14-17] Paper-based communications, where patients themselves occasionally carry laboratory information, waste a great deal of time and energy commuting between outpatient centers and laboratories outside these centers.[18,19] This imposes heavy delay and backlog on the transfer of test results, and physicians cannot always have timely access to these results. HCPs at offices should receive laboratory results on time so that they can make better treatment-related decisions. If HCPs fail to follow-up test results, patients are exposed to a heightened risk of misdiagnosis or delayed treatment, and this leads to unfavorable treatment outcomes and threatens the quality of care and patient safety and satisfaction. Therefore, it is essential to receive and follow-up laboratory results in order to improve patient safety and the quality of care.[20,21] In some cases, information exchange between physicians and the laboratory (both requests for tests and retrieval of results) is performed via email, fax, special landlines, and printers; in addition to suffering from the mentioned problems, these methods are not documented or reliable.[22-24]

Laboratory service process errors are more important in offices because these healthcare centers are most frequently visited by patients[25] and, as such, a large number of tests are requested and the process of test is more complicated in offices.[26] Accordingly, the present study aimed to overcome the problems associated with paper-based information exchange between laboratories and offices, improve outpatient safety and the quality of care, and help save time and energy by developing an electronic information exchange system[27] for laboratories and offices,[28] especially in the COVID-19 pandemic when electronic information exchange could be effective.[29,30]

Method

In this applied study, the processes related to information transfer between diagnostic laboratories and offices were examined, and a list of physicians' and laboratories' needs was drawn up based on a review of sources (books and articles) and surveying physicians (n=5) and laboratories (n=5). Next, conceptual models of the software connecting offices and laboratories were identified based on the processes discovered in the previous phase, and the software was developed via object-oriented programming and unified modeling language (UML)[31] in Enterprise Architect (Sparx System).[32]

Based on the resulting models, a web-based software was developed with the ASP.net technology[33] and C# programming language in Microsoft Visual Studio.net[34] with the Microsoft SQL Server database.[35]

Finally, the software was run for one month in May 2020 to connect four urban laboratories and eight urban offices. The users (physicians and laboratory personnel) were trained on how to use the software on its first day of running. After exchanging 60 requests and test results between laboratories and offices, the software was evaluated by assessing the satisfaction of the final users (physicians, laboratory personnel, and patients) via checklists. The checklists were developed upon a review of sources and based on the opinion of experts (three medical informatics faculty members and two computer specialists) with three dimensions of user interface, performance, and system functionality. The validity of the checklists was examined based on expert consensus, and their reliability was investigated by Cronbach's alpha. Every question on the checklists was answered with "yes," "no," or "to some extent" (scored 2, 0, and 1, respectively). The acceptable range for user satisfaction was ≥ 85 percent.

Results

Results of Software Preparation and Development

The web-based software was developed based on UML modeling (Figure 1). The developed software is responsive and can thus be run on any hardware, including laptops, tablets, cellphones, and desktop computers. Its user interface has been designed based on the general principles in order to facilitate its use, and all the menus and information items related to specific topics can be accessed when needed. Some important forms of the software can be observed in Figure 2 and Figure 3.

The software developed for the office can record patient information, request/send tests, view test results, set the next appointment, and manage the users. Physicians or their secretaries can register patients' identification information when they enter the office, and then register test requests in the electronic system and send the requests to the laboratory. Also, using this system, physicians can view and examine patient test results recorded by the laboratory. The software can also set the next appointment for the patient.

Following the logical workflow of the laboratory, the laboratory software can set a sampling appointment for the referred patients, record and send test results, manage

users, and define tests. The definition of tests lets the laboratory update its list of tests and send it to physicians via the electronic system.

In the patient system, patients can log in their profile, view the list of requests and test results, and be notified of the sampling time and physician's appointments set for them.

Results of Software Evaluation

The software was run at eight offices and four independent laboratories outside these offices in Tehran for 60 test requests and results during a month. The software was then evaluated by assessing the satisfaction of final uses (physicians, laboratory personnel, and patients) while focusing on user interface, system performance, and operational functionality via checklists.

Results of Software Evaluation at the Office

The checklist for assessing physicians' satisfaction with the software was designed based on a review of sources and the opinions of experts, and its validity was confirmed upon expert consensus. Its reliability was also approved by Cronbach's alpha (α=0.89). This checklist comprised five questions on user interface, six questions on operational functionality, and three questions on software performance. A score of 2 was assigned to "yes" and 0 to "no." Since there were eight participants, the score of each question could range from 0 to 16. Table 1 presents the results of assessing physicians' satisfaction.

Based on Table 1, physician's satisfaction was 93.75 percent with the user interface, 98.9 percent with the operational functionality, and 97.9 percent with the software performance, all of which are > 85 percent and, thus, acceptable.

Results of Software Evaluation at the Laboratory

The checklist for assessing the laboratory personnel's satisfaction with the software was designed based on a review of sources and the opinions of experts, and its validity was confirmed by expert consensus. Its reliability was also approved by Cronbach's alpha (α=0.91). This checklist comprised five questions on user interface, four questions on operational functionality, and four questions on software performance (13 questions in total). As there were four participants, the score of each question could range from 0 to 8. The valid range of 85-100 was set, and if the level of satisfaction was > 85 percent for each dimension, the software would be deemed acceptable. Table 2 presents the results.

Based on Table 2, the laboratory personnel deemed the software acceptable in all the dimensions.

Results of Software Evaluation According to Patients

The validity of the checklist developed to assess patient satisfaction was confirmed by expert consensus. Its reliability was also approved by Cronbach's alpha (α=0.9). This checklist comprised two questions on user interface, four questions on operational functionality, and two questions on software performance (eight questions in total). As there were 60 participants, the score of each question could range from 0 to 120. The

confidence level of 85-100 was set, and if the level of satisfaction was > 85 percent for each dimension, the software would be deemed acceptable. Table 3 lists the results.

Discussion

As part of the healthcare system meeting most of the needs of outpatients, offices are an important medical body in any society. Physicians who work at offices often need laboratory test results for making treatment-related decisions. Therefore, there is a need to exchange laboratory test requests and results between offices and laboratories. The present study established electronic exchanges to overcome the errors associated with paper-based exchanges. The web-based software connecting the offices and laboratories developed in this study can cover different phases of the laboratory service process.

Discussion and Examination of the Status of the Software in the Laboratory Service Cycle

The software is compatible with the laboratory service cycle and covers all its five phases, thereby improving the precision and speed of different phases. The software provides electronic access to previous laboratory results of a patient to the physician in the pre-preanalytical phase, and this can aid physicians in decision-making. Also, with an electronic request, the software reduces the physicians' workload in the pre-analytical phase. During the analytical phase, it improves the tracking of current requests and prevents the loss or delay of results. Similar to the analytical phase, it allows the physicians to track the results in the post-analytical phase. The main effect of this software in this phase is accelerating the turnaround time, such that the results are often sent to the physician as soon as they are received at the laboratory, and this allows for more rapid interventions by the physician. This phase is greatly affected by cognitive factors that may influence the interpretation of results and the choice of appropriate measures. As a result, by notifying the patient and quickly sending the test results to the physician, this software leads to a rapid response and quicker follow-up by the physicians.

User satisfaction with the software was also evaluated, and the results are reported in detail below.

Results of Examining User Satisfaction with the Software

Physicians' satisfaction with the software was assessed in terms of user interface, operational functionality, and performance. Although they were satisfied with the three dimensions, they did not consider it legally or culturally acceptable to choose the laboratory for the patients. Patients may change their mind and visit a laboratory other than that set by the physician in the software. To solve this problem, the research team suggests that the patients be given the choice of the laboratory in the software. After the physician selects a list of tests for the patient, the list is first transferred by the physician to the patient's user account in the software, and is then sent by the patient to their laboratory of choice. After applying the changes to the software, the final evaluation results showed that the physicians were satisfied with all three dimensions.

Laboratory personnel's satisfaction with the software in all three dimensions was also acceptable (>94 percent). Studies have rarely evaluated the software connecting the office and laboratory from the viewpoint of laboratory personnel, and this merits more attention in future studies. The only study to do so was[36] conducted by Félix Gascón et al. In their study, an integrated laboratory test request module was designed for communicating with the laboratory information system (LIS). All the examined laboratories showed that running the laboratory module in the EHR improved the analysis process, enhanced safety in patient identification, reduced errors of sampling containers, and shortened the response time. In the present study, enhanced communications between the office and laboratory, improved workflow, saving time and paper resources, and resolving the illegibility of physicians' handwriting have been mentioned, which indicate quality-related, organizational, and financial advantages.

Discussion and Examination of Similar Interventions in Previous Studies

This was one of the few studies that emphasized mutual exchanges, while most studies focus on unilateral transfer from the laboratory to the outpatient center, or vice versa, and others emphasize the exchange of alarms and suggestions.[37] Another advantage of the developed software is notifying the patient; this feature was not found in previous studies in the domain of outpatient care.

In practice, to convince outpatient centers, offices, and laboratories to adopt information technology for electronic transfer, the merits of such exchanges should be explained to them. Based on the evaluation, the physicians, laboratory personnel, and patients were satisfied with the outcomes of electronic exchanges. This result can motivate the use of this technology by outpatient centers and laboratories, and encourage the authorities to invest in this technology.

A challenge facing this project was convincing laboratories and, often, office physicians early in the work to use the software. Our team had to devote sufficient time to justify and persuade them. We also faced limitations, including the small sample size, since the use of technology in developing countries still requires culture-building.

Conclusion

Laboratory services are a major part of healthcare and contribute to the treatment-related decision-making of physicians, including those working in outpatient centers. Therefore, information exchange between outpatient centers and laboratories is essential. Still, there are inevitable errors in the paper-based exchange of such information, and these errors can be partly resolved by establishing appropriate computer-based interfaces. The web-based software developed in this study enables electronic communication between the office and laboratory (two important healthcare bases). It establishes information exchange (sending test requests and receiving the results) between these two bases, while also notifying the patients.

The most important feature of the present study was its focus on outpatient healthcare centers in which the majority of healthcare services are offered and where there is a great

need for information exchange with external institutes, including laboratories. Outpatient centers are often run by non-affiliated organizations or persons, and convincing these parties to accept and use information technology needs a further understanding of the effects and advantages of this technology.

Another point is that, in this study, the electronic viewing of results, electronic sending of requests, and, in general, the benefits were independent of electronic health record (EHR) acceptance. In fact, this study showed that better performance can be achieved without an EHR and only through sending the requests and receiving the results electronically.

Overall, the developed software enhances the quality of patient care, saves costs, and promotes patient safety. By ensuring the satisfaction of users, it demonstrates the need for establishing electronic communication in this domain for developing countries and countries without electronic systems.

Suggestions

With regard to the value added offered by electronic exchanges in the healthcare domain, it is suggested that developing countries and developed countries that have paper-based exchanges among healthcare centers use electronic information exchange software programs to reduce medical errors, improve patient care quality, and save the costs and time of patients and HCPs. To this end, standards and models should be developed, and the infrastructure for implementation of electronic exchange should be fortified. Moreover, measures should be taken with regard to electronic insurance to facilitate electronic exchanges in the healthcare domain.

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The Coding Impact of Acute Kidney Injury in Pediatric Hospital Documentation

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Abstract

Background: Acute kidney injury (AKI) increases patient morbidity and mortality. In value-based care, the documented and coded diagnoses during hospitalization influences an encounter's relative weight (RW), including severity of illness (SOI), and risk of mortality, which ultimately determines reimbursement for care. The impact of a secondary diagnosis of AKI on RW in pediatric patients has not been evaluated.

Methods: A single-center, retrospective observational study was conducted over six months. The institutional coding database was queried for secondary diagnoses signifying AKI. The RW for each case was determined with and without an AKI secondary diagnosis. Patients were further stratified by their SOI score to evaluate change in RW and SOI.

Results: Over a six-month period, 372 patients had a secondary AKI diagnosis, with a mean RW 2.14 decreasing to a mean RW 1.83 without an AKI diagnosis (p = 2.2e-16). When stratified by SOI, one patient had SOI 1 with RW change -0.286; six patients had SOI 2 with mean RW change -0.0669; 189 patients had SOI 3 with mean RW change -1.862 (p=2.23E-16); and 176 patients had SOI 4 with mean RW change -0.452 (p=9.46E-14), when the AKI secondary diagnosis was removed.

Conclusions: Significant negative changes in RW were observed when AKI was removed, suggesting diagnostic omission may result in inaccurately lesser representation of patient medical complexity and severity of illness upon hospitalization coding, which may lower reimbursement.

Introduction

Acute kidney injury (AKI) is the sudden onset of decreased kidney function characterized by a rise in serum creatinine and/or decreased urine output. It may be induced by a variety of etiologies, including low blood pressure, medications that injure kidneys, urinary tract blockages, or inflammatory kidney diseases. The sudden onset of AKI is potentially life threating when one is rendered unable to excrete metabolic waste products and excess volume from the body. AKI is a significant and increasing cause of hospital comorbidity in the United States, annually affecting thousands of hospitalized patients, and more than 50 percent of intensive care unit patients.[1-3] AKI is associated with both poor health outcomes and significant financial burden due to prolonged lengths of stay, prolonged need for mechanical ventilation, and increased mortality.[4-6] In the United States, AKI affects up to one in five hospitalized patients, and AKI-related hospital costs in adults are estimated to be $5 billion a year.[7] These numbers may be underestimated, as identification depends on proper recognition and documentation of AKI, and billing codes have been shown to lack sensitivity in truly capturing the condition.[8]

In pediatric patients, recognition and understanding of AKI is also a significant yet poorly understood issue, with studies demonstrating coded diagnostic data under represents AKI when compared to validated clinical criterion data.[9,10] In the United States, based on International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9) codes, used prior to 2015 when the Centers for Medicaid and Medicare Services (CMS) switched to ICD-10, nearly four in 1,000 of all hospitalized children develop AKI.[11] One in every three to four pediatric patients in intensive care units develop some degree of AKI, which has been associated with both increases in ICU and overall hospital lengths of stay.[12-14]

In practicing value-based care, outcomes are closely linked to the payments for care.[15] In the United States, CMS uses diagnosis-related group (DRG) based coding to determine a relative weight (RW) score for each admitted patient's encounter, along with associated severity of illness (SOI) and risk of mortality (ROM) scores. Relative weight (RW) thus reflects severity of illness and the degree of complication for a patient's illness encounter, as well as the overall cost of hospitalization. The RW for a hospitalization is multiplied by a hospital's base payment rate to determine facility reimbursement for the encounter. Both SOI and ROM are measured on a scale from 1-4, with 4 being the most severe, to describe the extent of disease manifestation. The indices are based on several dimensions, incorporating the level of principal diagnosis, complications, interacting conditions, dependence, procedures, response and recovery to treatment, and impairment.[15]

Around 44 million children in the United States have healthcare coverage via Medicaid or the Children's Health Insurance Program (CHIP), which is coded in many states using All Patients Refined (APR)-DRG methodology, which was developed for pediatric patients.[16, 17] Using APR-DRG coding, the RW for a patient encounter is determined as a compilation of all diagnoses incurred during a hospitalization, leading with a primary diagnosis and including all secondary diagnoses. While a diagnosis of AKI inherently carries additional weighting, the final value of RW is determined within the coding algorithm; thus, when considered case by case, an increased RW may not always be frankly evident.

As an under-recognized diagnosis, not only must practitioners recognize and treat the condition, they must understand the impact proper documentation imparts for improved reimbursement in the face of the condition's significant health impact.

The aim of this study was to estimate of the actual working RW impact an AKI secondary diagnosis has on RW in a pediatric patient population coded via APR-DRG. We hypothesized that documentation and coding including a secondary diagnosis of AKI significantly increases RW for a pediatric patient's hospitalization, reflective of the increased resource consumption required to manage a child with AKI.

Methods

An institutional board review approved retrospective observational study was conducted at Dell Children's Medical Center in Austin, Texas. The institutional database was queried over a six-month period, November 1, 2018, through April 30, 2019, for ICD-10 codes N17.0 (Acute kidney failure with tubular necrosis), N17.1 (Acute kidney failure with acute cortical necrosis), N17.2 (Acute kidney failure with medullary necrosis), N17.8 (Other acute kidney failure), and N17.9 (Acute kidney failure, unspecified) for all patients less than 18 years of age who had inpatient hospital stays. All cases were coded using APR-DRG coding within the 3M 360 Encompass System platform. APR-DRG relative weight, SOI, and ROM were extracted, and demographic data, including age, sex, and race or ethnic group was compiled for each patient. Each patient's encounter coding data was reviewed within the 3M 360 Encompass System platform to determine the patient's RW for their respective hospitalization without the AKI diagnosis.

Cases were excluded from the study if, upon review, coding data was no longer located in the 3M 360 Encoder software, most likely indicating a hospitalization status downgrade from an inpatient to an observation stay had occurred. Such cases are institutionally coded via a different system.

Data analysis was performed using RStudio Version 1.4 to assess statistical difference between the presence and absence of an AKI secondary diagnosis for the patient encounters. Wilcoxon signed-rank test was used because the data was determined to be non-parametric, suggesting no significant difference between the groups. Data was further stratified by SOI categories 1 through 4 to compare mean RW with and without an AKI secondary diagnosis.

Results

Four hundred fourteen patients with an AKI diagnosis were identified. Seven were excluded due to a lack of coding software data. Thirty-five patients were excluded who had a primary diagnosis of AKI (N17.0, n = 33; N17.9, n = 2). Three hundred seventy-two had a secondary diagnosis of AKI (N17.0, n = 370; N17.1, n = 1; N17.8, n = 2) and were included in further analysis.

Of the 372 patients with a secondary diagnosis of AKI, 52.5 percent were male and 47.5 percent were female, with a mean age of 7.3±6.9 years. The race or ethnic groups were parent or guardian reported as follows: white/non-Hispanic n=156 (41.9 percent), white/Hispanic n=150 (40.3 percent), black n=47 (12.6 percent), Asian/Pacific Islander n=14 (3.8 percent), and 'decline to specify/unknown' n=6 (1.6 percent). Patients with a secondary diagnosis of AKI had a RW mean 2.14 and median 1.02 (SD±2.91), and with removal of the AKI secondary diagnosis, had RW mean 1.83 and median 0.72 (SD±2.91). The group had a RW mean change of -0.31 (p = 2.2e-16) when the secondary diagnosis of AKI was removed (Table 1).

Patients with a secondary AKI diagnosis were further stratified by SOI categories 1-4 prior to removing the AKI diagnosis (Table 2).

One patient with a secondary diagnosis of AKI had had an SOI=1 (female, age 2 months, RW with AKI 0.6206, RW without AKI 0.3355).

Six patients with a secondary diagnosis of AKI had an SOI=2, 66.7 percent were male and 33.3 percent were female, with a mean age of 14±3.6 years. The group had a mean RW 0.452 with the AKI diagnosis and a mean RW 0.385 without an AKI diagnosis, for a change in mean RW -0.067, with a range of change of 0 to 0.102. Four patients' SOI decreased from 2 to 1 when the secondary AKI diagnosis code was removed.

One hundred eighty-nine patients with a secondary diagnosis of AKI had an SOI=3, 52.1 percent being male and 47.9 percent being female, with a mean age of 8±6.7 years. The group had a mean RW 0.754 and median RW 0.667 (SD±0.396), and with removal of the AKI diagnosis, mean RW 0.567 and median RW 0.453 (SD±0.39). The change in mean RW was -0.186 (p=2.23-16). The range of RW change was 0 to 1.138. 137 patient's SOI decreased from 3 to 2 and 16 patients' SOI decreased to 1 when the secondary AKI diagnosis code was removed.

One hundred seventy-six patients with a secondary diagnosis of AKI had an SOI of 4, 52.3 of which were male and 47.7 percent of which were female patients, with a mean age of 6.4±7.1 years. The group had a mean RW 3.698 and median RW 1.617 (SD±3.626), and with removal of the AKI diagnosis, mean RW 3.246 and median RW 1.617 (SD±3.741). The change in mean RW was -0.452 (p= 9.46e-14). The range of RW change was 0 to 4.324. 65 patient's SOI decreased from 4 to 3 and four patients' SOI decreased to 2 when the secondary AKI diagnosis code was removed (Table 3).

Discussion

Our study demonstrated a significant change in the relative weight of cases when an AKI diagnosis was removed from a patient's list of codeable secondary diagnoses. While less likely to be overlooked when AKI is a primary diagnosis, omitting an AKI secondary diagnosis may lead to a lesser, inaccurate reflection of the patient's overall complexity and healthcare resource consumption and lower reimbursement for the care provided.

Patients with AKI have prolonged lengths of stay and increased hospital costs.[7] A diagnosis of AKI that is both documented, then coded using the APR-DRG system, is recognized via both increased severity of illness and risk of mortality in the final relative weight value for an inpatient encounter. Proper identification and documentation of AKI, including accurate staging, is necessary to prevent revenue loss while providing care for patients with AKI.

The Assessment of Worldwide Acute Kidney Injury, Renal Angina and Epidemiology in critically ill children (AWARE) study conducted a large multicenter prospective study to evaluate the increased risk of morbidity and mortality associated with AKI in critically ill children. The AWARE study found that AKI was diagnosed in 27 percent of all the patients and that severe AKI was associated with increased 28-day mortality. It also highlighted that plasma creatinine levels by themselves were not enough to identify AKI in 67.2 percent of those with low urine output.[12] This further emphasizes the high prevalence of AKI in hospitalized children, solidifying the need for proper documentation and coding that reflects a patient's truer resource consumption and severity of illness.

There are potential limitations in our study. First, our population study period was over six months, a brief period more prone to situational changes. Additionally, there may be inconsistencies in the electronic charting system used in our facility; for example, not every patient has a nephrology consultation, and our system does not provide electronic validation for an AKI diagnosis, and it was beyond the scope of this study to interrogate the etiologies for AKI and validate the accuracy of each AKI diagnosis. Furthermore, in coding these cases, none of the patients carried a diagnosis code of N99.0, which would require coding both N99.0 as well as a diagnosis code of N17.1-N17.9; thus, we were unable to aspect the potential for this aspect of coding. Finally, coding is an inexact science, depending on both the coding professional's skills and the accuracy of the documentation.

We present work demonstrating the value impact of a secondary diagnosis of AKI, where increased RW carries an impact more tangible for a clinician than complex coding algorithms. Through this, we seek to highlight the ongoing need for accuracy and thoroughness in clinical documentation and coding to truly reflect the additional patient care resource consumption reflected in the diagnosis. In the ever-changing healthcare landscape, the advent of value-based care has imparted an urgency to properly recognize and document this key diagnosis for pediatric patients.

Conflict of Interest Disclosures: The other authors have conflicts of interest to disclose.

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Notes

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Application of Failure Mode and Effects Analysis in Managing Medical Records for Accuracy of INA-CBGs Health Insurance Claims in a Tertiary Hospital in Indonesia

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Abstract

Objective: Awareness of the importance of social security systems continues to grow in Indonesia, as mandated by the amendment of the 1945 Indonesian Constitution Article 34 paragraph 2, which states the obligation of the Indonesian government to develop and implement a social security system for all Indonesian people. This study aims to evaluate the effectiveness of applying failure modes and effects analysis (FMEA) in managing inpatient medical records at the Dr. M. Djamil Padang Central General Hospital.

Material Methods: This is a comparative research study that uses a retrospective approach and compares the data between 2017 and 2018 inpatient National Health Insurance (NHI) patient medical records. Study samples include randomly selected 24,005 files.

Results: The results showed a decrease in problematic claims by 13 percent and an increase in receipt of claims paid by 87 percent. There is a significant difference between the data in 2017 and 2018 in problematic claim decrease (p=0.000) and claim acceptance increase (p=0.000).

Discussion: It was found that the redesign process of the formation of hospital claims will make hospitals more organized, precise, effective, and efficient, therefore positively impacting hospital income. In addition, the redesign was carried out because of the large number of Social Security Administrator for Health patients; thus, it greatly affected hospital income.

Implication for Health Policies: The FMEA medical record flow process is very effective and can thus be implemented in hospitals.

Keywords: FMEA, health insurance, medical record, problematic claims, receipts

Introduction

Awareness of the importance of social security systems continues to grow as mandated by the amendment of the 1945 Indonesian Constitution Article 34 paragraph 2, which states the obligation of the Indonesian government to develop and implement a social security system for all Indonesian people. The inclusion of the social security system into the constitutional amendment, followed by the issuance of Law Number 40 of 2004 on the National Social Security System (NSSS), indicates that the government and the related stakeholders have a strong commitment to actualize social welfare for all its people.[1] The implementation of the universal health coverage (UHC), managed by a nonprofit organization called Badan Penyelenggara Jaminan Sosial Kesehatan (BPJS-Kesehatan), is one of the activities of NSSS. In this system, primary care facilities are paid by a capitation system. On the other hand, secondary and tertiary care facilities are paid by a case mix/diagnosis-related group scheme (INA-CBGs).[2]

INA-CBGs stands for Indonesian Case Base Groups, an application used by secondary and tertiary healthcare hospitals for submitting payment claims to BPJS-Kesehatan for healthcare services they have delivered for BPJS-Kesehatan participants. INA-CBGs is a payment method for patient care based on relatively similar diagnoses or cases. Before the payment is made by the BPJS-Kesehatan to the hospitals, the submitted claims are verified. The verification process is conducted to assess the validity and eligibility of the submitted claims, as well as the completeness of supporting documents. Patients' medical records are important documents in this process. The BPJS-Kesehatan cannot make payment for invalid, ineligible, and/or incomplete claims, which will be returned to the hospital, resulting in pending payments. The purposes of assessing claims are as follows: assess the cost of medical services being claimed, evaluate the insurance members' benefits, and prevent both intentional and unintentional fraud.[3]

Data collected in a government tertiary hospital in Padang, Indonesia, showed that there were 5,897 pending claims among the 23,463 claims submitted in 2017 (approximately 25 percent). Risk register, a document containing risks that may occur in the unit based on the category and scope of risk management in the hospital, showed that these pending claims were mainly related to incomplete and inaccurate medical records. Medical records are important documents in claim verification because data written in the records are used by BPJS-Kesehatan to assess the validity and eligibility of claims. Moreover, medical records serve as the basis for making payment to the healthcare facilities. Pending payments potentially interfere with hospital finances and the quality of care they deliver for patients.

Failure mode and effects analysis (FMEA) is a technique applied to improve a system by predicting the potential failures in the system and their solutions. FMEA is a team-based,

systematic, and proactive technique applied to prevent problems both on processes and products before they occur. FMEA can provide not only an overview of the problems that might occur but also the severity of the consequences.[4] According to the Joint Commission International (JCI), the FMEA model consists of eight steps: 1) determining a high-risk process that needs improvement and forming a team; 2) describing the process flow; 3) brainstorming failure modes and their effects on the process flow; 4) scaling up the failure mode priority; 5) identifying the root cause of the failure mode; 6) redesigning the process; 7) analyzing and testing the new processes; and 8) monitoring the new process implementation.

In June 2017, FMEA was conducted in a Padang government tertiary hospital to solve the problem regarding 5,897 pending claims due to incomplete and inaccurate patient medical records. Furthermore, 25 percent of INA-CBGs claims were pending for the same reason. The incomplete and inaccurate medical records are due to the overlapping medical record flow factors (back and forth). This research aimed to evaluate the effectiveness of applying FMEA in managing medical record for the accuracy of INA-CBGs health insurance claims in a tertiary hospital in Indonesia. Using the FMEA model, together with the formation of a team in the redesign process, will help in the regularity, accuracy, efficiency, and effectiveness of medical record management.

Literature Review

Medical records include documents regarding patient identity, examination, treatment, actions, and other services that have been provided to patients.[5] The filling out of medical records helps in the order of the administration and in improving the quality of health services in hospitals. To achieve this, at hospitals, medical records are filled out by doctors and nurses according to the results of the medical activities that have been carried out; therefore, medical records and documents should be completely filled out to produce accurate information and sustainability.[6]

The process of determining the INA-CBGs code and its rates begins when the patient is discharged from the hospital. The data that must be entered in the INA-CBGs software is variable data that can be taken from medical resumes and patient social data, both of which can be collected manually or through a hospital management information system (HMIS) for hospitals that already have a HMIS. After the variable data is entered into the INA-CBGs software, grouping is done to produce the INA-CBGs code along with the per-patient rate.[7]

According to Ilyas, the claim is defined as a request from one of two parties that have a bond, so that their rights are fulfilled. One of the two parties will submit their claim to the other party in accordance with the agreement or policy provisions agreed upon by both parties.[8] The purpose of the claim is to pay all valid claims, identify the possibility of fraud, whether intentional (fraud) or unintentional (abuse) in making a claim, meeting government regulations, avoiding or preventing lawsuits, coordinating benefit, and controlling the cost of claims (claim cost).[9]

The definition of a claim not worth paying is refusing to pay a claim to a provider that does not follow the policies/procedures of the insurance company or is waiting for additional information.[10] The NHI program is a guarantee system organized by the government through a social insurance mechanism that is provided to all Indonesians.

Meanwhile, FMEA is a systematic approach that implements a labeling method by determining modes of failure, causes of failure, and effects of these failures to help in the flow process. This approach is used by engineers to identify potential failure modes and their effects. FMEA is an evaluation technique that assesses the reliability of a system and determines the effects of the failure of the system. Failures are classified based on the impact they have on the success of a mission of a system. Therefore, to overcome this failure, FMEA is used by Dr. M. Djamil Central General Hospital in the flow process of inpatient medical record file.

Dr. M. Djamil Central General Hospital is the central general hospital in Padang, West Sumatera, Indonesia. The hospital has 800 beds and serves general patients, BPJS, and insurance. Admission of patients at the Polyclinic of Dr. M. Djamil Central General Hospital in 2017 consisted of 14,096 new visitors and 152,993 old visitors. In 2018, it consisted of 35,107 new visitors and 124,576 old visitors.

After the doctor's approval, the patient returns home. Then, when the patient returns home, the hospital must immediately make a patient claim file. From the flow process above, patient claims are taken by the medical record unit to the verification and finance unit. The process of submitting this claim usually takes 20 days. This is due to flow factors (back and forth) between the medical record and verification units. Then, claims are forwarded to the finance unit and proceed again to the medical record unit. Therefore, applying FMEA can help hospitals by being verified by a mixed team of existing hospital cases.

In implementing changes in the flow of medical services, the authors found distinction in problematic claims in NHI inpatients at Dr. M. Djamil Padang Central General Hospital from 2017 to 2018. After the redesign, the not problematic 74 percent in 2017 increased to 87 percent in 2018, which is a very significant increase. The problematic claims in 2017 were 26 percent; after being fixed, it dropped to 13 percent in 2018, which is same as the unpaid claim in 2017 (25 percent), which became 17 percent in 2018. The 75 percent automatically paid claims in 2017 increased and became 83 percent in 2018. When the changes were implemented in the flow of medical record services, we obtained the differences in problematic claims at the Dr. M. Djamil Padang Central General Hospital during 2017 to 2018. In 2017, there were 74 percent non-problematic claims, which increased to 87 percent in 2018. Problematic claims decreased from 26 percent in 2017 to 13 percent in 2018. This was also accompanied by the decrease of non-problematic claims from 25 percent in 2017 to 17 percent in 2018, while paid claims increased from 75 percent in 2017 to 83 percent in 2018.

After the changes in the flow, claim file printing was made faster by hospitals. The claim files that are entered at the inpatient unit are directly processed by the case mix team.

After processing, the claim files are directly given to the finance department within one day after the claim file is complete. Claim files that arrived at finance are first given to the BPJS verifier, which is then examined by the hospital fraud team.

In Iran, there are also those who have implemented FMEA, where the results of the research by Dastjerdi, HA., et al. (2017) showed that his research focused on processes carried out in pediatric and radiology wards as well as on nursing staff.[11] His research also expresses all the steps of implementing the FMEA model and applies strategies and interventions and risk priority numbers to determine the level of effectiveness of the model.

Research results Vida, MA., et al. (2017) showed the results that there were 99 failure modes associated with 80 side effects and 129 identified causes in eight pharmacy areas/subhospital processes.[12] The three areas with the highest percentage of failure modes are inpatient pharmaceutical care, pharmaceutical laboratories, and pharmaceutical technology and medication management. There are also 25 failure modes with an RPI score of 20 and 25 failure modes, with the highest frequency and criticality score classified as priority.

Methods

This study was conducted at Dr. M. Djamil Padang Central General Hospital from May 2019 to July 2019. This is comparative research that used a retrospective approach that compared the medical records of inpatient NHI in 2017 and 2018. The study sample included all NHI inpatient medical record documents submitted to BPJS in 2017 (29,424 files) and in 2018 (24,005 files). The study variables were the claim payment receipt and claims that were problematic. The medical record document included claim files by the hospital to BPJS. The BPJS will provide feedback on the claim submission document. We obtained data on the receipt of claims paid and claims that are problematic in accordance with those sent by BPJS.

To determine the frequency distribution of each variable, univariate analysis in the form of a frequency distribution table was used to evaluate the variable claim receipt paid and problematic claims of NHI inpatients. For the bivariate statistical analysis, the McNemar's test was used, with a significance level of 95 percent ($\alpha = 0.05$). In this study, the value of $p < 0.05$ means that there are significant differences.

In June 2017, the eight steps of the FMEA process were started as follows: 1) determining the topic and forming team, 2) describing the process flow, 3) brainstorming failure modes and their effects on the process flow, 4) scaling up the failure mode priority, 5) identifying the root cause of the failure modes, 6) redesigning the process, and (7–8) analyzing and testing the new process, and monitoring its implementation.

Finally, in conducting an evaluation by FMEA, we compared INA-CBGs' claim data for 2017 and 2018 (before and after the implementation of the FMEA activity) to evaluate the effectiveness of the FMEA implementation. We collected data on the number of INA-CBGs'

claim paid or unpaid by the BPJS-Kesehatan and the total rupiahs received by the hospital for inpatient services provided for the BPJS-Kesehatan member. The McNemar's statistical analysis was applied to see the difference between the two cohorts with a significance level of 95 percent.

Results

Based on the results of the conducted research, we have obtained the modes, effects, and causes of failure. After brainstorming with medical records, we obtained the Risk Priority Number (RPN) and the recommended actions.

Based on Table 1, the highest RPN is 280 with a failure mode consisting of the following: a) incomplete medical records with claims, b) related to incomplete medical record factors, c) the diagnosis is not included in the BPJS/IKS coverage list category, and d) the overlapping membership between BPJS and in health. Related to this problem can happen at the hospital associated with hospitals related to patients commuting to work/emergency room, while judging from the lowest RPN with a value of 80 at the lowest rank has obtained failure mode consists of medical records that have retention which has not been broken out. This will affect the stacking of medical record files in the medical record storage room.

Figure 1 illustrates the preparation of medical records and INA-CBGs' claim before being redesigned. The failure mode is also caused by the inpatient medical record service flow that is not optimal. The patient enters and is treated. The patient returns home after being declared cured. When the patient goes home, the patient's claim file must be immediately made by the hospital. From the flow above, the patient's claim file is brought by the medical record to the verification and fund mobilization installation. The process of submitting this claim file usually takes 20 days; this is due to the factor of going back and forth between the medical record to the verification installation, then forwarded to the mobilization of funds and returned to the medical record. If the claim is rejected, it will be corrected by returning it to the case mix team, case manager, DPJP, nurse, or returning it to the inpatient unit in the same way. In this case, the hospital redesigned the medical record and preparation of INA-CBGs' claims with FMEA activities. Figure 2 is a redesign chart that has been designed by Dr. M. Djamil Padang Central General Hospital.

Figure 2 illustrates the preparation of medical records and INA-CBGs' claim after being redesigned. The patient enters the first time through the registration unit, an empty medical record file from the medical record unit is given to the registration unit, after completion of registration, it is then submitted to the inpatient unit. If the patient is finished being treated, the medical record file is returned by the inpatient unit to the medical record unit.

After a flow change occurs, the hospital can print claim files faster. Claim files that are entered at the inpatient installation are immediately processed by the case mix team at the inpatient installation. After processing, the claim file from the inpatient will be sent directly to the mobilization of funds (MD) within one day after the claim file is completed.

The claim file that arrives at MD before being given to the BPJS verifier is first checked by the hospital fraud team so that the claim file can be marked accepted, rejected, or pending.

Based on the chart (before and after being redesigned), the flow process of the inpatient medical record service before the redesign occurred in two places, which causes failure mode; therefore, the service flow became unfocused and ineffective. After the redesign, the service flow was improved, and coding was only carried out by the case mix team in the inpatient room.

Since the implementation of the change in the flow of medical record services, we obtained the difference in problematic claims in NHI inpatients at Dr. M. Djamil Padang Central General Hospital in 2017–2018 (Table 2).

Table 2 shows that out of the 24,005 NHI claim documents, there were 3,074 (13 percent) reductions of problem claims in 2018 from 6252 in 2017 (26 percent). The analysis result shows that the p value of 0.000 means that there is statistically significant difference between NHI's 2017 problematic claims and 2018.

Table 2 also shows that, from the 24.005 NHI claim documents, there was an increase in claim receipt in 2018, amounting to 21.834.679.98 USD (83 percent), from 2017 amounting to 20.531.494.82 USD (75 percent). The analysis result shows that the obtained p value of 0.000 means that there is a statistically significant difference between the 2017 NHI claim receipt rate and 2018; namely, the acceptance of an increase in claims receipt from 20.368.001.54 USD in 2017 to 21.830.972.01 USD in 2018.

Discussion

Steps of Evaluation

Tooranloo and Saghafi, in their study titled "Assessing the risk of hospital information system implementation using IVIF FMEA approach," concluded that applying FMEA encouraged managers and staff to use the health information system to better manage data and information, upgraded the system to the current culture of the organization, and allocated funds to support and maintain the current upgraded systems that they used.[13] In this study, we have also applied this method at Dr. M. Djamil Padang Central General Hospital by following these eight steps:

Step 1: Determine the topic and form a team.

One FMEA activity is carried out at the hospital every year. Hospital risk records compiled from the units' risk registers guide the identification of a priority process for the annual FMEA activity. Risk registers are recordings of events that can be a potential threat to patient safety in every single component of the hospital system, including operational strategy, financial, compliance, types of patients, staff, facilities, environment, and business. In 2017, the risk register indicated that the INA-CBGs' pending claims that resulted in the hospital's financial difficulties were the priority threats that should be solved through the FMEA activity.

A multidisciplinary team for conducting the FMEA activity was formed and formalized via the issue of an assignment letter by the managing director of the hospital. The team consisted of 14 members. Identifying the right person for the job was very important. Team members must bring a diverse mix of knowledge bases to ensure that there were different points of view for the improvement process. The team members must be committed to performance improvement and had sufficient knowledge on the processes to be corrected. Representatives from areas that may be directly affected by changes (e.g., medical record department) were included within the team.

Step 2: Describe the process flow.

The next step in the FMEA activity was the reviewing of the process in full by describing or developing diagrams in a graphical format. The multidisciplinary participation of the FMEA team members and all stakeholders involved in the process was very important to identify every steps of the process in detail. The activity resulted in a more complex process flow description than what was actually being implemented. The team found that the process was too large and complicated to manage in one diagram. Thus, the team broke down the process into subcomponents and developed individual diagrams for each of them. Each team member had to truly understand the process and sub-process components, as well as the interrelationship between the chosen FMEA process (i.e., medical record management) and other related processes in the hospital system.

Step 3: Brainstorm failure modes and their effects on the process flow.

A small group discussion was conducted to identify potential failures in the process of medical record management to meet its objectives as an effective data source for the INA-CBGs' claim. The discussion also explored the effect of failures on patients' safety and satisfaction, including treatment delay, death, morbidity, tissue damage, violation of regulations, and financial loss.

Step 4: Scale up the failure mode priority.

An RPN was used to assess the priority scale of each identified potential failures. RPN was measured based on three scales: severity, occurrence, and detectability. Each scale has a value in the range of 0 to 10. The multidisciplinary team discussed and determined the value of the three scales for each potential failure identified. The RPN number for each failure was the multiplication of the three scales. For example, a potential failure had 6, 5, and 4 for the severity, occurrence, and detectability scale, respectively. Thus, the RPN number for the potential failure was 6 × 5 × 4, which was 120.[14] The FMEA team decided that the cutoff point of the RPN for a potential failure to be explored was 80. The potential failure with the RPN below 80 would be explored if the time was available.

Step 5: Identify the root cause of the failure modes.

The FMEA team discussed the root cause of the failure modes through brainstorming activities and drawing cause-and-effect diagrams. The activities also explored how to prevent future failures. If future failures could not be prevented, strategies to protect patients from the impact of the failures should be identified.

Step 6: Redesign the process.

The FMEA team redesigned the process of medical record management for supporting an effective preparation of the INA-CBGs' claim to eliminate the possibility of failure (to prevent failure), increase failure detection so that the failure could not reach patients, and mitigate the impact of errors that reach patients.

Steps 7 and 8: Analyze and test the new process, and monitor its implementation.

The revised process was implemented, and its effectiveness was monitored by collecting data of INA-CBGs' claim accuracy and percentage of claims being paid before and after the implementation of the new process designed using the FMEA activities.

Meanwhile, in their article "dP-FMEA: An innovative Failure Mode and Effects Analysis for distributed manufacturing processes," Maisano et al. have applied FMEA by the modification that is called distributed process (dp)-FMEA.[15] This method helps in managing dozens of experts without requiring them to physically meet and make collective decisions; therefore, this method is a flexible response mode that does not force experts to make detailed judgments, even in case of hesitation. Moreover, the methodology can be easily implemented. The dp-FMEA method basically still applied the principles found in the traditional FMEA. The advantage is that the dp-FMEA has a wider scope, such as for the production and manufacturing processes. Different from Dr. M. Djamil Padang Central General Hospital, the hospital uses FMEA that has been recommended by the JCI. The recommended FMEA already has the conditions set.

Implication of FMEA Evaluation

As a reinforcement in the use of FMEA, the authors compare this study to that of Yanagisawa et al., in their research about health preparedness plan for dengue detection during the 2020 summer Olympic and Paralympic games in Tokyo.[16] They used the FMEA method to prepare for future problem, of which the problem that they faced were outbreaks and other disease threats that have occurred in the area before. They used the FMEA method as a form of prevention to decrease the potential of future problems. The writer assumes that this method could be applied in Dr. M. Djamil Padang Central General Hospital to prevent problems in the future.

How did the use of the FMEA method in Dr. M. Djamil Padang Central General Hospital help in solving problems such as problematic and paid claims? The use of the FMEA method is very effective in solving this situation, especially claim problems. It can be seen in Table 2 that, in 2017, the number of patients with problem claims was 6,252, which then dropped to 3,074 patients in 2018.

In addition, in the study, "Evaluating the application of FMEA technology in hospital ward" by Dastjerdi et al., medical error is one of the greatest problems in any healthcare system. The best way to prevent such problems is by identifying error and their roots.[17] The FMEA technique is a prospective risk analyses method. This study is a review of risk analyses using the FMEA technique in different hospital wards and department. This paper has systematically investigated the available databases. After selecting inclusion and exclusion criteria, the related studies were found. This selection was made in two steps.

First, we investigated the abstract titles, and after omitting papers that did not meet the inclusion criteria, 22 papers were finally selected, and the text was thoroughly examined. At the end, the result was obtained. The results are the examined papers had focused mostly on the process and had been conducted in the pediatric ward and radiology department, and most of the participants were nursing staff. Many of these papers attempted to express almost all the steps of model implementation, and after implementing the strategies and intervention, the RPN was calculated to determine the degree of the technique's effect. However, these papers have paid less attention to the identification of risk effect. As a conclusion, the study revealed that the small number of studies had failed to show the FMEA technique's effect, but, in general, most of the studies recommended this technique and had considered it a useful and efficient method in reducing the number of risks and improving service quality. When we compared to the writer of the article, we can find that FMEA is really effective in reducing the number of risks and improving service quality.

In addition, another study by Saulino et al., titled "The application of failure modes and effects analysis methodology to intrathecal drug delivery for pain management," utilized the FMEA method to transform clinical insights into a risk mitigation plan for intrathecal (IT) drug delivery in pain management.[18] The FMEA methodology that has been used for quality improvement was adapted to the assess risks (effect analysis failure modes) associated with IT therapy. Ten experienced doctors at the hospital scored 77 failure modes in the following categories: patient selection for the initiation of therapy (efficacy and safety), patient safety during IT therapy, and product selection for IT therapy. Participants assign severity, probability, and detection scores for each failure mode, from which the risk priority figure is calculated. The failure modes with the highest RPN (i.e., most problematic) are discussed with the proposed strategy to reduce risk. The strategic discussion focused on the 17 failure modes with the most severe outputs, the highest probability of occurrence, and the most challenging detection.

The topic of the highest ranked failure mode (RPN= 144) was manufactured monotherapy versus compounded combination products. Addressing failure modes associated with appropriate patient and product selection was predicted to be clinically important for the success of IT therapy. In this study, Saulino et al. found that the FMEA method offers a systematic approach toward risk mitigation and strategic planning to prevent and manage failure.[19] When we compare with our article, both of these articles found that FMEA works proportionally in reducing risk, unmet needs, and information gap.

Furthermore, the study titled "Application of failure mode and effect analysis in a Radiology Department" by Thornton et al. showed that FMEA permits the proactive identification of possible failures in complex processes and provides a basis for continuous improvement.[18] With the increasing complexity of clinical radiology services, FMEA offers tools for predicting failure and implementing changes to prevent such failures from occurring in the future. In comparison with this article, both of these articles showed improved process and service quality in complex environment in the hospital. FMEA offers tools in predicting failure and implementing change for lack of process administration that will probably occur in the future. FMEA is a basis for continuous improvement and could proactively identify possible failure in the hospital environment.

From this study's results, it was found that the redesign process of the formation of hospital claims will make hospitals more organized, precise, effective, and efficient, therefore positively impacting hospital income. In addition, the redesign was carried out because of the large number of BPJS patients; thus, it greatly affected hospital income.

Conclusion

Based on the results of the research, we can conclude that, by applying the FMEA method, there was a decrease in problematic claims from 26 percent to 13 percent and an increase in claim payments from 75 percent to 83 percent. Thus, the use of FMEA in Dr. M. Djamil Padang Central General Hospital is very helpful and needs to be continuously improved for the effectiveness and efficiency of hospital claim files. In addition, based on the results of this study, we recommend hospitals carry out ongoing evaluations of redesigns that have been made so that, in the future, it will experience continuous improvement. We also expect the commitment and consistency of all staff involved in the flow of medical record services that have been redesigned.

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