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Implementation and Evaluation of an Alphanumeric Paging System on a Resident Inpatient Teaching Service

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BACKGROUND: Numeric pagers are commonly used communication devices in healthcare, but cannot convey important information such as the reason for or urgency of the page. Alphanumeric pagers can display both numbers and text, and may address some of these communication problems.
OBJECTIVE: Our primary aim was to implement an alphanumeric paging system.
DESIGN: Continuous quality improvement study using rapid-cycle change methods.
SETTING: General Internal Medicine (GIM) inpatient wards at 1 tertiary care academic teaching hospital.
PARTICIPANTS: All residents, attending physicians, nurses, and allied health staff working on the general medicine (GM) wards.
MEASUREMENTS: We measured: (1) the proportion of pages sent as text pages, (2) the source of the pages, (3) the content of the text pages, (4) the pages that disrupted scheduled education activities, and (5) satisfaction with the alphanumeric paging system.
RESULTS: After implementation, 52% of pages sent from physicians or the GM wards were sent as text pages ($P < 0.001$). 93% of pages between physicians were text pages, compared to 27% of pages from the GM wards to physicians ($P < 0.001$). The most common reason for text paging among physicians was to arrange work or teaching rounds (33%). The most common reason for text paging from the GM wards was to request a patient assessment or for notification of a patient's clinical status (25%). There was a 29% reduction in disruptive pages sent during scheduled educational rounds ($P < 0.001$).
CONCLUSIONS: We successfully implemented an alphanumeric paging system that reduced disruptive pages on a GM inpatient service. ***Journal of Hospital Medicine*** **2009;4:E34–E40**. © *2009 Society of Hospital Medicine.*

KEYWORDS: alphanumeric paging, communication, telecommunications.

Additional Supporting Information may be found in the online version of this article.

Effective communication between healthcare providers is essential to patient safety and quality of care.[1,2] Numeric pagers are commonly used communication devices in healthcare, but cannot convey important information such as the reason for the page, urgency of the page, or sender name. Physicians must respond to numeric pages, often disrupting patient encounters or educational activities.[3–6] In a study of medical interns, disruptions to patient care occurred with up to 65% of pages received, two-thirds of which were not felt to be urgent.[5] In addition to causing frustration, frequent disruptions can contribute to medical errors.[7,8]

Alphanumeric pagers can display both numbers and text, and may address some of the communication problems associated with numeric pagers. They also lay the groundwork for other patient safety initiatives such as automated paging of critical laboratory values[9] and real-time reporting of user-requested laboratory data.[10] Implementation of alphanumeric paging on a general surgery teaching service reduced disruptions to patient care and the number of pages requiring a return call.[11]

Our primary aim was to implement an alphanumeric paging system. We will describe our implementation strategies and barriers identified. We evaluated the implementation of alphanumeric paging by measuring (1) the proportion of pages sent as text pages, (2) the source of the pages (other physicians or from the general medicine [GM] ward), (3) the content of the text pages, (4) the number of pages that disrupted scheduled education activities, and (5) satisfaction with the alphanumeric paging system.

Materials and Methods

Setting

Sunnybrook Health Sciences Centre is a tertiary care academic teaching hospital affiliated with the University of

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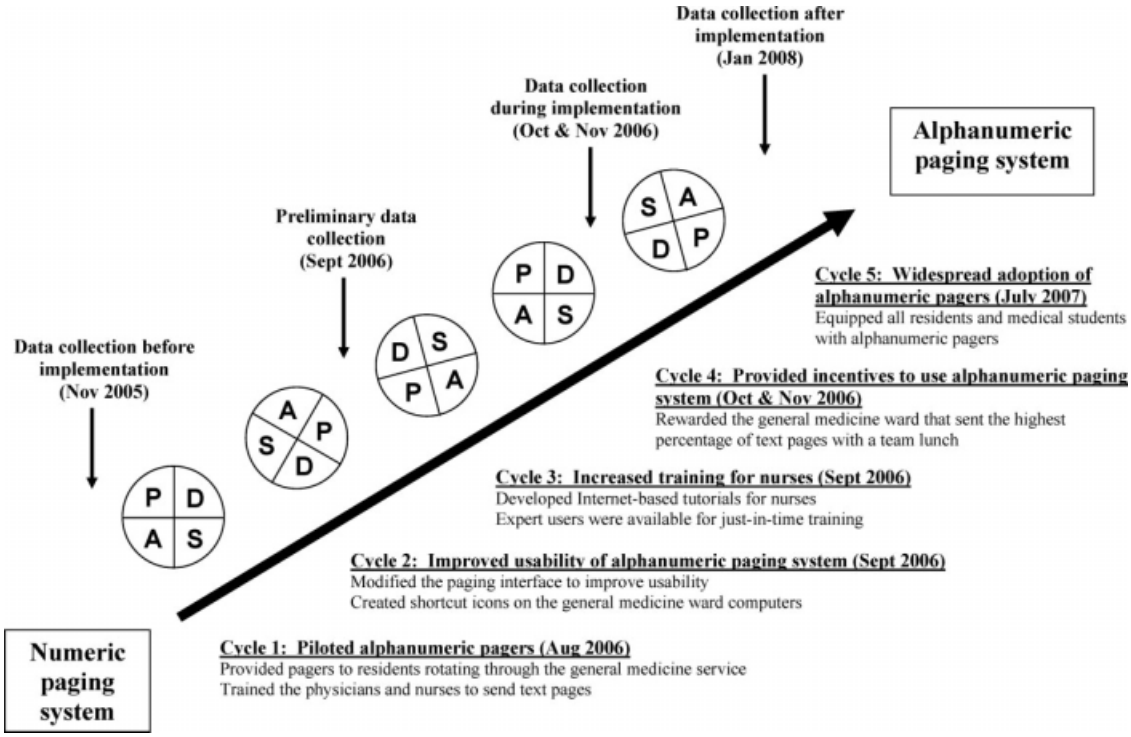

FIGURE 1. Plan-Do-Study-Act (PDSA) change cycles for the implementation and evaluation of an alphanumeric paging system.

Toronto (Toronto, Ontario, Canada). There are 4 physician teams that provide hospitalist care to admitted patients on the General Internal Medicine service. Each physician team consists of 1 attending physician, 1 second-year or third-year resident, 2 to 3 first-year residents, and 3 to 4 third-year and fourth-year medical students. In total, 12 to 13 residents rotate through the General Internal Medicine service per month. Each physician team is assigned to 1 of 4 GM wards, which are staffed with nurses and allied health staff. Five to eight Internet-enabled computer stations are located on each GM ward. All physicians, nurses, and allied health staff who worked on the 4 GM wards participated in the study.

Existing Paging System

Prior to July 2006, all physicians at our hospital carried numeric pagers. A physician could be paged by 3 methods: (1) through the hospital operator; (2) using the telephone; or (3) using an Internet-based paging system (Smart Web 3.6.2, AmCom Software Inc.). Most pages were sent through the hospital operator or by telephone.

Intervention

The intervention included: (1) equipping resident physicians with alphanumeric pagers and (2) increasing the use of the existing Internet-based paging system to send text pages. We equipped each resident with an alphanumeric pager (Motorola Flex Alphanumeric Pager). Users could send a text page using the existing Internet-based application (Smart Web 3.6.2). This application allows users to search for a specific physician either by name or by on-call assignment, and send a page up to 125 characters long from any Internet-enabled computer in the hospital. Numeric pages could be sent by telephone, through the hospital operator, or by using the web-based paging system throughout the study period.

Implementation Process

We provided alphanumeric pagers to the residents on the General Internal Medicine service in July 2006. Alphanumeric pagers were limited, so each resident traded their numeric pager for an alphanumeric pager at the start of each rotation. Once their rotation ended, they returned their alphanumeric pager for their original numeric pager. The communications department coordinated this process. The chief medical resident spent 10 minutes to teach the residents how to use the system at the beginning of the rotation. In August and September 2006, a member of the communications department trained the nurses on the 4 GM wards how to send a text page using the Internet-based paging application. We scheduled these 15-minute sessions throughout the day and evening in order to capture as many nurses as possible. We encouraged the nurses to include standardized information in the text message (eg, patient ID, issue, level of urgency, sender name, call-back number).

We used rapid-cycle change methods[12] to implement the alphanumeric system (Figure 1). The first change cycle in

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TABLE 1. Paging Patterns Before, During, and After Implementation of an Alphanumeric Paging System

Paging Characteristics	Before Implementation (all residents had numeric pagers)	During Implementation (all residents had alphanumeric pagers)		After Implementation (all residents had alphanumeric pagers)	
	November 2005	October 2006	November 2006	January 2008	*P* Value
Total number of pages	1431	1879	1813	1269	
Total number of resident weeks worked	29	33	33	21	
Pages per resident week, mean (SD)	46.2 (16.3)	57.9 (19.2)	46.5 (20.2)	59.0 (26.5)	0.17*
Number of patients admitted per night, mean (SD)	8.0 (2.7)	10.2 (3.5)	11.0 (2.9)	10.2 (3.5)	0.009*
Type of page, n (%)					
Numeric pages	751 (53)	462 (25)	580 (32)	374 (30)	<0.001†
GM wards-to-Doc	584 (41)	393 (21)	538 (30)	352 (28)	<0.001†
Doc-to-Doc	167 (12)	69 (4)	42 (2)	22 (2)	<0.001†
Non-GM ward/Doc pages	680 (47)	1107 (59)	809 (45)	487 (38)	<0.001†
Text pages	0 (0)	310 (16)	424 (23)	408 (32)	<0.001†
GM wards-to-Doc	0 (0)	175 (9)	221 (12)	129 (10)	<0.001†
Doc-to-Doc	0 (0)	135 (7)	203 (11)	279 (22)	<0.001†

Abbreviations: Doc, physician; GM, general medicine; SD, standard deviation.

*Student *t* test comparing November 2005 with January 2008.

†Fisher's Exact Test comparing November 2005 with January 2008.

August 2006 consisted of providing pagers to residents and training the nurses and physicians to send text pages. Users reported that the paging interface was difficult to use. For the second change cycle in September 2006, the communications department modified the paging interface to improve usability and created shortcut icons on the GM ward computers. While the system was easier to access, the nurses reported that 1-time training was insufficient. For the next change cycle in September 2006, we developed Internet-based tutorials that could be accessed at any time, and made expert users (charge nurses) available for just-in-time training. We asked these charge nurses what they believed would encourage adoption of the system. They suggested that contests worked well with other initiatives. For the final change cycle in October and November 2006, we held a contest and rewarded the GM ward that sent the highest percentage of text pages with a team lunch.

Our results from November 2006 were presented to our hospital medical leaders, who approved widespread implementation of alphanumeric pagers for all residents and medical students in all programs. The cost of this upgrade was approximately $35,000 per year to lease 500 alphanumeric pagers. By July 2007, all residents and students in our hospital had alphanumeric pagers.

Measures

Our primary outcome measure was the percentage of pages sent as text pages. We chose November 2005 as our "before implementation" period to account for temporal variations in patient load, and secular trends in resident knowledge and experience during an academic year. We collected data during our rapid-cycle improvement periods of implementation and testing in September to November 2006. We assessed sustainability "after implementation" by collecting data in January 2008, 6 months after hospital-wide implementation of alphanumeric pagers, and 14 months after the initial implementation on the GIM service.

We reviewed weekday paging records from our communications department for each study period. For text pages, we reviewed the text message to determine whether the page was sent by a physician or by another health care professional. We established 5 mutually exclusive categories of messages prior to the study: (1) A GM ward-to-physician (GM ward-to-Doc) numeric page was any page that contained only a phone number for 1 of the 4 GM ward main telephone numbers; (2) A Doc-to-Doc numeric page was any page that was preceded by 000- (a convention used at our hospital to indicate a physician sender), or that contained a phone number used only by physicians, such as the doctor's lounge; (3) A GM ward-to-Doc text page was a text page sent by any GM ward health care professional; (4) A Doc-to-Doc text page was a text page sent by any physician or medical student; and (5) All other numeric pages, such as those with phone numbers from other hospital wards, were classified as "numeric non-GM ward and non-Doc in-hospital page."

We evaluated the impact of the alphanumeric system on disruptions by studying pages received during scheduled educational rounds that occur every weekday from 12:00 to 1:00 PM. We classified a page as disruptive if it required an immediate call-back (ie, all numeric pages and urgent text pages).

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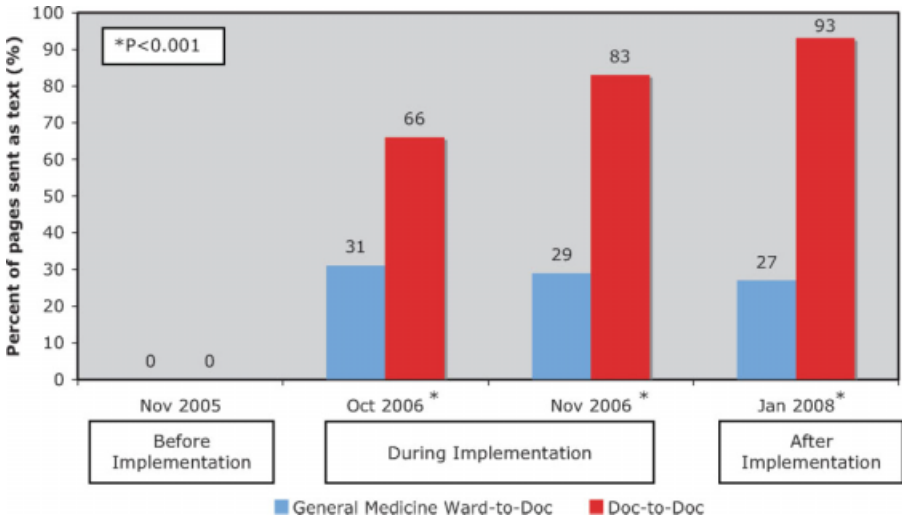

FIGURE 2. Physician and nursing use of the alphanumeric paging system on the general medicine service.

TABLE 2. Reasons for Paging the Physicians (GM ward-to-Doc)

Reason for Paging	Number (%)	Examples
Requests for patient assessment or notification of a patient's clinical status	55 (25)	Patient X. Temp 38.5. No other symptoms. [Nurse's name]. The repeat CXR on Patient X has been completed. Please call [ward] if NG can be used. Thank you.
Clarification of a written order	45 (20)	Would you like Patient X to get a second dose of Lasix? He has already had 100 mg and his output thus far is 500 cc. [Nurse's name] Patient X. BP = 100/62, pulse 54. Patient is supposed to have metoprolol 50 mg tonight. Do you want me to hold it? [Nurse's name]
Request for a medication prescription	28 (13)	Patient X needs an analgesic for pain in his arms and legs. Please call [ward]. Patient X has a daily coumadin order. INR 2.14. Please call with dosage for 1800. Ask for [Nurse].
Cosigning written order	25 (11)	Please co-sign neurology suggested orders for Patient X. [Nurse's name] Not urgent – at your leisure, please co-sign Patient X orders on [ward] for medical student. Thanks.
Notification of a recent laboratory result	23 (11)	Patient X's potassium is 3.0 today. Please call [ward]. Patient X. Sodium 163. Troponin unchanged at 1.54. [ward].
Arranging meetings with patients and/or family	18 (8)	Meeting with Patient X's family and social worker at 2 pm tomorrow on [ward]. [Social worker] is here. [Physiotherapist] expected any minute. We are going to meet in family room for Patient X.
Request to complete paperwork	15 (7)	Patient X is ready to go home, and just needs discharge orders and prescriptions Referral form for community palliative doctor on the front of the chart – fill in where marked by arrows. Can you please put on form prognosis as well? [Social worker]
Other	12 (6)	
Total	221 (100)	

NOTE: Represents data from November 2006.
Abbreviations: BP, blood pressure; CXR, chest X-ray; Doc, physician; GM, general medicine; INR, international normalized ratio; NG, nasogastric tube.

We surveyed residents and daytime GM ward nursing staff during the implementation period (October and November 2006) to assess satisfaction with the alphanumeric paging system using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). We distributed paper surveys to nurses, and used an electronic web survey for residents.[13]

Statistical Analysis

We compared the paging data after implementation (January 2008) to the period before implementation (November 2005) using a Student *t*-test for comparison of means, and chi-square and Fisher's exact tests for categorical value comparisons. We assigned a significance level of $P < 0.05$ for the *t* tests and chi-square tests, and $P < 0.01$ for the Fisher's exact tests. We used SPSS 11.0 to perform statistical analyses (Chicago, IL).

Results

Paging Patterns Before, During, and After Implementation

The number of pages per resident was similar before and during implementation, but higher afterwards. (46 ± 16 pages/resident/week in November 2005, 47 ± 20 pages/

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TABLE 3. Reasons for Paging Among Physicians (Doc-to-Doc)

Reason for Paging	Number (%)	Examples
Setting up meetings for work or teaching rounds	67 (33)	Confirmed diabetes teaching at 1400 hr in [room]. Please let medical students know. Thanks. Please come to [lecture theatre] if you can in the next 10 minutes for the teleconferenced noon rounds. Thanks. We are in the Emergency Department with [attending staff]. Come to meet us here if you can.
Relaying patient-care related messages	54 (27)	Patient X US query cholangitis, can we ask for a surgical consult. He may benefit from surgery or percutaneous drain. Please repeat his blood work. Patient X in [room X]. Presented with DKA. pH 7.2. pCO_2 23, bicarbonate 9. Lytes pending. Got IV insulin and NS. Need to check to clinical stability. [Resident]
Signing-over patients at the end of the day	46 (23)	I'm ready to sign out to you. Where are you? [Resident]. Patient X is back from cardiac cath, and is stable. Please check Cr over WE, and watch for CHF.
Other	36 (18)	
Total	203 (100)	

NOTE: Represents data from November 2006.
Abbreviations: cath, catheterization; CHF, congestive heart failure; Cr, creatinine; DKA, diabetic ketoacidosis; IV, intravenous; Lytes, electrolytes; NS, normal saline; US, ultrasound; WE, weakend.

TABLE 4. Pages that Disrupted Scheduled Educational Rounds

	November 2005 (3 weeks)*	November 2006 (3 weeks)	January 2008 (2 weeks)	*P* Value*
Total number of pages received during scheduled educational rounds	104	129	103	
Total pages from GM ward or Doc	61 (59%)	76 (59%)	62 (60%)	0.888
Numeric	61 (59%)	43 (33%)	25 (24%)	<0.001
Text	0 (0%)	33 (26%)	37 (36%)	<0.001
Urgent	0 (0%)	16 (13%)	7 (7%)	0.007
Nonurgent	0 (0%)	17 (13%)	30 (29%)	<0.001
Numeric pages non-GM ward and non-Doc	43 (41%)	53 (41%)	41 (40%)	0.888
Pages requiring an immediate call back	104 (100%)	112 (87%)	73 (71%)	<0.001

Abbreviations: Doc, physician; GM, general medicine.
*Fisher's Exact Test comparing November 2005 (before implementation) with January 2008 (after implementation).

resident/week in November 2006, and 59 ± 27 pages/resident/week in January 2008; $P = 0.17$; Table 1). The mean number of admissions per night was 8.0 ± 2.7 before implementation, compared to 10.2 ± 3.5 after implementation ($P = 0.009$).

We observed a significant and sustained increase in the use of text paging during the study (Table 1). After implementation, 32% of all pages sent to our residents were text messages ($P < 0.001$). Physicians almost exclusively sent text pages by the end of implementation (increase from 0% to 83% text paging rate during implementation, and 93% after implementation; $P < 0.001$; Figure 2). GM ward text paging rates also increased from 0% to 29% during implementation, and 27% after implementation ($P < 0.001$; Figure 2). The alphanumeric paging system was used to a greater degree by physicians compared to other workers on the GM ward after full implementation (93% vs. 27%; $P < 0.001$). We explored the proportion of GM ward-to-Doc pages sent as text from different GM wards during implementation, and found significant variation, ranging from 14% to 57% ($P < 0.001$).

The most common reasons for text paging from GM wards were to request a patient assessment or for notification of a patient's clinical status (25%), to clarify written orders (20%), and to request a medication prescription (13%) (Table 2). Among physicians, the most common reasons for text paging were to set up meetings for work or teaching rounds (33%), to relay patient-care related messages (27%), and to sign-over patients at the end of the day (23%) (Table 3). The remainder of the other Doc-to-Doc pages (18%) were mostly personal messages or team communication that was not related to clinical work.

Impact of Alphanumeric Paging System on Disruptions

We evaluated the impact of the alphanumeric system on disruptions by studying pages received during scheduled educational rounds (Table 4). Prior to implementation, residents were paged 2.9 ± 2.4 times per week during educational rounds, compared to 3.4 ± 3.6 times per week after implementation ($P = 0.66$). Prior to implementation, all pages were numeric necessitating an immediate call-back,

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causing an educational disruption. During the implementation period, 13% of pages received during educational rounds were nonurgent text pages that did not require an immediate call-back, increasing to 29% after implementation ($P < 0.001$).

User Satisfaction

Physicians (18/25; response rate = 72%) were very satisfied with the alphanumeric paging system (mean, 4.6/5), felt that the alphanumeric paging system minimized disruptions to patient care duties (4.1/5) as well as educational rounds (4.2/5), and allowed them to prioritize their tasks effectively (4.6/5). Nursing staff (32/80, response rate = 40%) were also satisfied with the alphanumeric paging system (4.1/5), and found the technology very easy to use (4.5/5).

Potential Barriers to and Unintended Downsides of Implementation

We identified a number of barriers that limited the broader adoption of alphanumeric paging at our hospital. Nursing staff expressed concerns about limited computer and typographical skills. We addressed this by involving nursing champions to promote the alphanumeric paging system and to assist with nurse training. There were insufficient computers available for the nurses to send text pages, so many opted to page the physician using the conventional telephone system. The limited number of alphanumeric pagers during the implementation period meant that cross-covering and off-service residents were not carrying alphanumeric pagers. This undermined our ability to encourage use of a single paging system. We addressed this by convincing the hospital to provide alphanumeric pagers to all residents and medical students at our institution, a practice that was adopted in July 2007.

We also identified several potential unintended downsides to the implementation of alphanumeric paging. Nurses received no confirmation that nonurgent pages had reached the residents. We asked the residents to close the "communication loop" by making a phone call or confirming in person at the next convenient opportunity. Pagers store confidential transmitted patient information unless the resident deletes it. Communication using the pagers may replace discussions that should occur in person. For example, residents might send a text page with brief updates about patients as the only form of sign-over. Even though the majority of "sign-over" pages in our study were simply a text message to arrange a place to meet for face-to-face sign-over, we did encounter a small number of pages where it is unclear whether provision of actual "sign-over" information via text message was in lieu of a formal handoff, or whether it was accompanied by an in-person handoff as well. Finally, nurses had to leave the patient's bedside to send a text page from a computer workstation. We highlighted that sending a nonurgent text page allows nurses to return to the bedside rather than wait at the nursing station for a call-back.

TABLE 5. Key Elements for Optimal Implementation of Alphanumeric Paging

- Equip all members of the healthcare team with alphanumeric pagers
- Use a web-based paging program that allows easy and accurate identification of the responsible physician 24 hours a day, 7 days a week
- Install sufficient computer terminals for accessing the paging program
- Provide 2-way communication so the page recipient can acknowledge the receipt of the message
- Maintain patient confidentiality by encrypting or encoding messages and sending them via a secure server
- Choose pager technology that ensures reliable delivery of messages without dropped pages
- Ensure ongoing technical support and training services for health care team members

Our opinions regarding key elements of an alphanumeric paging system implementation are summarized in Table 5.

Discussion

We successfully implemented an alphanumeric paging system on a resident inpatient internal medicine teaching service, with 42% of pages from our GM wards or physicians sent as text pages during implementation period. Six months after widespread use of alphanumeric pagers at our hospital (and 14 months after the initial implementation on the General Internal Medicine service) the text paging rate was 52%. Physicians have nearly universally adopted the use of alphanumeric paging as a means of communicating with one another, while the adoption by nursing staff was modest. The implementation of the alphanumeric paging system was associated with a significant reduction in disruptive pages.

We could identify only one prior study of alphanumeric paging implementation in a hospital setting. A general surgery teaching service in the United States demonstrated that 35% of all pages received by residents were text pages 3 months after implementation,[11] similar to our result of 32% text paging rate after full implementation. We found a greater use of text paging among physicians in our study (93% of Doc-to-Doc pages were text), compared to 55% in this prior study. This difference may be partially explained by varied methods for identifying Doc-to-Doc pages between the studies.

A number of factors influence the adoption of new technology, such as the technology's features, end-user characteristics, and dissemination strategies.[14] During the implementation, even though the web-based paging system was deemed easy to use, there was a lack of computers available to send text messages at each of our nursing stations. Residents were generally more familiar with technology and the use of computers for communication than nurses, and therefore more likely to use the technology. The presence of "innovators" influenced the success of adoption, evidenced

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by the fact that the GM ward that sent the highest percentage of pages as text was also the GM ward where the project leader (B.W.) worked as the attending staff during the implementation period.

Our study has several limitations. First, our method for classifying the source of numeric pages was imperfect. Our method systematically underestimates Doc-to-Doc numeric pages, because we assumed that all pages from GM ward phone numbers were not from physicians. We also may have misclassified the origin of some text messages. These limitations would not affect our conclusion that text messaging increased, but may overestimate the increase in Doc-to-Doc text messaging, and underestimate the increase in GM ward-to-Doc text messaging. The reasons for paging are not known for the numeric pages. The number of pages received per resident increased after implementation, so it is possible that alphanumeric pages increased calls for certain nonurgent issues, such as co-signing orders. Finally, we assumed that residents were attending scheduled educational rounds, but were unable to confirm attendance, so we cannot be sure that disruptions actually were reduced.

In summary, we implemented an alphanumeric paging system, and observed a sustained use of text messaging after 1 year. The implementation of alphanumeric paging was associated with a reduction in disruptive pages sent during scheduled educational rounds.

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References

1. Penson RT, Kyriakou H, Zuckerman D, Chabner BA, Lynch TJJ. Teams: communication in multidisciplinary care. *Oncologist*. 2006;11:520–526.
2. Zinn C. 14,000 preventable deaths in Australian hospitals. *BMJ*. 1995;310:1487.
3. Blum NJ, Lieu TA. Interrupted care. The effects of paging on pediatric resident activities. *Am J Dis Child*. 1992;146:806–808.
4. Harvey R, Jarrett PG, Peltekian KM. Patterns of paging medical interns during night calls at two teaching hospitals. *CMAJ*. 1994;151:307–311.
5. Katz MH, Schroeder SA. The sounds of the hospital. Paging patterns in three teaching hospitals. *N Engl J Med*. 1988;319:1585–1589.
6. O'Leary KJ, Liebovitz DM, Baker DW. How hospitalists spend their time: insights on efficiency and safety. *J Hosp Med*. 2006;1:88–93.
7. Coiera E, Tombs V. Communication behaviours in a hospital setting: an observational study. *BMJ*. 1998;316:673–676.
8. Volpp KG, Grande D. Residents' suggestions for reducing errors in teaching hospitals. *N Engl J Med*. 2003;348:851–855.
9. Kuperman GJ, Teich JM, Tanasijevic MJ et al. Improving response to critical laboratory results with automation: results of a randomized controlled trial. *J Am Med Inform Assoc*. 1999;6:512–522.
10. Poon EG, Kuperman GJ, Fiskio J, Bates DW. Real-time notification of laboratory data requested by users through alphanumeric pagers. *J Am Med Inform Assoc*. 2002;9:217–222.
11. Nguyen TC, Battat A, Longhurst C, Peng PD, Curet MJ. Alphanumeric paging in an academic hospital setting. *Am J Surg*. 2006;191:561–565.
12. Berwick DM. A primer on leading the improvement of systems. *BMJ*. 1996;312:619–622.
13. SurveyMonkey.com. The simple way to create surveys. Available at: http://www.surveymonkey.com. Accessed September 2009.
14. Rogers EM. Diffusion of innovations. New York: Free Press; 1995.

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