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Pediatric Resident Use, Perceptions, and Desires for Improvement of a Clinical Secure Messaging Application

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PII: S2666-9900(24)00029-6
DOI: https://doi.org/10.1016/j.cmpbup.2024.100162
Reference: CMPBUP 100162

To appear in: *Computer Methods and Programs in Biomedicine Update*

Received date: 19 January 2024
Revised date: 2 July 2024
Accepted date: 17 August 2024

Please cite this article as: Andrew W Halterman , Anneli R Cochrane , Andrew D Miller , Joy L Lee , William E Bennett , Emily L Mueller , Pediatric Resident Use, Perceptions, and Desires for Improvement of a Clinical Secure Messaging Application, *Computer Methods and Programs in Biomedicine Update* (2024), doi: https://doi.org/10.1016/j.cmpbup.2024.100162

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Highlights.

- We explored the use of a secure messaging app by residents at our institution.
- Users disagreed on appropriate use of secure messaging for acute patient care needs.
- Few residents are satisfied with training in the use of secure messaging.
- Secure messaging may replace traditional paging, but there are gaps in current use.

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Pediatric Resident Use, Perceptions, and Desires for Improvement of a Clinical Secure Messaging Application

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STM	Secure Text Messaging
PGY	Post Graduate Year
HIPAA	Health Insurance Portability and Accountability Act
ED	Emergency Department
TeamSTEPPS	Team Strategies and Tools to Enhance Performance and Patient Safety

Keywords: Computer-mediated communication, Mobile technology, Interprofessional collaboration

Abstract

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Background: Hospitals are transitioning away from traditional pagers to secure text messaging (STM) applications. STM is perceived to improve efficiency and accessibility. There is limited research on user's impressions of how STM impacts patient safety, provider wellness, and quality of patient care.

Objectives: To understand the use and perceptions of a clinical STM by pediatric residents at a free-standing quaternary care children's hospital.

Methods: A survey was conducted of pediatric residents regarding their experience with Diagnotes®. Demographic data were obtained along with use patterns, ability to perform tasks, and perceptions of intended purpose. Further questions evaluated agreement with communication strategies and satisfaction with features. Three open-ended questions asked about experience where STM impacted (1) patient care coordination and (2) patient safety. A final question asked for any additional STM feedback.

Results: Of 169 surveys, there were 112 respondents (66.3% response rate). Respondents unanimously endorsed daily STM use on their personal mobile devices with good knowledge of basic features. Respondents were overall satisfied with Diagnotes® (73.9%) including the ability to communicate efficiently (84.8%) and effectively (79.5%). Yet only 32.1% were satisfied with Diagnotes® training. Only 59.5% believed Diagnotes® was appropriate for urgent patient care needs and only 43.2% believed its purpose was to inform the team of patient emergencies. Key qualitative themes included improved coordination of patient care tasks through STM, but there were concerns raised around sending and receiving messages, the additional cognitive burden placed by STM, and differences in culture of use that created conflict.

Conclusions: Diagnotes® is viewed positively including use for effective coordination of patient care and familiarity of functions of Diagnotes®. Barriers included unclear interprofessional expectations for use. Future research should incorporate a broad range of healthcare professionals' perceptions and co-creation of STM best practice guidelines for use, including around urgent or emergent patient care issues.

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Introduction

Technology is rapidly changing the way healthcare professionals communicate. Historically, healthcare institutions have relied on one-way alphanumeric paging systems. Now, many institutions have recognized their limitations and implemented new systems, including: two-way paging, [1-4] task management systems, [5,6] display-based paging,[7] and other tools directly integrated into the electronic medical record.[8] Providers generally find these systems useful, often citing their convenience, the ability to triage messages and to respond more quickly to relevant pages.[9] Yet, these systems can also provide unintended consequences such as frequent interruption to workflow and notification fatigue.[10] Such consequences can have significant impact on patient safety, healthcare professional wellbeing, and ultimately quality of patient care.

At our institution, a free-standing children's hospital, pagers have been replaced by Diagnotes®, a smartphone and computer-based secure text messaging (STM) application. As an academic children's hospital, residents are an integral part of the patient care team as they are often the first point-of-contact when making treatment decisions for patients admitted to the hospital. They are members of all service care teams within the hospital including those with admitting service roles and among the consulting services. Therefore, we considered them as key stakeholders given their role in the use of the Diagnotes® application. The purpose of this study was to elicit pediatric residents' current use, perceptions, and desires for improvement of Diagnotes®. We hypothesized that resident perceptions of Diagnotes® would be generally positive but that there may be aspects concerning to residents. The results of this study will be used to determine future research interventions to impact care coordination and ensure high quality, safe patient care while using the STM application.

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Methods

Eligibility and Survey Distribution

Participants were identified through an institutional list of all pediatric residents and their associated emails. They were eligible to complete the survey if they were a current resident who rotated on the pediatric services at Riley Hospital for Children.

The survey was sent by email via Qualtrics (Provo, UT), with 2 reminders one week apart (January 2023) (See Appendix for survey). Links to the survey were connected to the potential participant's email address so that only pediatric residents at Riley Hospital for Children could complete the survey and only those who did not complete the survey received reminders. Upon opening the Qualtrics link, potential participants were given the study information sheet then asked to respond to the question "Do you agree to participate in this survey?" to proceed with the survey. Participants received a $10 Amazon gift card as incentive for participation. The study was approved by the Institutional Review Board at Indiana University (IRB #17460).

Description of Secure Text Messaging Application

The Diagnotes® application is a HIPAA-compliant STM application with both mobile health application and web-based versions. Communication can be via one-on-one text messaging, group text messaging, and through "Rooms" where healthcare professionals can either join the room or broadcast (send a one-way message without joining the room) into the Room. Features include being able to directly message to the individuals in a room using "@oncall" or to direct a message at specific individuals using "@name". Users can search for contacts using either the

"Schedules" tab or the directory, where each option can be included as a user's favorite contact. Diagnotes® is designated by our hospital system as the sole means of secure communication between all healthcare providers when discussing patient care.

Survey

In the online survey, participants completed basic demographic questions which included age, gender, and pediatric residency program training level. Next, participants were asked a series of questions intended to help us understand residents' current use and experience with Diagnotes®. They were asked what devices they use Diagnotes® with, what platform they use it on, their use during an inpatient/emergency department (ED) rotation, and which tasks they knew how to perform in Diagnotes®. Next, they were asked about their understanding of the purpose of Diagnotes®, their opinions about and level of satisfaction with its functions and use, and their expectations for timing of reading and responding to a Diagnotes® message. Finally, there were three open-ended questions that were qualitatively explored. Participants were asked to share an experience in which Diagnotes® positively or negatively impacted (1) patient care coordination and (2) patient safety. The third open-ended question asked the participants for any other feedback about Diagnotes®. The survey was created by the research team and piloted with non-resident physicians with refinements to improve clarity and ease of completion (see Appendix).

Analysis

Quantitative survey data were analyzed using Qualtrics, Microsoft Excel, and SAS 9.4 (Carey, NC). Comparisons were done in SAS and Fisher's Exact Test for small sample sizes generated p-values. Comparisons were considered significant if less than 0.05. Satisfaction levels for

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comparisons were combined into satisfied, neutral, and dissatisfied due to small sample sizes. PGY categories for comparisons were combined into four categories as follows: (1) PGY1, (2) PGY2-3, (3) PGY4, and (4) PGY5-6.

To evaluate usability, we utilized the System Usability Scale (SUS),[11,12] which has ten questions on a 5-point Likert scale (from "not important" to "very important"). The SUS has a calculated final score that is based on a well-established reference standard and is suitable for use even among small populations. A higher SUS score indicates better product usability by the participants evaluated.

Qualitative data was analyzed using Microsoft Excel and Dedoose (version 9.0.107). First, two members of the research team (ARC, ELM) independently reviewed each response and assigned codes based on an initial codebook based on both positive and negative themes. Further coding was iteratively revised based on new themes that emerged through data review.[13-15] We continued to code and seek new themes until no further novel concepts were revealed. A final review was performed between both team members (ARC, ELM) until agreement on codes and themes was obtained. All members of the study team then met to discuss and approve the final codes and themes.

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Results

Survey Response

A total of 169 surveys were sent, and all were successfully delivered. A total of 118 residents responded to the survey, three did not consent to participate, and three completed less than 75%

of the survey. Our final data set included a total of 112 residents who completed the survey at 75% or higher, which was a response rate of 66.3%. For the qualitative data, 69 of the 112 respondents (61.6%) offered written comments in at least one open-ended question that were utilized for qualitative evaluation.

Demographics and Use

Demographics of the residents and types of use are included in Table 1. They had a median age of 29 (range: 25-41), were mostly female (67%), and were primarily PGY-1 (29%), PGY-2 (27.2%), or PGY-3 (25.4%). All residents used Diagnotes® on their personal mobile phone, followed by 97 who used their work computer (86.6%), while only 12 (10.7%) used it on their personal computer. On mobile devices, Diagnotes® was most often used on Apple iOS (n=98, 87.5%) and only 14 participants (12.5%) used on Android. Ninety participants (80.4%) used the web-based computer version. All residents used Diagnotes® daily during their inpatient/ED rotation.

Quantitative Survey Evaluation

Satisfaction with Diagnotes®. Most participants were satisfied with the overall experience using Diagnotes® (73.9%) and in their ability to navigate the app (83.0%). When asked about satisfaction with key components of communicating with Diagnotes®, most were satisfied with the ability to communicate efficiently (84.8%) and effectively (79.5%). A minority of respondents (32.1%) were satisfied with the training they received on using Diagnotes®.

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Perceived Purpose and Communication Needs. There was overall agreement that the purpose of Diagnotes® was to replace pagers (92.8%) and coordinate the care of patients (90.1%).. Yet only 59.5% believed that Diagnotes® should be used to discuss urgent patient care needs and 43.2% believed its purpose was to inform the team of patient emergencies. When given patient care scenarios, participants stated agreement that there was a need for in-person or phone conversation: 40.5% for conversations between sender and recipient for a message that is broadcast into a room, 59.8% for new consults between services, 74.1% for new admission discussion between resident and attending, and 88.4% for urgent or emergent messaging between sender and recipient.

Resident Task Performance. A summary of residents' experience with Diagnotes® is presented in Table 2. Among the listed tasks, those that were most familiar to the participants included: sending a message to one recipient (100%), broadcasting into a room (100%), sending a message to multiple recipients (98.2), adding a recipient to a message you are already part of (98.2%), and removing yourself from a message (97.3%). Tasks that were least familiar to the participants included: making a contact part of your favorites list (17%), searching the directory by filtering only your favorites (17%), finding who is the first contact for a non-provider service (18.8%), and creating a room (34.8%).

Read and Respond Expectations. Participants expected recipients to read a sent message within 11 minutes (mean, SD 6.3 minutes), with the minimum of two minutes to the maximum of 30 minutes. Participants expected recipients to respond to a received message in 18.5 minutes (mean, SD 9.0 minutes), with a minimum of five minutes and a maximum of 45 minutes.

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System Usability Score. There was an average SUS score of 72.3 with a 95% confidence interval of 69.3 to 75.2. This falls above the generally recognized lower limit of acceptability for technology applications (70 or greater).[11,12]

Comparisons by PGY categories. When we compared level of satisfaction by our PGY categories for the following statements: ability to communicate efficiently, ability to communicate effectively, ability to navigate the app, training for use of Diagnotes®, and overall experience with Diagnotes®, there was no statistically significant difference found. All *p* values were greater than 0.05.

Qualitative Evaluation

Qualitative topics, themes, and subthemes are summarized in Table 3.

Facilitators. Regarding the positive attributes of Diagnotes, respondents appreciated the ability to communicate and collaborate within the care team, for outside consults, and the ability to triage messages.

Barriers. The residents made many comments related to barriers to patient care coordination and safety, and barriers to an overall positive experience. These comments were divided into three main themes: (1) sender/receiver issues, (2) cognitive burden, and (3) culture of use. Subthemes within sender/receiver issues included messages being sent to the incorrect recipient, response time delay, and issues surrounding notifications that were delayed or ineffective. Cognitive

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burden included notification fatigue, difficulties discerning which patient was being discussed, and lack of closed loop communication. Lastly, many barriers surrounding culture of use were noted. These included overall etiquette differences, physician vs. nurse use difference (such as nursing being without a mobile device), urgent concerns with no other way of contacting the intended recipient, and unclear expectations for urgent issues.

User Interface Experience. Several themes emerged that were related to the user interface experience. Many residents noted problems with the on-call schedule and the ability to find out who was on call. Other themes included ongoing technical issues, search function problems, a lack of notification after being added to a conversation, and a wish list for improvements. Ongoing technical issues included issues like inconsistent hospital Wi-Fi access, search function noted a lack of naming convention for various services throughout the hospital, lack of notification after being added to a conversation resulting in missed communication. The wish list included desired features for an improved STM.

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Discussion

This survey of residents at a free-standing children's academic hospital provides multiple methods of evaluation regarding the use and perceptions of the STM application, Diagnotes®, after near-universal adoption. Our study highlights the application's perceived benefits including ability to perform a broad variety of tasks within the application and its role in efficient and effective communication. Conversely, several key barriers to effective communication were identified including issues around sending and receiving messages, the additional cognitive

burden placed by STM, and differences in culture of use that created conflict. As seen in similar studies, this demonstrates that new, integrated applications can aid in workflow and communication, but they can also negatively impact provider workflow, patient safety, and care coordination.[16,17] Future research on the impact of bi-directional STM applications should focus on creating a framework to understand the flow of information and identify areas of intervention. These efforts could lead to universal STM best practice guidelines that could mitigate concerns regarding safe, high quality patient care and healthcare professional workload burden.

Although residents in this study have universally adopted the new technology, perceptions and use vary. This may impact the burden on both the sender and receiver. Prior studies of paging communication demonstrated a significant workload burden on residents,[10,18-20] Studies to characterize what types of communications were received demonstrated that a significant proportion of communications were either non-urgent, or served as "inform only" communication which has been shown to occupy up to 10% of resident on-call time.[8,10] Text paging serves as a partial solution to this problem as it allows the recipient to effectively triage messages and frees time previously spent dialing, calling and waiting for a response to receive comparable information. Transitioning from paging to STM has shifted the cognitive burden of the recipients from temporal burden – responding to pages in sequence as they are received – to cognitive burden of triaging an increased volume of information. Adding to this burden, HCP had trouble when trying to identify and contact the correct individual to complete the necessary care tasks. Sending messages to the incorrect recipient results in delayed patient care, failures to maintain patient privacy limited to those responsible, and user frustration from ineffective communication. As institutions adopt STM, they should consider both system features and user

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expectations. The system should provide tools that reduce cognitive burden such as a single, clear directory for identifying the appropriate contact including internally consistent naming conventions. Additionally, institutional guidelines and expectations should be made clear, such as the expectation of clear and concise close-looped communication.

The Agency for Healthcare Research and Quality revised the Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS)[21] in 2023 to address changes in healthcare delivery and learning methods. TeamSTEPPS provides modules on communication, including bi-directional communication, and situation monitoring that apply when using a secure messaging application that have been successfully implemented in healthcare.[22-24] Interestingly, SMS-like messaging can provide unique types of communication not seen previously in prior alphanumeric paging applications, including use of emojis and emoticons. In a study of Diagnotes® amongst hospitalists within our system, the inclusion of emojis within the secure messaging application was evaluated and found one-third of emojis or emoticons were used to open, maintain, or close communication.[25] This demonstrates that creating expectations around the “thumbs up,” “hands together,” or “phone” emojis, which are available in Diagnotes® as default responses, could streamline the process by which individuals acknowledge and take responsibility for a patient care task. The specific emphasis could be on the ability to ensure closed-looped communication which was also studied through the formation and implementation of a Diagnotes® room to communicate regarding performance improvement and patient safety concerns.[26] This intervention led to increased reporting, secure texting being the primary mode of reporting, but also observed a decrease in time-to-loop closure through the chatroom modality.

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It is notable that only one-third of residents were satisfied with their training using this system. Also, there was variation in participant perceptions regarding the use of STM for urgent patient care or patient emergencies. Additionally, there was lack of agreement existed in perceptions of whether STM messages regarding patient care handoffs or inter-team consults should lead to person-to-person conversations. Regarding these differences, previous literature has demonstrated that inadequate training is a barrier to adopting new messaging applications in hospital settings.[17] In our study, lack of education did not impede universal adoption, but many of the qualitative concerns identified differences in expectations. Training in healthcare for the use of STM comes in many forms such as brief training presentations, web-based tutorials, on-site coaching, informal and group teaching, and one-on-one question and answer sessions.[1,27] There is room for meaningful improvement in the training for use of STM as it serves an integral role in patient care and can have impacts on patient safety and coordination of care. Training should not just focus on how to perform specific STM tasks; it should integrate and disseminate institutional expectations for appropriate use of the STM application. Specifically, a recent publication involving both physicians and nurses demonstrated a lack of shared understanding of the appropriateness of text messages including conveying or the timing of non-urgent updates.[17] Therefore, a key consideration of future educational interventions will be to include all invested stakeholders in the creation and delivery of best practice guidelines for STM to ensure alignment.

This study was limited as it focused on a single group of healthcare professionals who provide clinical care at a single institution in an academic medical setting. The impact of the institutional training and culture around communicating through secure applications can impact perceptions

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and use, therefore these findings may not be generalizable. However, we had participation from many levels of trainees which offered insight into current practices, even for those now familiar with the application. Another limitation is that we only included the perceptions of the physician group, yet the messaging is frequently utilized by all types of healthcare professionals at the institution including nursing, case management, and other hospital-based services. Therefore, our depth of understanding the bi-directional experience was limited.

Conclusion

The use of Diagnotes® as a STM application was universally adopted and viewed positively among residents. While residents identified patient care tasks that improved coordination through STM, there were concerns raised related to issues around sending and receiving messages, the additional cognitive burden placed by STM, and differences in culture of use that created conflict. Residents are familiar with most functions of Diagnotes® but had differences in expectations regarding the timing and need for a direct conversation and how urgent/emergent patient care situations should be handled. One key element emphasized in this study was the importance of consistent norms across professions regarding the use of STM for patient care. Future work should include evaluations of other healthcare professionals to better understand the expectations and perspectives of all stakeholders on the use of STM. By integrating all involved healthcare professionals, a universal STM best practice guideline could be created to address concerns around patient safety, coordination of care, and healthcare professional workload burden.

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Summary Table

What was already known on the topic.

- Secure text messaging applications are being implemented as replacements for pagers.
- Secure text messaging is convenient; however, unintended consequences include workflow interruption and notification fatigue.
- Studies exploring resident physicians' perspectives on secure text messaging following implementation are limited.

What this study added to our knowledge.

- Expectations differ among residents about when secure messaging is most appropriate compared to other modalities.
- Specific concerns were raised related to issues around sending and receiving messages, the additional cognitive burden placed by STM, and differences in culture of use that created conflict.
- Residents desire further education to establish institutional norms and expectations regarding the use of secure messaging.

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CRediT authorship contribution statement

Andrew W Halterman: Conceptualization, Data curation, Formal Analysis, Methodology, Writing – original draft, Writing – review & editing

Anneli R Cochrane: Conceptualization, Data curation, Formal Analysis, Methodology, Visualizations, Writing – original draft, Writing – review & editing

Andrew D Miller: Conceptualization, Data curation, Methodology, Writing – review & editing

Joy L Lee: Formal analysis, Writing – review & editing

William E Bennett: Formal analysis, Writing – review & editing

Emily L Mueller: Conceptualization, Formal analysis, Funding Acquisition, Methodology, Writing – original draft, Writing – review & editing, Supervision

Funding

Dr. Emily L Mueller was funded by a mentored career development award from the National Institute of Health National Cancer Institute. This grant also provided funds for Anneli Cochrane as the research assistant.

Declaration of Competing Interest

The authors declare they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1. Demographics of Pediatric Resident Study Participants and Types of Diagnotes® Usage

N=112	N	%

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Age (years)		
Median	29	
Range	25-41	
Sex		
Female	75	67.0
Male	36	32.1
Prefer not to answer	1	0.9
Training Level		
PGY-1	33	29.0
PGY-2	31	27.2
PGY-3	29	25.4
PGY-4	13	11.4
PGY-5	7	6.1
PGY-6	1	0.9
Device Using Diagnotes®*		
Personal Mobile Phone	112	100
Personal Computer	12	10.7
Work Computer	97	86.6
Platform Using Diagnotes®*		
App on Apple IOS mobile device	98	87.5
App on Android mobile device	14	12.5
Web-based on computer	90	80.4

Table 2. Diagnotes® Tasks Able to be Performed by Pediatric Residents

Diagnotes® Tasks Able to Perform*		
Send a message to one recipient	112	100
Broadcast into a Room	112	100
Send a message to multiple recipient	110	98.2
Add a recipient to a message you are already part of	110	98.2
Remove yourself from a message	109	97.3
Check the read receipt on a message	108	96.4
Find a Room	106	94.6
Complete a message	105	93.8
Set my status as "unavailable"	104	92.9
Send a message to the whole “Room”	100	89.3
Send a message to the on-call person in a “Room”	95	84.8
Mute notifications on a specific message	93	83.0
Auto-forward messages to another user	83	74.1
Enable a backup notification for messages you have not read	83	74.1
Include a "status update" on your messages	81	72.3

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Join a Room	77	68.8
Find who is on call for a different service	73	65.2
Find who is on call for the service you are on	72	64.3
Set a time limit for a read receipt notification if a recipient has not read your message	71	63.4
Review notices in the "What's New" section	42	37.5
Create a Room	39	34.8
Find who is the first contact for a non-provider service (i.e. PT, OT, Speech, CM, Wound Care)	21	18.8
Search the directory by filtering only your favorites	19	17.0
Make a contact part of your favorites list	19	17.0

*More than one option for each question could be selected by the participant

Table 3. Qualitative Summary of Key Themes

Positive/Facilitators	
• Ability to Communicate and Collaborate • Ability to Triage Messages • Other	*It is a great way to receive non-urgent messages from other members of the care team in order to better triage issues to address. Whereas with old pagers, callback numbers do not give a good idea of what the issue is to set a more organized task list.* *When several services/teams are involved, Diagnotes greatly benefits care coordination.* *Bringing together multiple teams to coordinate care on a very complex patient who needed consultation with numerous medical and surgical sub-specialty services.* *Codes and cart messages seem to be delivered quicker through Diagnotes than pagers.* *It is easy to communicate with consults over the app.*
Negative/Barriers	
Sender/Receiver Issues: • Incorrect Recipient • Response Time Delay • Delayed/Ineffective/Lack Notifications – App Issue	*All of my friends have been woken up by Diagnotes when they are post-28hr call, despite being marked as unavailable.* *When residents are post call - important messages are sent to their Diagnotes and not followed up by the person who sent it to make sure the message was communicated to the team.*

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	Many times I have sent a Diagnotes to someone who is not working that day for a service, but there is no easy way to tell this. *The person does not respond and it is up to me to re-evaluate who I should message, which takes time and delays patient care.* *Sent an urgent message on patient status update to a person who was listed as on for the team, but they did not open it in a timely fashion and we were unable to figure out who next to contact.* *Some areas of the hospital do not have great signal/wifi therefore making it difficult to receive/send Diagnotes in real time. This has the potential to harm patient care.* *When in a Diagnotes room, if someone does not address the room correctly, messages can be missed due to lack of notification on your mobile device. In one incident this led to a direct admit being on the floor and not being seen for nearly an hour since we did not know they had arrived.*
Cognitive Burden: • Lack of Closed Loop • Notification Fatigue • Which Patient is Being Discussed?	*I feel like there has been multiple times where there is confusion between specialty teams on who is coordinating follow up via Diagnotes.* *When people send a message and then remove themself from a room it negatively impacts care coordination because the message disappears and it discourages follow up questions.* *The ability to access everyone makes using Diagnotes hard. I feel like I'm consistently attached to my phone and often get messages when I'm post call/off about patients I've had contact with 3 days prior.* *I love closed-loop communication, but erroneous messages regularly frustrate residents.* *On a busy service, it can be difficult to figure out which Diagnotes is about which patient when all that are present are the care provider's name. It can take a couple minutes to scroll through and find the right thread.* *Too many message threads happening in Diagnotes led to me being mistaken about which patient a nurse was discussing with me. No harm came to the patient but if there was an urgent concern there may have been a patient safety event.*

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Culture of Use: • Etiquette • Physician/Nurse • Nursing Without Mobile Device/Use Culture • Too much Texting • Urgent Concerns with No Other Way of Reaching Out • Used for Urgent Issues and Should Not Be	*I think more education surrounding Diagnotes fatigue and the proper v. improper use of Diagnotes.* *There are often unnecessary messages sent such as "Thanks" and "Ok" that can disrupt workflow especially during rounds.* *I sometimes find nursing tends to use it too casually and message providers about not very impt things (esp at not ideal times, i.e. asking for miralax right away at 3am for a stable kid when you've been on call all day/night and are attending to sicker patients.* *I don't mean to create a physician vs. other divide but if feels like there are different perspective[s] on Diagnotes etiquette. There are still numerous non-urgent interruptions during sign outs, patient staffing, etc. in physician workrooms that could easily have been FYIs via Diagnotes.* *I have observed numerous CARTs that could have been avoided had the nurse preemptively FYI'd the resident team with concerns prior to things escalating.* *Nursing needs more training and they should have access to it on a mobile device if it is going to be used for patient care long term* *Nursing staff routinely uses Diagnotes to message residents but does not read follow-up messages and does not leave a callback number. Extremely poor and unsafe communication.* *Diagnotes is useful to use in place of pagers but can sometimes result in excessive messaging and numbness to the sound due to frequent beep of messages.* *Diagnotes is used too much as a text messaging app than a paging service part of the medical chart.* *Rooms are difficult to use when you have a specific or more time sensitive question, as you can provide a callback but there is no other way to reach the person answering the Diagnotes.* *Recently, I think the existence of Diagnotes has potentially harmed patient safety as some of the call pagers are broken, and Diagnotes is not a reliable method of learning about CARTs when you are on call.* *Emergent or urgent needs being communicated on Diagnotes happens frequently and leads to safety errors.*
User Interface/Experience	

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• On-Call Schedules Problem • Ongoing Technical Issues • Search Function Problems • Lack of Notification After Being Added on to a Conversation • Wish List	*The "on call" schedules are not always up to date nor always easy to figure out who is on call for that consult team.* *The schedule/on call portion is very difficult to navigate.* *The autocorrect function on the app is terribly inaccurate particularly for medical words.* *There is a glitch sometimes that when a message is open and someone responds, you can't see it and it doesn't alert you, so I have missed an important message before because of that.* *The search function is quite poor when looking up call schedules or care team rooms. If you do not type in the name exactly how it is written, it will not show up. This is frustrating and there is not always a posted list of what the names are. The app could be greatly improved with added ability to search for similar or related words such as getting cardiac team when searching heart or general surgery when typing trauma.* *Have an option to notify someone or be notified if you add or you're added to a conversation without additional messages being sent.* *You should be able to link a patient chart to a Diagnotes message; this would improve patient safety so that everyone knows what patient is being discussed.* *I wish there was a function to leave certain messages as marked so you can keep track of which you still need to respond to when you are getting many different messages at the same time.*

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Declaration of Competing Interest

The authors declare they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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