Identifying Patient-Related Information Problems: A Study of Information Use by Patient-Care Teams during Morning Rounds

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ABSTRACT

Objective: This study identifies the types of patient-related information problems (PIPs) that patient-care teams encounter during morning rounds, and how those PIPs are identified and managed. PIPs are any issues related to patient information (e.g., wrong, missing, incomplete information) that affect the patient-care team's ability to perform their work. Not addressing PIPs can lead to workflow challenges, delayed patient-care decisions, and negative impacts to the patient.

Materials and Methods: We employed qualitative data collection methods by shadowing patient-care teams during 29 morning rounds resulting in 155 hours of observation. We observed the interactions between the rounding physicians and other patient-care team members, including: nurses, consulting physicians, care coordinators, pharmacists, social workers, and therapists.

Results: This study resulted in identifying seven types of PIPs that occur during morning rounds. Additionally, the study presents the different ways that participants identified and managed the PIPs.

Discussion: We discuss the potential negative effects of PIPs on the patient-care workflow. We also discuss socio-technical recommendations for organizational policies and training, as well as electronic health record (EHR) design improvements that could help patient-care teams more effectively identify and manage PIPs.

Conclusion: Hospital teams rely on accurate, available, and up-to-date information in order to make informed decisions on patient care. However, PIPs exist in EHR systems, paper documents, and verbal conversations. This study identifies a set of PIPs and how they are currently being identified and managed.

1. INTRODUCTION

Patient-care teams are dependent on the availability of accurate information in order to make informed decisions about their patients. Morning rounds are an important time when the teams gather and discuss patient information in order to make decisions about diagnosis and treatment [11]. This is also a time when they deal with any problems that arise with the patients' information. We define *patient-related information problems* (PIPs) as issues related to clinical patient information (e.g., wrong, missing, incomplete information) that impact the patient-care team's ability to perform their work. The impact of PIPs can lead to additional work [13], confusion about what treatments or procedures were done to the patient [2], delayed patient-care decisions [23], decisions being made on wrong, outdated, or incomplete information [9, 23], and even medical errors that could harm the patients [2].

Researchers currently focus on what *causes* PIPs in hospitals [1, 2, 9, 10, 11, 14, 17, 23, 25, 26] and the *impact* that PIPs can have on the workflow of patient-care teams [2, 5, 6, 17, 23].

1.1. Causes of PIPs

PIPs can be caused by both the design of electronic health record (EHR) systems and by its users. Due to the structured and rule-based nature of EHR systems, data standardization mechanisms (e.g., drop-down menus, text entry restrictions) are frequently used, which can lead to PIPs caused by the system design [2]. Koppel et al. [17] discuss how EHR design can result in fragmented displays that prevent a coherent view of patients' medications, inflexible forms that lead to wrong orders, and segregation of functionality that result in double dosing on medication orders. Additionally, other studies describe how a medication ordering system automatically selected the default dosing resulting in inaccurate medication requests [1] and an EHR system bug that truncated data entry fields resulting in lost patient data [26].

Users can also be the cause of PIPs. Data entry errors, including the use of copy-and-paste functionality, can lead to wrong or outdated information being proliferated throughout the system [2, 9, 11, 25]. Additionally, Park, Lee, & Chen [23] and Collins et al., [9, 10] describe how clinicians delay information entry when they are too busy to enter patient data into the EHR directly after seeing the patient due to tight schedules or frequent interruptions, which leads to information in the patient record being outdated or incomplete for extended periods of time. Furthermore, Collins et al., [9] describe how patient-care teams, especially in emergency settings, prefer quick verbal communication to transfer patient information among team members instead of formally entering it into the EHR because "*it's a lot faster and easier to just ask,*" which can leave the patient's EHR record outdated or incomplete (p. e145).

1.2. Impacts of PIPs

Medical Informatics researchers have long studied the impacts that PIPs can have on the patient-care workflow. Some of these impacts include delayed procedures [17], confusion

about what treatments a patient received [2], medical decisions being made based on wrong or outdated information [23] and even the occurrence of medical errors that could harm patients [2, 16, 27]. The most critical impact that PIPs can have on patient-care is when they lead to medical errors that negatively affect the patient. In hospitals, a medical error is any mistake in administering or failing to administer patient care that may adversely affect the patient [27]. There are many hospital-related taxonomies that classify the types of medical errors that occur in the hospital in order to better understand how they happen and how they can be prevented from occurring in the future [13, 17, 27, 29, 31]. Many of these medical error taxonomies include types of patient information problems (e.g., wrong, missing, outdated information) that led to clinicians making a medical error.

Due to the pervasive implementation of HIT systems into hospitals, medical informatics researchers began investigating how HIT systems played a role in contributing to medical errors. In 1999, a report by the Institute of Medicine even stated that medical errors are caused by “*faulty systems, processes, and conditions that lead people to make mistakes or fail to prevent them*” [16]. This report motivated researchers to take a closer look at how HIT systems could lead to medical errors and has resulted in the development of HIT-related medical error taxonomies that have allowed system designers and practitioners to anticipate the unintended consequences that system design can have on medical errors [13, 17, 26, 29, 31]. According to these taxonomies, PIPs that exist in these health systems were listed as one of the reasons why medical errors occur.

Consequently, it is important that we not only examine what causes PIPs and their effects on workflow but also identify the different types of PIPs. By doing so, we can then begin to develop workflow and design solutions to address the specific types of PIPs. In order to do this, we undertook a qualitative research study of patient-care teams and their information use during morning rounds to start to identify the different PIPs that occur in the electronic health record (EHR). Furthermore, since there is still a limited understanding of how these PIPs are *managed* by patient-care teams, we also wanted to investigate how the patient-care teams identify and manage these PIPs from a workflow perspective. Therefore, this study focuses on classifying the types of PIP that arise during morning rounds and examining how the patient-care teams identify and manage the PIP that they encounter. Our study extends the existing research on the *causes* and *impacts* of PIPs to include how patient-care teams *identify* and *manage* PIPs that they encounter during daily patient rounds.

2. MATERIALS AND METHODS

2.1. Setting and Participants

Our study was conducted in the in-patient ward of a large teaching hospital in northeastern United States. The hospital has 551 beds and admits more than 25,000 patients per year. The first author shadowed 5 Internal Medicine (IM) physician teams in the in-patient ward of the hospital during morning rounds. These teams were led by an attending physician (“attending”) and included residents and interns. During the morning rounds, a care coordinator also rounded with the team and a pharmacist rounded with the team once a month as part of a multidisciplinary rounding initiative at the hospital. The shadowing also included observing the physician teams’ interactions with other members of the broader patient-care team, including nurses, consulting physicians (e.g., cardiology, neurology), therapists (e.g., occupational, physical), and social workers.

A total of 116 participants were observed during the study (Table 1). The IM team, care coordinators, and pharmacists were directly shadowed by the researcher who followed them throughout the hospital during their daily activities. Other members of the patient-care team were also observed and informally interviewed when they interacted with the IM physician team during the study. These other staff members were only included as study participants if they were involved in the discussion or management of a PIP.

Participant Role	Number
IM Attending	5
IM Resident	19
IM Intern	5
Care Coordinator	3
Pharmacist	2
Nurse	60
Consulting Physician	15
Therapist	4
Social Worker	3
TOTAL	116

Table 1. Study Participants by Role

The patient-care teams communicated, documented, and managed patient information using a variety of information sources, including:

- *Electronic health record (EHR) system*: Participants accessed this system using desktop computers at nurses’ stations and in workrooms, laptops carried during rounds, mobile devices (e.g, iPads, tablets), and the nurses’ computers-on-wheels (COWs) located in hallways.

- *Verbal communication:* Participants had conversations about patient information either face-to-face or on the phone (mobile and desk phones).
- *Paper-based notes:* Participants used “Patient Care Summary” reports printed from the EHR during rounds to make notes about changes in the patient’s status or tasks they needed to do for the patient. After rounds, any patient-related information was then documented in the EHR.

The EHR is the primary and preferred method for documenting patient data in the hospital. The hospital uses the Cerner Corporation’s Millennium EHR system, including the PowerChart, FirstNet, SurgiNet, and PharmNet modules. The system includes the patients’ medical records, laboratory and medication ordering, laboratory results, imaging results (e.g., x-rays, scans), clinical progress notes, and patient registration information. The hospital’s General Electric Centricity imaging system (i.e., picture archiving and communication system (PACS)) that generates and stores the x-rays and other scans is a separate system. However, the images are integrated with the Cerner EHR system so that the users can seamlessly view the imaging information within the EHR interface. Additionally, if a patient required heart monitor reports, they were printed on paper from the heart monitor machine and stored in a drawer outside the patient’s room.

In this study, 4 of the 5 attendings carried paper reports with handwritten notes and one attending carried a laptop during morning rounds. On occasion, the IM attendings without a laptop would access the EHR by using nurses’ computers-on-wheels (COWs) in the hallways outside patient rooms or desktop computers at nurses’ stations. The residents and interns carried paper reports with handwritten notes and also shared one team laptop that they would pass to each other throughout rounds. A few residents (2 of 19) and interns (3 of 5) also carried an iPad or tablet device to access the EHR system and make digital notes. The care coordinators rounding with the team carried paper reports with handwritten notes, and the pharmacists rounding with the team carried their own laptops as well as paper reports with handwritten notes about patients’ medications.

Hospital staff members are required to be regularly trained on organizational policies, including how to properly manage medical records in both electronic and paper form. We reviewed 30 information management policies that were part of the hospital staff’s training at our field site. The policies state that the medical record is the primary means of communication for all hospital staff and that every patient must have a documented medical record. The following is a summary of hospital policies that are relevant to this study:

- **Documentation Management:** Hospital policies state that the patient's data should be documented as soon as it is collected by the person who collected it, and it should be documented in only one place when possible. All electronic and paper records must "be authenticated," which requires the author's signature, and date and time of data entry. The unique login credentials for each employee are considered the author's electronic signature in the EHR system. The hospital's EHR system is called the "gold copy" and is the primary and preferred method for documenting patient data. A clinical team can print a Patient Care Summary from the system to be used as a Rounds Report. This report is considered a "*snapshot in time of the patient's values and signs*" and includes the physician's handwritten notes taken during rounds.
- **Documentation Modification:** All entries made to the EHR or paper medical records are never removed or deleted. However, if the data requires modification, a staff member can only modify his/her own data entry by making the modification and providing a reason for the modification. Clinicians may not modify other clinicians' documentation unless they are authorized to do so (e.g., an attending may modify a resident's progress note with proper annotations when co-signing the note). The policies also discourage the use of abbreviations, and when one is used, staff should ensure it is listed on the hospital's list of approved abbreviations.
- **Documentation Accountability:** According to the hospital policies, the attending physician of the patient is "ultimately" accountable for preparing and completing an accurate medical record for every patient in his/her care. The registered nurse assigned to the patient is also "ultimately" accountable for keeping an accurate and complete record of the patient's activities, ongoing progress, and responses to care.

2.2. Data Collection

In this study, we employed qualitative data collection methods [2, 5, 23, 24]. The first author shadowed the IM teams during 29 morning rounds over 3 months resulting in 155 hours of observations. The observations primarily focused on shadowing the patient care team during morning rounds and conducting informal interviews to clarify assumptions and gather the opinions of the participants.

During shadowing, the first author met the IM physician team in the resident workroom each morning between 5-8 am and follow the team through their morning rounding activities until approximately 2-3 pm. The observed rounding activities included: reviewing and discussing the patients' records, visiting and assessing 10-16 patients in their rooms, talking to other team members about the patients (e.g., nurses, consulting physicians, care coordinators, social workers), updating patient records in the EHR, and making decisions about the patients' treatments, tests, and diagnoses. The observations primarily focused on the morning rounds because this is the time when the team was thoroughly reviewing patient records together and, therefore, more likely to discuss any problems that they had with the

information in the patient record (i.e. identifying PIPs). The first author also observed other patient-care activities outside the morning rounds, including: hand-off discussions between night and day shift, pre-rounds by the residents and interns, EHR documentation in the resident workroom, and new in-patient admissions in the emergency department (ED). The first author observed the teams' activities in hallways, workrooms, patient rooms, and nurses' stations. Detailed field notes were taken in a paper notebook about the participants' workflow, communication, collaboration, documentation, and use of information technology.

The first author also conducted informal interviews with participants during shadowing to clarify assumptions, obtain additional information about specific situations, and ask the participants for their opinions on a variety of different topics. These topics included:

- *Hospital-specific terms and processes* (e.g., questions about how the hospital is structured, role and responsibility of various team members, definition of acronyms, opinions on how different units manage and communicate information),
- *Identification of PIPs* (e.g., questions about how participants identify PIPs, how PIPs affect their work), and
- *Management of PIPs* (e.g., questions about who participants thought are responsible for specific tasks, how work is delegated among the team members, who is responsible for fixing PIPs that occur, how participants resolve unclear or conflicting assumptions about responsibilities for tasks).

During shadowing and informal interviews, the first author took detailed field notes in a paper notebook, which was the most discrete and efficient way to capture data while moving throughout the hospital. In order to account for differences in the behaviors and opinions of the individual participants and rounding teams, an anonymized identifier was assigned to each participant based on his/her role (e.g., N01, N02, N03 for nurses, etc.) and a log was created to document which participants were part of each rounding team and hospital unit. Additionally, to protect the privacy of participants, the researcher did not record any personally identifiable information during the shadowing or interviewing activities. The handwritten field notes were then transcribed into a Word document within one day of the data collection. Throughout the study, the data was reviewed in an iterative, systematic way to ensure that the researcher was capturing rich, descriptive data that addressed the study's objectives. The study was approved by the university Institutional Review Board.

We used qualitative methods because it allowed for the observation of participants' naturalistic processes and behaviors through field site immersion [18]. Our observations resulted in detailed descriptions of the participants' processes and behaviors related to how they identify and manage PIP, which were situated within the real-time context of the participants' daily, collaborative patient-care activities [19]. These qualitative methods have also been used in other biomedical informatics studies for a similar purpose [2, 5, 23, 24]. We also specifically choose to study morning rounds because this is a highly collaborative,

information-intensive activity where patient-care team members are communicating, documenting, and making decisions on patient information.

2.3. Data Analysis

The transcriptions resulted in 280 pages of electronic transcribed data. We analyzed the data using Braun & Clarke's thematic analysis approach [8]. This analytical approach facilitates the process of becoming familiar with the data, and systematically organizing individual coded data into broader final themes (Figure 1). The first author iteratively performed this analysis during data collections so that the themes were progressively refined as more data was collected throughout the study.

More specifically, the first author created *individual codes* in the data any time there was a field note about a patient information problem being discussed by the team (e.g., the attending physician cannot find the assessment note from the consulting Cardiology physicians in the EHR). All of the individual codes were then grouped into *preliminary themes* based on prevalent similarities identified across all of the individual codes (e.g., missing information found in the EHR). The preliminary themes were then grouped into broader *final themes* that were named, defined, and bounded to be mutually exclusive (e.g., missing information). This data analysis process resulted in the themes described in the findings section. There were no *a priori* codes used as part of this data analysis. The resulting themes (e.g., types of PIPs) are grounded in the data itself and were generated through the described thematic analysis process.

Figure 1. Example of the Thematic Analysis Approach

PIP Type	Description	Examples (from observation field notes)
Wrong	Information is not accurate.	<i>When the physician team exits the patient's room, the rounding pharmacist tells the team that the patient is on the medication "Penicillamine" and asks if this is correct, or if it is supposed to be the very similar sounding medication "Penicillin V" instead. After reviewing the medication list and patient history, the team realizes that the wrong medication was carried over in the system from the ED admission. The patient was supposed to be on Penicillin V.</i>
Missing	Information is expected to be there, but it is not.	<i>The attending physician points out that there are no assessment notes in the system from Cardiology even though they said that they saw the patient last night and would provide notes afterwards.</i>
Incomplete	Only part of the information is provided.	<i>The resident says that the Urology assessment notes in the system mention that they "placed the stent" but not that they also "removed gritty stones," which they had told the resident they did while discussing the patient over the phone. The attending mentioned that the removal of gritty stones is good to know about and it should have been included in their notes.</i>
Outdated	Information that frequently changes is no longer accurate and has not been updated.	<i>During morning rounds, a resident says that the system is showing older inputs and outputs for a patient from 5pm yesterday and they need to talk to the nurse to provide more recent numbers before they decide on next steps.</i>
Unclear Meaning	There is uncertainty about the meaning of the information.	<i>The physician team is reviewing surgery notes and the attending says, "There's a recommendation for 'CLD'? What does 'CLD' mean?" The two medical residents do not know. One resident looks it up on her iPhone and after a few minutes says, "Oh I think it means 'clear liquid diet.' I've never seen that used as an acronym before." The others agree and discuss how they are confused about why surgery still wants the patient on a clear liquid diet. The</i>

PIP Type	Description	Examples (from observation field notes)
		<i>attending says, "I don't see why she still needs to be on a 'CLD' as they call it, if that's what 'CLD' actually means. We should follow-up with them to figure out what's going on."</i>
Questionable Accuracy	There is uncertainty about the correctness of the information and there is no way to verify if the original information is correct or not.	<i>The physician team visits 3 patients in the ICU and they all have lower than expected blood sugar levels. The attending says, "this patient seems low, the other guy seems low, they all seem lower than they should be. I'm seeing a trend, maybe something is up?" They look for the nurse and ask her to do the blood sugar tests again.</i>
Segregated	Multiple pieces of related information are stored in different locations and are not easily viewed together.	<i>A resident explains that the night shift's notes don't specify which anti-coagulant the patient was given. The attending tells the resident to look it up in the pharmacy system. The resident says "yes, but it's such a pain, why can't they just write it in the notes."</i>

Table 2. Classification of Patient Information Problems

3. RESULTS

3.1. What are PIPs?

We define PIPs as any issues in patient information (e.g., wrong, missing, incomplete information) that impact the patient-care team's ability to perform their work. These impacts can include preventing or delaying patient-care decisions or activities until the PIP is managed. During our study, we identified 120 discrete PIPs and classified these PIPs into seven types (Table 2).

The 120 PIPs occurred during one of three different communication modes: (1) viewing the EHR system, (2) verbally communicating with others (i.e. face-to-face or phone discussion), or (3) referencing paper-based notes. Although the participants used both EHRs and paper reports as their source of patient information during rounds, the participants identified 69% of PIPs while viewing the EHR system. The hospital policies state that the EHR system is the official source of patient data. Therefore, this was the primary source of patient information for the participants, and where the participants identified a majority of PIPs. However, when participants are busy and unable to immediately enter information into the EHR, they verbally communicated with other team members to get the most recent information and used paper-based notes to temporarily store information until they were able to enter it into the EHR system. This is why some PIPs were identified during these other information management activities outside the EHR system.

Understanding the types of PIPs can provide researchers, designers, and hospitals with an overview of the various types of PIPs that occur, and provide a foundation for discussing how patient-care teams can better identify and manage the different types of PIPs before they lead to medical errors. Although this single study cannot provide an exhaustive list of PIPs that occur in hospitals, it does provide a preliminary PIP categorization that should be further refined as more research is conducted.

3.2. How are PIPs Identified?

Patient information problems continue to persist in documentation and discussions until someone clearly identifies them as a problem. Therefore, another focus of this study was to understand how the patient-care teams identified each type of PIP (Table 3).

The PIPs were identified in four ways:

- *Not finding needed information*: Team members were simply unable to find information they were searching for.
- *Encountering conflicting information*: Team members identified a discrepancy between two sources of information.

- *Making sense of information:* Team members questioned the accuracy of information based on their medical training, experience, and knowledge of the patients' conditions.
- *Generalizing unreliable sources of information:* Team members associated certain hospital units as having a reputation for being unreliable sources of information.

PIP Type	Not Finding Needed Information	Encountering Conflicting Information	Making Sense of Information	Generalizing Unreliable Information Sources
Wrong	0	16	9	1
Missing	24	6	1	1
Incomplete	18	2	2	2
Outdated	0	2	6	0
Unclear Meaning	0	3	2	0
Questionable Accuracy	0	9	7	1
Segregated	8	0	0	0
TOTAL	50 (42%)	38 (32%)	27 (23%)	5 (4%)
n = 120				

Table 3. Identification of Patient Information Problems

Team members identified 42% of the PIPs when they came across missing, incomplete, and segregated information when they were *not able to find* information that they needed. In one observed situation, an attending was looking up the medication list for a patient admitted from the ED and could not find it. This was because the ED staff did not have time to enter the medications into the system before the patient was transferred to in-patient, so the attending had to ask the patient for his medications again. In this case, the lack of transferring accurate and complete information during the transfer of the patient from the ED to the in-patient ward caused a PIP for the in-patient team.

Additionally, team members identified 32% of the PIPs when they *encountered conflicting information*. In one instance, a patient's intake status was listed as "NPO except meds" in the system, but the nurse said that a resident told her that morning that the patient could have liquids; however, that resident forgot to update the status in the system. Therefore, this PIP was not identified until the team realized that the nurse and the EHR were presenting conflicting information.

Team members also identified 23% of the PIPs when they were trying to *make sense* of the information based on their medical training, experience, and knowledge of the patient. This most frequently helped to identify patient information that was *wrong*, had *questionable accuracy*, or was *unclear*. There were a number of times when an acronym was used in the patient's record that was either unknown or had a different meaning to multiple participants. In one incident, a nurse and a resident had a conflicting understanding of what the term "PRN" meant. The nurse believed it meant that the physicians would tell her when to do the

procedure. Whereas, the resident believed that PRN meant the nurse should just use her best judgment for when to give the procedure to the patient, which lead to the patient not receiving a needed procedure. The process of making sense of the term helped the team identify the PIP.

Lastly, participants identified 4% of the PIPs by associating certain hospital units with poor documentation practices. This resulted in identifying information that was wrong, missing, incomplete, or had questionable accuracy. Although this is a small percentage of individually identified PIP, the act of generalizing units as unreliable sources of information resulted in a noticeable frustration and distrust between different units.

3.4 Who Identified the PIPs?

A variety of roles were responsible for helping to identify PIPs, including: residents or interns, attending physicians, nurses, patients, patients' family members, pharmacists, and care coordinators (Table 4).

Since the teams primarily consisted of physicians, it is understandable that a majority of the roles who identified PIPs were the medical residents/interns and attendings. However, we also identified that nurses, pharmacists, care coordinators, and even the patients and patients' families helped to identify PIPs. More specifically, these results highlight the critical role that nurses can play in PIP identification. For instance, they identified the same amount of *wrong* information as the residents/interns. Additionally, there were numerous times that nurses followed-up with the physicians in the team about a PIP. This highlights the importance of team members double-checking and communicating concerns about information to one another. This collaborative effort to manage PIPs can prevent the problems from persisting in the documentation, and, more importantly, it can prevent any negative impacts to the patients.

PIP Type	Resident/ Intern	Attending	Nurse	Patient	Patient's Family	Pharmacist	Care Coordinator
Wrong	6	8	6	2	1	2	1
Missing	14	11	3	2	3	1	0
Incomplete	11	11	2	0	0	0	1
Outdated	4	2	0	0	0	0	0
Unclear Meaning	3	1	3	0	0	0	0
Questionable Accuracy	10	9	3	0	0	0	0
Segregated	5	2	1	0	0	0	0
TOTAL	53 (41%)	44 (34%)	18 (14%)	4 (4%)	4 (3%)	3 (2%)	2 (1%)
n = 128*							

Table 4. Roles Who Identified Patient Information Problems¹

¹ In some cases, multiple roles helped to identify one PIP, which is why there are 128 roles identifying 120 PIP.

3.5. How are Patient Information Problems Managed?

After participants identified PIP, they then responded by managing the PIP in a way that helped them continue with their work. We identified five ways in which participants managed the different types of PIPs (Table 5):

- *Find more information about the PIP*: When participants sought out other individuals or systems that could provide them with more information about the PIP.
- *Fix the PIP themselves*: When participants had the knowledge and system rights to directly fix the PIP.
- *Find someone to fix the PIP*: When participants could not fix the PIP themselves due to lack of knowledge or system rights, so they had to find the person(s) who could fix the PIP.
- *Ignore the PIP*: When participants did not need the information to accomplish any immediate tasks, so they continued with their work and did not attempt to fix the PIP.
- *Work around the PIP*: When participants still needed to accomplish an immediate task, so they found a way to continue their work without the information and did not attempt to fix the PIP.

PIP Type	Find more information	Fix themselves	Find someone to fix	Ignore	Work around
Wrong	4	13	8	0	1
Missing	5	12	14	0	1
Incomplete	13	2	4	4	1
Outdated	0	2	5	1	0
Unclear Meaning	2	2	0	0	1
Questionable Accuracy	9	4	1	3	0
Segregated	7	1	0	0	0
TOTAL	40 (33%)	36 (30%)	32 (27%)	8 (7%)	4 (3%)
	n = 120				

Table 5. Management of Patient Information Problems

When participants encountered PIPs, they had to collaborate with others in order to *find someone to fix* the problem or *find more information* about the problem in order to proceed 60% of the time. Researchers have discussed how hospital teams are highly collaborative and dependent on each other to perform patient-care tasks [2, 5, 9, 24]. This finding further supports this point by highlighting how the collaborative management of PIPs is critical to maintaining accurate patient records.

Participants had to *find more information* 33% of the time in order to manage the PIPs. Additionally, 27% of the time, participants were unable to fix the PIPs themselves and had to *find another person to fix* the problem. This was especially true if the person who identified the problem was not authorized to change the information in the system or needed verification from someone else before proceeding. Finally, 10% of the time, the PIP did not directly relate to the participants' work, so they either found a way to *work around* it or *ignore* it. This resulted in the PIP not being resolved and still persisting in the system.

4. DISCUSSION

In this section, we discuss how PIPs can impact the workflow and then provide socio-technical recommendations for improving organizational policies and EHR design to help patient-care teams better identify and manage PIPs they encounter during their work.

4.1. Impact of PIPs on Patient-Care Workflow

Due to the distributed, mobile, and multi-tasking nature of hospital work [4, 7, 9, 10, 21], patient-care teams rely on the EHR system to keep them updated on the status of the patient while they work throughout the hospital. This means that team members rely on each other to provide accurate and up-to-date information about their shared patients. The EHR can provide a centralized view of a patient's history and current status, which creates a shared awareness of that patient across the entire patient-care team, even when team members are physically dispersed throughout the hospital. However, when a team member encounters a PIP, it does not just affect the one team member who identifies the problem. It can also affect the entire patient-care team who relies on the accuracy and completeness of that information to do their work [2, 5, 6, 17, 23]. Therefore, the way in which team members manage PIPs can impact the entire team's shared understanding of a patient. In this study, when there was a problem with the patient information, the team members who identified the PIP either fixed the PIP, or they found a way to work around or ignore the PIP. Both of these responses led to cascading effects on the collaborative work of the patient-care team. These cascading effects include delayed work and persistent errors.

If team members take on the responsibility of managing the PIP, it typically leads to additional work of tracking down other people to obtain the needed information or spending time searching through other sources of information (e.g., paper notes, other systems). This then delays their own patient-care tasks [5], which can result in patients waiting for decisions related to their diagnosis, treatment, or discharge plans. On the other hand, team members may choose to work around the PIP and not fix it. This then results in PIPs that persist in the EHR system and have a cascading effect on other members of the team [15]. These cascading effects included multiple people doing the same work, multiple teams ordering the same test, confusion about treatment decisions, and frustration and tension between units or roles.

The challenge of PIPs lies not just in the fact that they need to be properly identified but also that if they are not properly managed, they can persist and continue to create problems in the patient-care workflow.

4.2. Informing Organizational Policies by Understanding PIP Identification and Management

The identification of medical errors associated with hospital systems [17, 31] have allowed system designers and practitioners to anticipate the unintended consequences that system design can have on medical errors and improve the system design to reduce these medical errors [13]. Additionally, researchers studying clinical decision support systems [3, 29, 30] have generated categories of tool capabilities that can help designers and practitioners effectively evaluate systems and implement functionality that better supports clinical decision-making. Similarly, this study has resulted in a preliminary classification of seven categories of PIPs. This classification can help medical informatics researchers, EHR designers, practitioners, and hospital administration become more aware of existing PIPs and anticipate future PIPs. Additionally, looking at patterns within this classification data can help inform improvements to organizational policies and EHR design.

The classification of PIPs can increase hospital staff's awareness about the existence of these information problems and what they actually look like within the context of their own work. The discussion about how the PIPs are identified and managed can also guide the patient-care teams on the behaviors that best identify and manage the PIPs. For instance, certain PIP identification and management activities lead to the PIP being resolved before it impacts the patient-care process. When hospital staff better understand how to successfully identify and manage PIPs, it can prevent PIPs from becoming medical errors that negatively impact the patient [13, 17, 31]. Additionally, the PIP classification can also make hospital administrators more aware of socio-technical factors that can influence the teams' abilities to identify and manage the PIPs. This can result in improvements to hospital policies, training, and processes.

For example, certain hospital units may have a reputation for poor documentation. One activity that patient-care teams use to identify PIPs is *generalizing sources of unreliable information*, such as when team members view documentation from one unit (e.g., the emergency department) as incomplete or unreliable. The types of PIPs identified while generalizing other units as unreliable were *questionable accuracy*, *incomplete*, and *unclear information*. Additionally, the three most common sources of these PIPs were the ED, surgical ward, and local VA hospital.

Therefore, analyzing the data using the PIP classification can help identify the specific sources of unreliable information for specific types of PIP. Looking at patterns like this could help hospitals create targeted training or policies that aim to improve documentation

practices in units or facilities that frequently cause PIPs. However, since the reputation and work practices of specific units or facilities might be difficult to change, this PIP analysis could also result in developing EHR system features that color-code or clearly indicate which unit provided the patient information in the EHR system. This could at least make team members visually aware of who provided the patient information and denote if it is a unit or facility who is known for having poor documentation.

4.3. Informing EHR Design by Understanding PIP Identification and Management

The design of EHRs allows for patient information to be dynamically displayed in a digital format that can be viewed from a variety of distributed locations (e.g., computers, laptops, mobile devices). This differs from paper records that include static information with visual cues indicating who updated the record (e.g., signature, initials, handwriting) and when it was updated (e.g., date, change in ink, new sheet of paper) [28]. This shift from paper to electronic documentation changes the way that patient-care teams enter, view, and share information and how they do their work. Therefore, given the serious effects that PIPs can have on patient care [2, 5, 6, 17, 23], it is important to better understand how PIPs are identified and managed by patient-care teams in order to provide insight into how to more effectively design EHRs. The following design recommendations focus on improving EHR system design to help users more effectively identify and manage PIPs.

Connecting segregated data: The segregated design of EHR systems results in users having to enter and review patient data across many different fields located on many different screens. This results in users losing a cohesive overview of the patients' records and, at times, the ability to identify emerging problems with the patient [2]. This study classified *segregated data* as a PIP that many team members encountered during work. Participants primarily acknowledged segregated data when they needed to know who ordered a medication/test/procedure and why that medication/test/procedure was ordered, which resulted in user frustration and additional work to piece together the segregated data. Therefore, EHR designers should consider how to make system interfaces more responsive to users' information needs. This could include linking standardized fields (e.g., medication orders) to free-text fields (e.g., progress notes that state why the medications were ordered) by allowing users to click or hover over fields to see additional information. Miller et al. have proposed the use of hover boxes in EHRs that allow users to hover over the "first-line information" in order to see additional information that can then be "saved, printed, or copied into the patient record" if relevant [20]. This design recommendation could help decrease the occurrence of the *segregated data* PIP type and prevent team members from having to delay their patient-care work to piece together the segregated information.

Consider the *segregated data* findings where a clinician is looking in one area of the EHR (e.g., in the patient's record where they see that the patient is on medication), but she needs information from another area of the system (e.g., the progress note from the previous shift to

understand who ordered the medication and why it was ordered). In order to find out who ordered a patient's medication and why it was ordered, the clinician has to leave the current EHR screen and spend additional time searching for the information that she needs within other areas of the system. This task could be simplified if the EHR included functionality that would allow users to visually connect this segregated patient information (Figures 2 and 3).

Figure 2. User right-clicks and selects “View order details”

Figure 3. System displays a hover box that connects segregated data

Flagging and annotating PIPs: During rounds, the patient-care team focused on discussing the patient and deciding on next steps in the care plan. When they encounter a PIP, they frequently waited until after rounds to manage the problems and/or obtain the necessary information. However, this delay in PIP management allows the problems to persist in the system and potentially affects any other team member who also relies on the accuracy of that information in the EHR. Therefore, including a flagging mechanism in EHRs would allow users to flag and annotate information in order to alert other members that there is a concern with the accuracy of the data [22]. This allows team members to notify others without having to interrupt their own work to immediately fix the PIP. This flagging mechanism also visually alerts the authors of the information that there is something questionable about their original data entry. This flagging and annotating function can also start a dialogue between team members about who is responsible for fixing the PIP if there are multiple team members responsible for fixing it.

Consider the previous example where a physician is questioning why a patient is still on a medication. If that physician believes that the patient no longer needs to be on the medication, but wants to verify a few things first, she may leave the medication order in the system. However, the nurse who is responsible for medication administration would still see the medication order as active in the system. This could lead to the nurse giving the patient the medication even though the physician believes that the patient may not need the medication anymore. The only way for the nurse to know that the patient may not need his medication is if the physician calls or pages the nurse this information, if she remembers to do so. In order to improve awareness across the team, the system could include a flagging function that would visually alert anyone looking at patient's record that the medication order was currently being discussed. An annotation function could also allow users to write a short, temporary note that explains the flagged information. (Figures 4, 5, and 6).

Figure 4. User right-clicks and selects “Flag item”

Figure 5. System flags the PIP using red text and a flag icon

Figure 6. User adds an annotated comment to the flagged data

5. STUDY LIMITATIONS

A limitation of this study is that a single researcher collected the data. One researcher is not able to observe all instances of PIPs that occurred, nor follow the management of every PIP over time. However, the study's goal was not to present an exhaustive list of PIPs, but rather to start to identify common PIPs that occur during rounds and how they were identified and managed by the patient-care teams. We believe that we were able to achieve this in the study.

6. CONCLUSION

Patient information problems frequently occur in hospitals and can negatively impact the patient-care workflow and potentially cause harm to patients. This study classifies some common types of PIPs that patient-care teams encountered during their morning rounds and identifies how team members identified and managed them. By better understanding the types of PIPs that occur and how they are currently identified and managed, hospitals could reduce the negative impact of the PIPs on their patient-care workflow and design better EHR systems that help patient-care teams more effectively identify and manage the PIPs.

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