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ORIGINAL RESEARCH

Smarter Hospital Communication: Secure Smartphone Text Messaging Improves Provider Satisfaction and Perception of Efficacy, Workflow

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BACKGROUND: Though current hospital paging systems are neither efficient (callbacks disrupt workflow), nor secure (pagers are not Health Insurance Portability and Accountability Act [HIPAA]-compliant), they are routinely used to communicate patient information. Smartphone-based text messaging is a potentially more convenient and efficient mobile alternative; however, commercial cellular networks are also not secure.

OBJECTIVE: To determine if augmenting one-way pagers with Medigram, a secure, HIPAA-compliant group messaging (HCGM) application for smartphones, could improve hospital team communication.

DESIGN: Eight-week prospective, cluster-randomized, controlled trial

SETTING: Stanford Hospital

INTERVENTION: Three inpatient medicine teams used the HCGM application in addition to paging, while two inpatient medicine teams used paging only for intra-team communication.

MEASUREMENTS: Baseline and post-study surveys were collected from 22 control and 41 HCGM team members.

RESULTS: When compared with paging, HCGM was rated significantly ($P < 0.05$) more effective in: (1) allowing users to communicate thoughts clearly ($P = 0.010$) and efficiently ($P = 0.009$) and (2) integrating into workflow during rounds ($P = 0.018$) and patient discharge ($P = 0.012$). Overall satisfaction with HCGM was significantly higher ($P = 0.003$). 85% of HCGM team respondents said they would recommend using an HCGM system on the wards.

CONCLUSIONS: Smartphone-based, HIPAA-compliant group messaging applications improve provider perception of in-hospital communication, while providing the information security that paging and commercial cellular networks do not. *Journal of Hospital Medicine* 2014;9:573–578.

Pagers, though reliable and familiar technology, can be suboptimal for facilitating healthcare team communication.[1,2] Most paging systems utilize single-function pagers and only allow one-way communication, requiring recipients to disrupt workflow to respond to pages. Paging transmissions can also be intercepted, and the information presented on pager displays can be viewed by anyone in possession of the pager.

Smartphones allow for instantaneous two-way and group communication through advanced technological features. Their use is widespread; over 81% of American physicians owned a smartphone in 2011.[3] Previous studies demonstrate that healthcare providers rate smartphone-based email positively, and that team smartphones can facilitate communication between nurses and physicians.[4,5] However, these studies specifically examined the utility of smartphone-based email and voice calls, and did not include text messaging. Limitations of traditional smartphone-based text messaging include Health Insurance Portability and Accountability Act (HIPAA) noncompliance and dependence on in-hospital cellular reception, which can be unreliable. HIPAA is a 1996 US federal law that established a set of privacy and security rules governing not only what is considered protected health information (PHI), but also minimum standards for the protection of such information. HIPAA compliance is defined as meeting these minimum standards for physical, network, and process security.[6,7] Though PHI is often transmitted via paging systems and commercial carrier-based text messaging, these modalities are not secure and are thus not HIPAA-compliant.

Text messaging applications that address these security and reliability issues have the potential to greatly enhance in-hospital communication. We hypothesized that a smartphone-based HIPAA-compliant group messaging application could improve in-hospital communication on the inpatient medicine service. To our

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knowledge, our study is the first to examine a HIPAA-compliant text messaging system, and also the first to compare a combination paging/HIPAA-compliant group messaging (HCGM) system with a paging-only system in assessing healthcare provider perception of communication efficiency.

METHODS

Intervention

This study utilized Medigram (Medigram, Inc., https://medigram.com), a free HCGM application for smartphones (available on iOS and Android) that allows users to send and receive encrypted, password-protected text messages via the hospital wireless fidelity (Wi-Fi) network, using commercial cellular networks as backup.

Study Design

In an eight-week prospective, cluster-randomized, controlled trial conducted at Stanford Hospital (June 25, 2012–August 17, 2012), three of five inpatient medicine teams were randomized to use Medigram in addition to the existing hospital paging system (HCGM teams); the remaining two teams were assigned to use hospital paging only (control teams). Each team included one attending physician, one resident, two interns, two medical students, and a case manager. According to prescheduled rotations, attendings rotated every two weeks, and residents, interns, and medical students rotated every four weeks. All rotations were either off-service or off-site, with the exception of two attendings who rotated between study teams but within their experimental designations. Case managers remained with the same team. Additionally, the satellite pharmacy was provided with an HCGM-equipped smartphone to communicate with experimental teams.

Participation was voluntary, with a 96% participation rate (n = 75). HCGM teams downloaded the free application onto their smartphones. Participants without smartphones were provided with one for the duration of the study. Proper application use was demonstrated by one researcher in a 10-minute standardized presentation. HCGM teams were encouraged to use the application in lieu of paging, except when patient care could be compromised.

All participants completed linked baseline and post-study surveys. Gift cards valued at $10 were provided on completion of each survey. Though participants were assigned to either HCGM or control groups based on the randomized assignment of their preset cluster (hospital team) to an HCGM or control group, analysis was performed on the individual level due to the hospital's set rotation schedule, which resulted in dynamic, frequently changing clusters. We also compared average length of stay and time of discharge for patients treated by control versus HCGM teams. Clinical outcome data were obtained from the hospital's database using Midas+ Statit Solutions (Midas+ Statit Solutions Group, Tucson, AZ). Survey and clinical outcome data were analyzed in Stata (StataCorp, College Station, TX) and R (R Foundation for Statistical Computing, Vienna, Austria).

Survey Design and Analysis

Identical, anonymous baseline surveys were administered to control and HCGM teams. These surveys assessed attitudes toward the hospital paging system using a 5-point Likert scale (1 = low, 5 = high) to evaluate perceived measures of effectiveness, workflow integration, and overall satisfaction. Wilcoxon rank sum tests were used to compare control and HCGM group responses to these questions. Free response questions asked participants to list the most effective and ineffective aspects of the paging system.

Post-study surveys included all baseline survey questions, as well as questions about personal texting behavior. Post-study HCGM surveys also included a parallel set of questions rating the HCGM application on the same measures of perceived effectiveness, workflow integration, and overall satisfaction. Wilcoxon signed rank tests were used to compare HCGM participants' baseline evaluations of paging to their post-study evaluations of the HCGM application. Baseline and post-study surveys were linked by the last four digits of respondent cell phone numbers. To compare control and HCGM group perceptions of the hospital paging system at study completion, post-study survey responses were evaluated using Wilcoxon rank sum tests. The family-wise error rate was left unadjusted due to concerns around inflated type II errors, given the high degree of correlation between survey questions.

All free response questions were analyzed using thematic analysis and grounded theory. After reviewing responses to each question, a list of overarching themes was constructed. Two researchers then independently reviewed each free-response entry to assign it to one or more of these themes (some responses included several ideas with distinct themes). Entries with concordant theme assignments (~90%) were coded as such; nonconcordant entries required an additional round of review to reach concordance. Finally, objective outcome measures including length of stay and time of discharge were analyzed by two-sample *t* test.

Information Security

The HCGM application in this study features 256-bit encryption technology and requires a six-digit password to access texts. For added security, a study-dedicated server (HP ProLiant DL 180 G6; Hewlett-Packard Co., Palo Alto, CA) with 4-TB hard drive capacity (4 Seagate Barracuda ST1000DM003 1 TB 7200 RPM internal hard drives; Seagate Technology PLC, Cupertino, CA) was installed in the Stanford School of Medicine Data Center to store encrypted

text messages. Data stored on the phones/server were accessible only to study participants, not researchers. These security measures were approved by Stanford Hospital and Stanford School of Medicine's security and privacy review process.

Hospital Paging System

Stanford Hospital and Clinics is a quaternary care academic medical center with 613 beds, 49 operating rooms, and over 25,000 inpatient admissions per year.[8] The institution uses one-way alphanumeric pagers (primary model: Daviscomm BR802 Flex Pager from USA Mobility, secondary model: Sun Telecom Titan 3 Plus from USA Mobility; USA Mobility Inc., Springfield, VA). USA Mobility operates the largest one- and two-way paging networks in the United States.[9]

RESULTS

Of 26 control and 49 HCGM group members participating in the study, linked baseline and post-study surveys were collected for 22 control and 41 HCGM participants (completion rates of 84.6% and 83.7%, respectively). To minimize recall bias, surveys not completed within a prespecified timeframe upon entering or leaving a team (two days attendings, four days others) were excluded.

Control and HCGM Group Characteristics

Control and HCGM groups were well matched demographically (Table 1). The average ages of control and HCGM group members were 30.10 and 30.95, respectively. Both groups were 59% male and 41% female.

A similar distribution of team member roles was observed in both groups, with two exceptions. First, the proportion of attending respondents in the HCGM group was lower than in the control group. This was due to the fact that several HCGM attendings entered discrepant ID codes on their surveys, thus making it impossible to link baseline and post-study responses; these data were excluded. Additionally, two HCGM attendings were on service for four, rather than the standard two weeks, meaning two additional data points from unique attendings could not be obtained. Second, the experimental group included four pharmacists, whereas the control group did not. As a sensitivity test, we analyzed the data excluding the pharmacists, and this did not change our results.

TABLE 1. Comparison of Control and HCGM Groups

	Control Group	HCGM Group
Paired surveys collected (completion rate)	22 (85%)	41 (84%)
Average age ± 95% CI	30.10 ± 1.71	30.95 ± 2.94
Gender		
Male	13 (59%)	24 (59%)
Female	9 (41%)	17 (41%)
Role		
Medical students	6 (27%)	11 (27%)
Interns (PGY 1)	7 (32%)	12 (29%)
Residents (PGY2 and 3)	3 (14%)	6 (15%)
Attending physicians	5 (23%)	5 (12%)
Case managers	1 (5%)	3 (7%)
Pharmacists	0 (0%)	4 (10%)

NOTE: **Abbreviations:** HCGM, HIPAA-compliant group messaging; CI, confidence interval; PGY, postgraduate year.

Baseline Evaluations of the Hospital Paging System

At baseline, there were no significant differences between control and HCGM participants' perceptions of paging effectiveness (see Supporting Table 1, in the online version of this article). On a 5-point rating scale (1 = low, 5 = high), 63 subjects rated their overall satisfaction with the paging system an average of 2.79 (95% confidence interval: 2.55-3.03).

In free response questions, components of the paging system most frequently cited as effective included: reliability of message transmission, alphanumeric text paging, and ease of use (30.4%, 25.0%, and 14.3% of 56 respondents, respectively) (Table 2). Ineffective aspects included: time wasted waiting for responses to pages, the unidirectional nature of pagers, and needing to find a computer to send a text page (29.3%, 24.1%, and 20.7% of 58 respondents, respectively) (Table 2).

Baseline Utilization of Text Messaging

The majority of participants were familiar with text messaging and regularly used it personally and professionally prior to the start of the study. 90.5% of participants (n = 63) reported sending an average of ≥1 personal text messages per day, with the largest proportion (39.7%) sending 1-5 texts per day (see Supporting Figure 1A in the online version of this article). 58.1% of respondents (n = 62) reported sending an average of ≥1 text messages per day related to patient care (see Supporting Figure 1B in the online version of this article), with the largest fraction (58.3%) sending 1-5 texts per day.

HCGM Adoption and Usage Patterns

Active use of HCGM was defined as using the application to send or receive an average of ≥1 text messages per day. Of HCGM participants, 67% self-reported ≥1 week of active use of the application, indicating a strong compliance rate. Among non-attendings, 70% reported sending 1 or more texts to other team members per day; this percentage increased to 86% among those whose attendings texted them at least once per day (47% of non-attendings). Respondents who text frequently in their personal lives (>5 texts/day) were more likely to use the application; 90% of these respondents sent 1 or more HCGM texts per day.

Among 12 subjects who did not report sending or receiving ≥1 HCGM text/day, the top three reasons were: other team members were not using it (67%),

TABLE 2. Effective and Ineffective Aspects of the Hospital Paging System

What do you find *effective* about the current hospital paging system?			What do you find *ineffective* about the current hospital paging system?		
Theme	No. of Respondents, (% of Total)	Response Example	Theme	No. of Respondents, (% of Total)	Response Example
Reliability of message transmission	17 (30.4%)	"Everyone is able to receive the pages I send, regardless of service"	Time wasted waiting for a response	17 (29.3%)	"Inefficient use of time waiting for reply"
Ability to text page	14 (25.0%)	"Text paging allows targeted questions"	One-way nature of communication	14 (24.1%)	"Cannot text back instantly"
Ease of use	8 (14.3%)	"Easy to use"	Needing to find a computer to send a text page	12 (20.7%)	"Have to find an available computer to send a page"
Search function	5 (8.9%)	"Search function is pretty effective in finding the people you're looking for"	Character limitation	10 (17.2%)	"Length of text allowed too short"
Ubiquity	5 (8.9%)	"Everyone is on paging system"	Search function	6 (10.3%)	"Delay in looking people up in the system"
Speed	4 (7.1%)	"Fast"	Finding a phone to return a page	5 (8.6%)	"When you receive a page you need to find a phone"
Loud alerts	4 (7.1%)	"Pager loud enough to hear all the time"	Receipt of page uncertain	3 (5.2%)	"Unknown if page received"
Staff responsiveness to pages	4 (7.1%)	"I know MD has to be onsite or covering the pager so someone eventually will call back"	Sender's pager number not always included in page	3 (5.2%)	"Not everyone puts their pager number when they page. Then it's impossible to get back to them."
Brevity of messages	3 (5.4%)	"Requires very brief messages (easier for recipient)"	Needing to remain near a phone while waiting for a page response	3 (5.2%)	"Wait by a phone for someone to call back; sometimes they do not call back"
Helpful page operators	2 (3.6%)	"Page operators very helpful"	Reliability of message transmission	3 (5.2%)	"Sometimes messages don't go through"
Other	10 (17.9%)	"It's online and allows paging from anywhere there's internet access"	Other	11 (19.0%)	"You cannot text with patient info on it"

NOTE: **Abbreviations:** MD, doctor of medicine.

no need to use it given the close proximity of other team members (67%), and "other" (33%). A Wilcoxon rank sum test was used to compare the ages of "active" versus "nonactive" users; no significant age difference was found ($P = 0.200$).

To provide an objective measure of application adoption, usage data for each HCGM participant were obtained from the application developers. Because much of the study's first week was spent onboarding and instructing participant, the first week was not included in the analysis. Of 43 individuals enrolled in the study for at least one of the seven remaining weeks, 56% sent a total of $\geq$5 texts, 44% sent $\geq$10 texts, and 28% sent $\geq$20 texts. HCGM users on three teams sent an aggregate mean of 123 texts/week. Data on number of messages received by each user were not available.

Perceived Effectiveness: Paging Versus HCGM

In post-study surveys, HCGM participants rated HCGM significantly higher ($P < 0.05$) than paging (Table 3) in terms of ability to communicate thoughts clearly ($P = 0.010$) and efficiently ($P = 0.009$). HCGM was also deemed more effective at integrating into workflow during rounds ($P = 0.018$) and patient discharge ($P = 0.012$). Overall satisfaction with HCGM was also significantly higher ($P = 0.003$).

Comparison of Pre- and Post-study Perceived Effectiveness of the Hospital Paging System

In post-study evaluations, both control and HCGM participants rated the paging system's effectiveness less favorably ($P < 0.05$) compared to baseline in terms of ability to receive messages/stay informed in real time (control $P = 0.002$, HCGM $P = 0.031$) (Table 4). Controls also reported a decrease from baseline in perceived effectiveness of paging in terms of ability to send messages ($P = 0.019$) and integrate into workflow during patient admissions ($P = 0.020$). HCGM participants found paging less effective at communicating thoughts clearly ($P = 0.004$) and efficiently ($P = 0.018$). No significant differences existed between control and HCGM groups' average

TABLE 3. Perceived Effectiveness: Paging System Versus HCGM Application, as Rated by HCGM Participants (n = 41)

Question	Baseline Average Rating of Paging System*	Post-Study Average Rating of HCGM Application	*P* Value†
Rate the effectiveness of each in allowing you to…			
Communicate your thoughts clearly	3.194	3.806	0.010
Communicate your thoughts efficiently	3.200	3.829	0.009
Send messages to other hospital staff	3.543	3.571	0.480
Receive messages/stay informed in real time	3.222	3.306	0.405
Rate the effectiveness of each in integrating into your workflow during…			
Work rounds	2.313	3.000	0.018
Patient discharge	2.448	3.276	0.012
Patient admissions	2.862	2.621	0.238
Teaching sessions	2.292	2.458	0.448
Overall satisfaction	2.811	3.459	0.003

NOTE: **Abbreviations:** HCGM, HIPAA-compliant group messaging.
*HCGM participants' baseline average ratings of the paging system in this table differ slightly from those presented in Table 3 due to the inclusion of different paired datasets (a result of different missing data values).
†*P* values are unadjusted.

TABLE 4. Comparison of Baseline and Post-Study Perceived Effectiveness of the Hospital Paging System

	Control (n = 22)			HCGM (n = 41)		
	Baseline Mean	Post-Study Mean	*P* Value*	Baseline Mean	Post-Study Mean	*P* Value*
Rate the effectiveness of each in allowing you to…						
Communicate your thoughts clearly	2.905	2.619	0.103	3.250	2.850	0.004
Communicate your thoughts efficiently	2.952	2.762	0.106	3.250	2.825	0.018
Send messages to other hospital staff	3.762	3.190	0.019	3.550	3.450	0.253
Receive messages/stay informed in real time	3.667	2.857	0.002	3.300	2.900	0.031
Rate the effectiveness of each in integrating into your workflow during…						
Work rounds	2.429	2.476	0.303	2.410	2.718	0.078
Patient discharge	2.500	2.350	0.251	2.472	2.861	0.071
Patient admissions	2.905	2.524	0.020	2.889	3.000	0.384
Teaching sessions	2.143	2.200	0.386	2.367	2.400	0.418

NOTE: Abbreviations: HCGM, HIPAA-compliant group messaging.
**P* values are unadjusted.

assessments of paging at the conclusion of the study (see Supporting Table 2, in the online version of this article).

HCGM User Experience

When asked if they would recommend using an HCGM system to facilitate communication on the internal medicine wards, 85% of HCGM participants replied "yes," 15% reported "not sure," and 0% reported "no." Based on free response entries, HCGM's most effective features (Table 5) included ease of use, group texting capacity, and speed (32.4%, 32.4%, and 23.5% of 34 respondents, respectively); its most ineffective aspects (Table 5) included lack of ubiquity, inconsistent usage by those with access to the application, and reliability of message transmission (30.3%, 24.2%, and 15.2% of 33 respondents, respectively).

DISCUSSION

We are the first to report that smartphone-based, HIPAA-compliant, group messaging applications improve provider perception of in-hospital communication, while providing the information security that paging and commercial cellular networks do not. HCGM participants rated the application more favorably than paging in terms of clarity and efficiency of communication. These findings may be attributed to the expanded functionality offered by the application, including no character limit per HCGM text, the ability to use special characters such as slashes and ampersands, group texting, and the ability to reply immediately. HCGM may result in more efficient communication by facilitating direct two-way communication via smartphones, whereas sending or returning pages requires a landline or computer.

HCGM participants rated the application higher than paging in terms of workflow integration during rounds and patient discharge, but not during patient admissions and teaching sessions. We had hypothesized that HCGM would integrate better into participants' workflows because HCGM texts could be replied to immediately. The reasons for the equivalence of HCGM and paging for workflow integration

TABLE 5. Effective and Ineffective Aspects of the HCGM Application

What do you find *effective* about the Medigram system?			What do you find *ineffective* about the Medigram system?		
Theme	No. of Respondents, (% of Total)	Response Example	Theme	No. of Respondents, (% of Total)	Response Example
Ease of use	11 (32.4%)	"Easy to use"	Lack of ubiquity	10 (30.3%)	"Not enough people using it"
Group texting feature	11 (32.4%)	"Ability to communicate with entire team—everyone seeing same message"	Inconsistent usage	8 (24.2%)	"No one used it reliably"
Speed	8 (23.5%)	"Faster than a page to send a message"	Reliability of message transmission	5 (15.2%)	"Big negative is it requires Wi-Fi"
Accessibility	5 (14.7%)	"Able to get messages across quickly and anywhere without a computer"	Missed message alerts	4 (12.1%)	"Unable to reliably know message was received if phone on silent"
Efficiency	4 (11.8%)	"Very efficient way to communicate"	Password login	3 (9.1%)	"Having to type a 6-digit password in"
Real-time communication	2 (5.9%)	"Real-time results"	User interface	2 (6.1%)	"Interface is a little convoluted"
No character limitation	2 (5.9%)	"No limit on words"	Other	10 (30.3%)	"Not sure if all of the texts were relevant"
Other	4 (11.8%)	"Great UI"			

NOTE: **Abbreviations:** UI, user interface; Wi-Fi, wireless fidelity.

during patient admissions and teaching sessions may have been due to weak Wi-Fi in certain areas of the hospital, and may warrant further investigation.

Analysis of HCGM utilization indicated that there were factors that made participants more or less likely to use the application. Individuals who reported that their attendings used HCGM regularly were more likely to use it themselves. Attending usage may legitimize use of HCGM for housestaff and medical students, who may otherwise feel that texting appears unprofessional. Participants who texted frequently in their personal lives were also more likely to utilize HCGM regularly, perhaps due to increased familiarity with/affinity for the platform.

HCGM participants who did not utilize the application regularly most often cited the fact that other team members did not use it. Among all users, the most frequently noted ineffective aspects of the application were its lack of ubiquity (HCGM was made available only to the small subset of individuals involved in the study) and inconsistent usage by those who did have access to the application. These findings suggest that HCGM effectiveness may be maximized with unrestricted access and mandated use; patchwork implementation, as in this study, detracts from perceived effectiveness.

Though objective outcome measures (average length of stay and average time of discharge) for patients of control attendings and HCGM attendings were examined, no significant differences were observed ($P = 0.089$ and 0.494, respectively). These results may be due to the small size and short duration of the study.

Limitations

Our study had several limitations. HCGM was available only to individuals in the experimental arm of the study; most members of the internal medicine department and all other departments were not reachable through the application. This lack of ubiquity was a frequently cited frustration. Among individuals to whom HCGM was made available, barriers to adoption included: close proximity to would-be message recipients, concern that smartphone usage in front of patients might appear unprofessional, and inconsistent or dropped service (weak or no Wi-Fi signal in some areas). A technical problem with the Android platform midway through the study served as a potential frustration to several participants.

Due to the aforementioned issues, some participants used the HCGM application in a very limited way. We also did not replace hospital pagers (infeasible in this hospital setting); the HCGM application was added as a supplemental system. Future studies might explore the replacement of paging systems with HCGM-type applications, as well as delve further into quantitative patient care outcomes.

It should be noted that the start of the study unintentionally coincided with the start of new interns and medical students in the hospital. Although it is possible that their relative unfamiliarity with the hospital may have made them more amenable to adopting a new technology, it is also possible that they may have been less likely to do so in the midst of such a major transitional period. Finally, this was a single-site study, and as such, its findings may not be broadly generalizable. More research on such interventions is warranted, particularly in the context of current insecure communication methods such as paging that may make hospital-wide adoption of new methods of secure communication, such as HCGM, mandatory.

CONCLUSION

Our study is the first to demonstrate that HCGM applications improve healthcare provider perception of multiple measures of in-hospital communication, including efficiency of communication, workflow integration, and overall satisfaction. Notably, 85% of HCGM team respondents said they would recommend using an HCGM system on the wards. As smartphone use is expected to continue to increase among physicians and the general population, it is increasingly important to understand how to utilize these powerful communication tools to improve healthcare in an effective and secure manner.

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