Healthcare improvement based on learning from adverse outcomes

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Chapter 8

Text paging of surgery residents: Efficacy, work intensity, and quality improvement

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ABSTRACT

Background

Text pages can communicate important information but also disrupt workflow, which can affect the safety of patient care. The purpose of this study was to analyze the content, volume, and distribution of text pages received by general surgery residents and physician's assistants (PAs) using natural language processing (NLP).

Methods

We studied text pages received by residents and PA's at a tertiary care teaching hospital from March to May 2012 using NLP. Paging volume and content were stratified by recipient seniority, surgical service, patient census, and patient location. Chi-square tests, t-tests, and analysis of variance were used to detect statistical significance.

Results

We captured 48,202 pages. The average number (mean ± standard deviation) of pages per hour was 3.1 ± 2.2 for postgraduate year (PGY)-1s and 2.8 ± 1.9 for PAs (P <.0001). The greatest number of pages per day by service was 86.1 ± 37.5 on acute care surgery service. The most common paging topic was medications (18,444 [38.3%]) and the most common symptom was pain (6,240 pages [12.9%]). On services where patients were located near each other (regionalized), the number of pages per day per recipient per patient on census was almost half that compared with nonregionalized services (1.40 vs 2.43; P<.0001).

Conclusions

Residents receive a high volume of pages at this tertiary care center, particularly regarding medications and pain. Services with regionalized patients exhibit less paging need per patient. Initiatives to improve pain management and regionalize patients may streamline communication, decrease the number of pages, and increase patient safety.

Key words: Natural Language Processing, text paging, paging, resident paging, surgical residents

INTRODUCTION

Communication between health professionals is critical to patient safety and work efficiency, so it is important that electronic communication protocols such as paging are effective. Although many different systems of medical communication and information technology have been implemented, studied and improved, there is limited evidence that our communication has actually improved.[1] Indeed, it is difficult to measure improvement when the baseline for paging behavior to surgical residents is unclear in terms of both number and content.

At the end of the 1970s, many hospitals still relied on either the physical presence of their house staff on the floor for communication or on complicated "over-head" paging systems.[2] Since then, communication systems have been enhanced, transitioning from overhead paging to numeric paging to alphanumeric "text" paging. The evolution of text paging was considered a boon to residents, because this enabled them to triage their pages.[3,4] Nonetheless, frequent paging of residents and physician's assistants (PAs) interrupts workflow and patient care.[2,5-8] A text page can call a clinician's attention to an opportunity to prevent harm, but can also distract the clinician from a task at hand, potentially leading to harm.

Multiple prior studies estimated paging volume at 1-5 pages per hour.[2,9] Although this number of pages may not sound disruptive, one must consider that residents and PAs are quite busy even when they receive no pages per hour. The baseline tasks of both residents and PAs vary by level but all residents and PAs are responsible for performing surgery in the operating room, postoperative checks, assessment of patients in person as their postoperative status evolves, order entry after rounding, review and response to all lab and radiology tests ordered on each patient, minor procedures in patient rooms, admission of patients from clinic or as a transfer from another hospital, consenting patients for procedures, and communicating with the patients and their families. Meanwhile, responding to pages usually requires an order entry or a return phone call as the nurses don't carry pagers. Because of the effort required to respond to a page, receipt of a single page can take significant time. These interruptions, distractions and changes in focus away from these baseline tasks have been reported to be an important cause of active errors.[10] Human error is one of the greatest contributors to accidents in health care and patient safety.[11] By assessing the communication method of paging, we may find an opportunity to make systems changes that improve patient safety and the quality of care we provide while also decreasing the number of pages.[12]

Prior studies have suggested that a decrease in the number of pages can occur through improved communication, reduction of redundant paging, and postponement of nonurgent pages.[2] To assess the urgency and possible redundancy of pages, it is important to not only understand the number and timing of pages, but also the content of pages. Although the number of pages has been investigated, there are no prior studies detailing the content of these text pages or correlating the quantitative and qualitative aspects of text pages that can explain how they help and hurt a clinician's ability to care for patients. Using the technique of natural

language processing (NLP), our aim was to quantify paging topics to identify opportunities to improve on efficiency of text paging and to decrease the number of pages while improving patient care and maintaining a high quality of communication between providers.

METHODS

We obtained 48,202 time-stamped text pages received by 31 general surgery residents in post-graduate years (PGY) 1-3 and 3 PAs at a tertiary care hospital from March through May 2012. In this hospital, the PAs assist with preoperative and postoperative surgical care for patients on the floor. They function similarly to interns except that they work 4 days per week for 10 hours each day and are less likely to go to the operating room (OR). Our study did not exclude any page senders. Pages were limited to 200 characters of alphanumeric text.

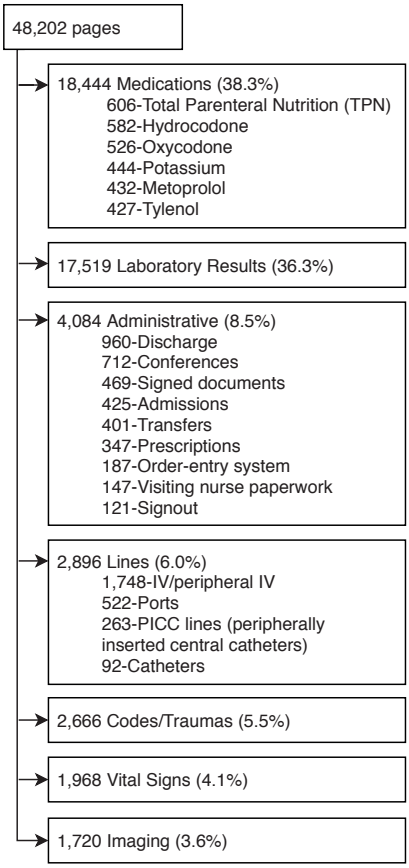
The paging data was anonymized using a Python Programming Language (available from: *www.python.com*; Worldwide Distributed Development) script so that names of all senders, recipients, and patients were replaced with a random identifier. An NLP program was written in Python to identify words of interest from a list of Medical Subject Headings (MeSH terms) referred to as the MeSH term dictionary.[13] Common abbreviations for terms such as "abdomen" were added manually to the dictionary so that "abd" in a text page would be identified as the MeSH term "abdomen." Paging content was then analyzed using the linguistic-based NLP program.[14] The output of the program included a list of MeSH terms and the number of times each term occurred in the paging data. Misspellings were corrected manually. MeSH terms were then categorized manually by topic (medications, laboratory results, etc), system, and symptom (Figure 1, Table 1). These topics were not mutually exclusive. For example, the MeSH term "metoprolol" was categorized under both "medication" and "cardiac."

We used the Tableau Visual Analytics Tool (Tableau Software, Seattle, WA) to assess the results graphically and analyze trends in paging over time by recipient, surgical service, and paging context. Number of pages and content were assessed by controlling for PGY level (or PA), patient census of service, and whether patient beds on the service were close to each other (regionalized) on the same hallway or floor.

Using work schedules, we identified the number of residents and PAs on service at any given time. We calculated number of pages per day by service and by recipient. We also adjusted for the patient census by service to create the unit of pages per day per recipient per patient census (pages/day/recipient/pt census). Page to some residents were unavailable for analysis because they had left the institution; this loss of pages decreased the number of pages available for analysis on some services but there was ≥1 month's worth of pages available for every service.

To study paging behavior by surgical service location, we compared regionalized services (where patients were located on the same floor or hallway) to nonregionalized services (where patients were located on different floors and in different parts of the hospital). For nonregion-

Figure 1. Flow chart. Text pages may include content from multiple categories.



alized services we used 2 general surgery services and focused only on the patients on their regular patient wards as opposed to those in the intensive care unit (ICU). For regionalized services we used both ICU services as well as ward services. Most of our ICUs consist of 1 circular arrangement of 10 patient beds with a desk and computer available for the resident on call. The only exception is the cardiac surgery ICU, which is arranged the same way as vascular surgery; the beds are all on 1 floor and with 28 patient beds in a big circle. The thoracic surgery service consists of 4 pods. Each pod holds 10 patients. One pod is on floor 12 while the remaining 3 pods are on floor 11.

Statistical analysis

We used *t* tests for comparison between means of 2 groups and analysis of variance was used for comparison between the means of multiple groups. All statistical analyses were performed using Statistical Analysis System (SAS) 9.3 software (SAS Institute Inc, Cary, NC). Continuous variables are presented as mean values ± standard deviation.

Table 1. Pages adressing medications.

Medication categories	n (%)
Total	18,444
Pain	3,925 (21.2)
Opioids	2,594 (14.1)
Hydromorphone	684 (3.7)
Oxycodone	650 (3.5)
PCA	572 (3.1)
Epidural/PCEA	261 (1.4)
Fentanyl	180 (1.0)
Morphine	126 (0.7)
Acetaminophen	534 (2.9)
Ketorolac	168 (0.9)
Other	750 (4.1)
Electrolytes	1,385 (7.5)
Cardiac	1,110 (6.0)
Pulmonary	966 (5.2)
Antibiotics	913 (5.0)
Insulin	872 (4.7)
Anticoagulants	854 (4.6)
TPN	689 (3.7)
Antiemetics	580 (3.1)

PCA, Patient-controlled anesthesia; *PCEA*, patient-controlled epidural anesthesia.

RESULTS

Number of pages

A total of 48,202 pages were sent to 31 general surgery residents and 3 general surgery PAs on 25 services in a 3-month period. Over all surgical services, the number of pages received per day by a single recipient ranged from 1 to 249 pages, with an average of 2.7 ± 2.0 pages per hour (minimum [min], 1; maximum [max], 20) across all 3 residency levels and PAs. The average number of pages per hour was 3.1 ± 2.2 (min, 1; max, 20) for PGY-1s, 2.8 ± 1.9 (min, 1; max, 16) for PAs, 2.0 ± 1.4 (min, 1; max, 12) for PGY-2s, and 1.8 ± 1.2 (min, 1; max, 12) for PGY-3s (P <.0001). When analyzed by day (6 am-6 pm) and night (6 pm-6 am) rotations, similar results were found (Table 2). The number of pages per hour was greater during the day than at night for every PGY level except for PGY-2s, consistent with the data when stratified by surgical service and number of pages per hour (Figure 2).

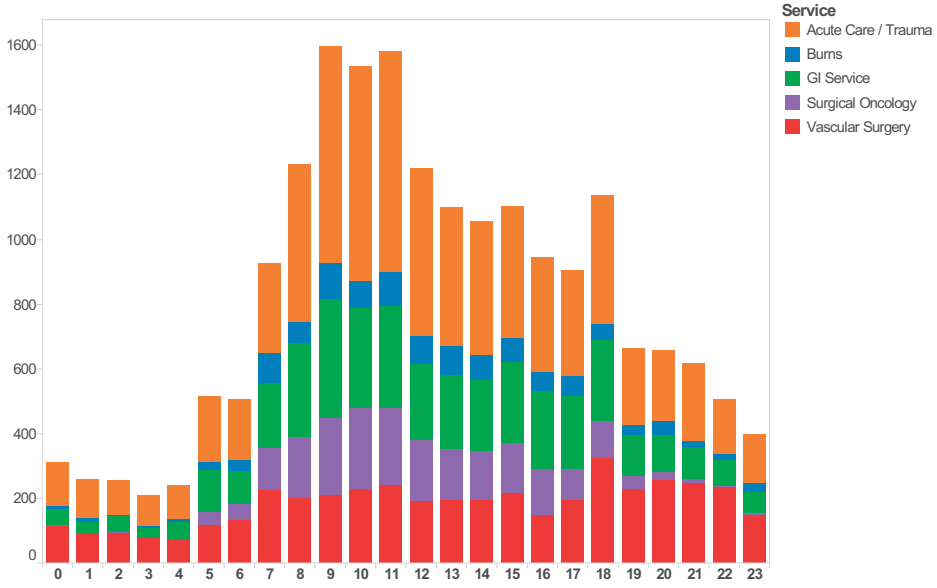
By surgical service, the average number of pages per day ranged widely from 9.5 ± 2.0 (min, 1; max, 30) on the burn / trauma ICU to 86.1 ± 2.0 (min, 3; max, 192) on the acute care surgery service. The number of pages per day was highest for the acute care surgery and thoracic surgery services. When controlled for census, services with the greatest mean number of

Table 2. Pages per hour by recipient role and day versus night rotations.

	PA	*PGY-1*	*PGY-2*	*PGY-3*
Day: 6 am-6 pm				
Average number pages/h	2.9	3.2	1.8	1.9
Minimum	1	1	1	1
Maximum	16	20	10	12
Standard deviation	2.0	2.3	1.1	1.2
P	.0007	reference	<.0001	<.0001
Night float: 6 pm-6 am				
Average number pages/h	1.4	2.9	2.2	1.6
Minimum	1	1	1	1
Maximum	7	20	12	7
Standard deviation	0.9	2.0	1.6	1.1
P	<.0001	reference	<.0001	<.0001
Overall: 6 am-6 am				
Average number pages/h	2.8	3.1	2.0	1.8
Minimum	1	1	1	1
Maximum	16	20	12	12
Standard deviation	1.9	2.2	1.4	1.2
P	<.0001	reference	<.0001	<.0001

PCA, Patient-controlled anesthesia; *PCEA*, patient-controlled epidural anesthesia.

Figure 2. Mean number of pages over 24 hours (midnight to midnight) by surgical service.



pages / day / recipient / pt census were transplant surgery (5.8) and urology (3.1; Table 3). Residents and PAs on regionalized services experienced fewer mean pages / day / recipient / pt census compared with residents and PAs on nonregionalized services (1.4 ± 0.3 vs 2.6 ± 0.6; P<.0001; Table 4).

Table 3. Number of pages according to surgical service per 24-hour period

Service	*Number of pages per day mean ± SD (min,max)*	*Mean number of recipients*	*Mean pages per day per recipient*	*Mean census of service*	*Mean pages per day per recipient per patient census*
All days (Monday-Sunday)					
Acute care surgery	86.1 ± 37.5 (3, 192)	2.4	35.9	12.8	2.9
Thoracic surgery	61.8 ± 29.3 (1, 120)	1.9	32.5	34.8	0.9
Gastrointestinal surgery	59.3 ± 33.9 (2, 121)	2.2	27.0	29.5	0.9
Surgical oncology	53.7 ± 24.1 (16, 107)	1.3	41.3	21.9	1.9
Vascular surgery	49.1 ± 22.5 (1, 130)	2.0	24.6	14.7	1.7
Neurosurgery	45.0 ± 24.0 (1, 112)	1.3	34.6	19.3	1.7
Cardiac surgery ICU	31.9 ± 20.5 (3, 95)	1.8	17.7	12.3	1.4
Urology	26.4 ± 14.7 (1, 58)	1.0	26.4	8.4	3.1
Burn surgery	13.9 ± 10.2 (1, 46)	1.0	13.9	11.2	1.2
Plastic surgery	13.3 ± 10.6 (1, 42)	1.0	13.3	7.5	1.8
Surgical ICU, general	11.7 ± 10.4 (1, 50)	1.4	8.4	6.6	1.3
Transplant surgery	11.6 ± 7.1 (1, 29)	1.0	11.6	2.0	5.8
Thoracic ICU	11.0 ± 8.6 (1, 36)	1.0	11.0	7.9	1.4
Surgical ICU, burn / trauma	9.5 ± 7.5 (1, 30)	1.0	9.5	6.3	1.5
Weekdays (excluding Saturday and Sunday)					
Acute care surgery	97.5 ± 32.2 (16, 192)	2.7	36.1	13.1	2.8
Thoracic surgery	73.4 ± 24.3 (28, 120)	2.0	26.7	36.2	1.0
Gastrointestinal surgery	65.0 ± 32.9 (5, 121)	204	27.1	31.5	0.9
Surgical oncology	53.9 ± 23.6 (16, 107)	1.3	41.5	22.1	1.9
Vascular surgery	55.0 ± 21.0 (15, 130)	2.1	26.2	15.2	1.7
Neurosurgery	53.0 ± 19.2 (1, 112)	1.4	37.9	21.3	1.8
Cardiac surgery ICU	32.9 ± 20.9 (3, 95)	1.9	17.3	13.2	1.3
Urology	28.8 ± 15.1 (1, 58)	1.0	28.8	9.2	3.1
Plastic surgery	13.3 ± 11.4 (1, 42)	1.0	13.3	8.0	1.7
Transplant surgery	12.3 ± 7.5 (1, 29)	1.0	12.1	1.9	6.5
Burn surgery	12.1 ± 7.6 (1, 29)	1.0	12.3	10.9	1.1
Surgical ICU, general	12.0 ± 10.8 (1, 50)	1.4	8.6	6.7	1.3
Thoracic ICU	11.5 ± 9.2 (1, 36)	1.0	11.5	7.9	1.5
Surgical ICU, burn / trauma	9.7 ± 7.5 (1, 30)	1.0	9.7	6.2	1.6

ICU, Intensive care unit; *SD,* standard deviation.

Table 4. Number of pages per day per recipient per patient census

	Nonregionalized services (mean = 2.6)		*Regionalized services (mean = 1.4*)*					
Month	*Trauma / acute care surgery (census)*	*Oncologic surgery (census)*	*Surgical ICU, burn/ trauma (census)*	*Surgical ICU, general (census)*	*Thoracic surgery ICU (census)*	*Cardiac surgery ICU (census)*	*Vascular surgery (census)*	*Thoracic surgery (census)*
March	3.2 ± 1.2 (11.5)	1.8 ± 0.8 (19.4)	2.1 ± 1.6 (4.6)	1.0 ± 0.6 (6.5)	1.6 ± 1.2 (9.3)	1.8 ± 0.9 (11.0)	1.7 ± 0.7 (16.0)	0.9 ± 0.3 (35.1)
April	2.6 ± 1.1 (14.2)	1.9 ± 0.7 (25.4)	1.1 ± 0.9 (6.5)	1.7 ± 1.1 (6.1)	1.2 ± 0.7 (7.1)	1.3 ± 0.6 (13.3)	1.9 ± 0.6 (13.4)	0.9 ± 0.3 (38.4)
May	3.2 ± 1.5 (12.8)	2.8 ± 0.9 (21.6)	1.5 ± 1.2 (7.5)	1.1 ± 0.9 (7.3)	1.6 ± 1.4 (7.9)	1.4 ± 0.7 (12.6)	1.4 ± 0.6 (14.7)	1.0 ± 0.3 (31.3)

ICU, Intensive care unit; *SD,* standard deviation.

Content of pages

Of all 48,202 pages, 38.3% were about medications, 36.3% were about laboratory results, and 8.5% were about administrative concerns (Figure 1). Given that these topics (medications, laboratory results, administrative, etc) are pertinent to all organ systems (cardiac, pulmonary, urinary) and symptoms (pain, diet, nausea and vomiting), pages were also tagged by system and symptom. Overall, the most common symptom was pain (6,240 pages, 12.9% of all pages) and the most common system was cardiac (2,782 pages, 5.8%). Of all pages about medications (18,828), the most common classes of medications involving pages addressed pain (3,925 pages, 20.8%), electrolytes (including potassium, magnesium, calcium, and phosphate repletion; 1,385 pages, 7.4%), cardiac medications (1,110 pages, 5.9%), and pulmonary medications (966 pages, 5.1%; Table 1). The most frequently discussed pain medications were opioids (2,594 pages, 66.1%), the most commonly mentioned opioids were hydromorphone (684 pages, 17.4%), oxycodone (650 pages, 16.6%), and patient-controlled anesthesia (572 pages, 14.6%). Of all medications addressed via paging, the most frequently mentioned were total parenteral nutrition (689 pages, 3.7%), hydromorphone (684 pages, 3.6 %), and oxycodone (650 pages, 3.5%) (Table 1).

DISCUSSION

The number of pages received by interns, residents, and PAs was consistent with their duties and type of service. Number of pages averaged 3.1 per hour for interns, which is consistent with prior published studies showing 1-5 pages per hour. Our study also identified the impact of recipient training level and time of day on paging volume and includes data about peak paging volume. PAs have a similar paging volume to interns (2.8 per hour), which is expected,

because PAs do a similar job caring for surgical patients on the patient care floor in our institution. The number of pages may be slightly lower as they spend less time in the operating room (OR) and so have more time available to be directly present with patients and other care providers on the floors. PAs also have more clinical experience than the interns and have had time to build trust with other care providers. These and other factors may explain the slightly fewer number of pages per PA compared with the interns.

We found lesser overall rate of paging for PGY-2 and PGY-3 residents compared with interns. At our tertiary care hospital, the PGY-2 residents spend about one-half of their year managing patients in the ICU's. These units are limited to 10 patients who are all located in 1 circular hallway, which makes communication between the providers (doctors, nurses, respiratory therapists, and pharmacists) much easier, because everyone can easily meet face to face. The physical layout of these units may explain the decreased number of pages to the PGY-2 residents, especially because ICUs are regionalized services, and these units used fewer text pages compared with nonregionalized services. In our hospital, the PGY-3 residents are often responsible for the surgical consults, which may explain why their number of pages includes the initial consult page as well as any follow-up pages regarding questions or clarifications in patient management. Because the primary teams are responsible for enacting the recommendations of consultants, the PGY-3 residents generally do not receive pages regarding ward management for patients in whom they are asked to provide a consultation. This may explain the lesser number of pages sent to PGY-3 residents. We believe that the decrease in the number of pages from PGY-1 to PGY-3 reflects their decreased direct responsibilities to floor and ICU patients as well as their increased responsibilities in the operating room.

Although the number of pages may average 1.8-3.1 pages/hour, recipients received as many as 20 pages per hour. The effect of such a communication load on residents, PAs, and patient safety is unknown and worthy of further study. While much effort has been focused on decreasing human error by limiting resident work hours, the level of work intensity may also play a role in human error and patient safety.

A wide range in number of pages per hour was noted for all groups of paging recipients. Although the range is greater (≤20 pages per hour) for PGY-1 residents than for senior residents (≤12 pages per hour), these data illustrate the unpredictable nature of each day for residents and PAs. It is difficult to plan for many social or family occasions, because the resident may not know if it will be a 16-page day or a 192-page day. In an era where all healthcare providers are increasingly evaluated on their communication skills and their standardized test scores, there is no formal truly protected time for communication with patients and family or for studying a disease process.

Pain was overwhelmingly the most popular symptom discussed by paging, which may suggest that surgeons were systematically undertreating pain in the study period. Before to the time period of this study, our hospital had implemented protocols for management of pain medications and created a postoperative pain service to assist the surgical services. Nurses

across all services are allowed limited options for dose adjustment of pain medications, but these include a few small bolus doses for breakthrough pain when a patient has a patient-controlled anesthesia device or administration of a narrow range of oral pain medications (examples such as 5-10 milligrams of oxycodone or 1-2 milligrams of hydromorphone). Despite these measures, there remains the need for paging as a form of communication regarding patient pain compared to other medical issues. Based on the results of this study, we held a meeting that included the heads of surgical nursing, the chief medical officer of the hospital (the senior author of this study [S.W.A.]), and a representative of surgical residents (the first author [A.D.B.S.]). Pain management was discussed and the point of transition from intravenous pain medication to oral pain medication was identified as a potential source for the greatest number of pages about pain. For this reason, a next step for this study includes creation of a protocol specifically for transition from intravenous to oral pain medication in our hospital.

Finally, our study identified clear differences in paging behavior between regionalized and nonregionalized surgical services. Services with patients whose beds were in close proximity to each other (regionalized) sent fewer pages per patient than did those services whose patients were spread out across the hospital (nonregionalized). This difference may be a result of several factors. Services with regionalized patients are staffed by nurses who regularly care for the same type of patient, likely resulting in a greater level of comfort with patient care. Additionally, when a clinician comes to the ward to see a patient, they can easily see other patients on that service and address issues in person without requiring pages to be sent. Not only are the patients regionalized, but the nurses caring for all of their patients are also grouped together. This proximity facilitates in-person communication, builds trust between clinicians, and makes it easier to address patient concerns. Comparisons of organized inpatient care by specialty versus care on general wards have been found in prior studies to improve patient outcomes such as reduction in the odds of death.[15] In contrast, when patients are dispersed, the nursing staff may be less familiar with the care protocols of any given service and less familiar with the residents and PAs caring for the patient. This situation creates an environment where familiarity and time to spend with the patients and nursing staff is less, requiring increased levels of communication via paging. Given this finding, we plan to try to better implement the regionalization of all general surgery patients in our tertiary care hospital to increase the quality and safety of patient care.

Although an educational intervention regarding paging could be beneficial to both page senders and recipients, measuring the impact of such an intervention would be difficult owing to ongoing regionalization of surgical services and new additional pain management protocols. We plan to assess a new baseline for paging once these changes have occurred and then consider an educational intervention.

This study is limited by being a single-institution study at an academic medical center and therefore may not be generalizable to other hospitals. Another limitation is that there were

some residents (9 interns and 2 PGY-3 residents) who had already left our tertiary care hospital by the time the pages were retrieved; therefore, the pages they had received were already deleted from storage. For this reason, the rotations they covered from March-May 2012 do not show any pages. These absent values did not contribute to any surgical service totals or averages, but their absence reduced the number of months of data we had for some services. As a result, our paging volume by service may vary in future studies.

Furthermore, to meet the requirements of resident duty hours by giving the on-service resident 1 day off each week, another resident or moonlighter covered the service. Because we did not have the coverage schedule for residents, we were unable to capture service-related pages on these days. Also, because our data periodically shows about 1-3 pages per day for the usually busy service on some days, it seems likely that these were the days when the resident who covered the service could not be identified. For this reason, paging volumes by service may further be underestimated.

Our measure of the number of pages per day per resident in Table 3 is not weighted for working during the day versus the night, which should be considered when comparing paging volume between services. As shown in Figure 2, there are a greater number of pages across services from 6 am to 6 pm when the day residents residents and PAs work compared with 6 pm to 6 am when the night resident is on call. The same difference in number of pages is quantified in Table 2 where pages per hour were compared between the day recipients and the night float recipients. For this reason, the measures underestimate the number of pages residents and PAs received during the day and overestimate the number of pages received by the resident at night, because the total number of pages per day is divided by the total number of residents and PAs who received pages for the service in any 24-hour period.

No call schedules were accounted for in this analysis, because our services work on a night float system rather than an on-call system. One or more residents and PAs cover a service during the day from 6 am to 6 pm. A different resident covers the service at night from 6 pm to 6 am. Schedules vary on the weekends. For this reason, the results in Table 3 that show the mean number of pages per day to the surgical services were split to exclude any data from weekends; however, show the same effect is shown.

These limitations notwithstanding, our study represents a detailed analysis of quantity and content of pages during the conduct of care for surgical services within a tertiary teaching hospital. Our results are likely an underestimation of the number of pages that occur, and hence further support the need for changes that improve work efficiency and hospital communication while maintaining excellent patient care.

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