Case report

Implementation of smart phones to facilitate in-hospital telephone communication: Challenges, successes and lessons from a neonatal intensive care unit

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ABSTRACT

Implementation Lessons 1. Mobile telephony use in the hospital setting is complex and sub-optimal implementation of mobile communication technology can create inefficiencies in clinical workflow 2. Objective measurement of mobile technology's impact on clinical communication workflow is necessary to identify and remediate associated inefficiencies in real-time 3. Functionality between mobile applications and devices should be evaluated when implementing technology, particularly when an application is non-native to a device 4. Continual collaboration between front-line clinicians and technical teams allows for early identification of adverse impacts from, and optimization of, mobile communication technology implementation.

1. Background

Collaborative patient management across a hospital setting requires reliable and efficient communication between healthcare providers.[1–5] Caregiver communication can take on many forms, with telephony being an important mechanism for sharing critical clinical information.[6,7] Despite the importance of telephony in hospital communication, successfully connecting healthcare providers by telephone can be fraught with inefficiencies.[6] Mobile smartphone technology has the potential to facilitate critical communication among providers and improve patient care delivery.[8–10]

The potential benefits of mobile communication have prompted the emergence of devices, software platforms, and applications to enhance mobile communication for clinicians.[11] With the increasing number of applications and devices available, successful integration of these tools are necessary to ensure efficient communication.[1,12,13] A number of technical factors, including how devices and applications are designed to work together, can impact implementation; yet, few studies have evaluated the integration of multiple technologies on clinical communication.[10,12,14–16]

In this case study, we describe the implementation of smartphones to facilitate telephony in a newly designed neonatal intensive care unit (NICU), and the optimization of device-application interaction for telephone communication.

2. Organizational context

This study was performed in a newly designed Level IV NICU which treats neonates throughout the state. The NICU is housed within an urban academic medical center in the Mid-Atlantic, USA. It is staffed by physicians, nurse practitioners, nurses, trainees, and various ancillary service providers. Staff generally remain present in the NICU physical space but may leave the NICU for conferences, transporting patients, or performing consults and procedures in other areas within the hospital. The new physical space houses 52 individual patient rooms and replaced an older NICU with open bay patient care areas. As a result, the size of the clinical care areas significantly increased. Nurses were spread among workstations rather than at centralized nursing stations, decreasing the opportunities for face-to-face communication.

To reduce noise for patients and staff, an overhead paging system was not included as a mechanism for clinical communication. Its absence was a unique feature within the institution, as other units including the previous NICU, relied on overhead page notification to signal a need to respond to incoming telephone calls.

The unique physical design and absence of overhead paging in the NICU highlighted the need for reliable mobile telecommunication. To

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accommodate these needs, individuals are provided Motorola MC40 smartphones (Zebra Technologies Corp., Lincolnshire, Illinois). The devices are shared among staff and handed off at shift changes. Calls to devices can only be received from within the institution, as not to disrupt clinical workflow with unscreened or non-urgent calls. Calls to the unit are screened by the unit secretaries and answered on Cisco desk phones (Cisco Systems, Inc., San Jose, CA). Unit secretaries transfer phone call from within and outside the hospital to individual devices, as appropriate to facilitate communication between parties. If phone calls are unanswered after a pre-determined number of rings, the call is automatically forwarded back to the unit secretaries.

3. Personal context

The re-organization of the NICU physical space was designed and engineered by a multi-disciplinary project team that included re-presentation from the medical team, pharmacy, environmental services and infection control. This group influenced the decision to transition from open-bay rooms to individual patient rooms, as individual rooms were felt to best support intensive and developmental care delivery for our neonatal population.[17] This decision was in keeping with current trends to privatize care areas for neonates in our region.[18]

The motivation to eliminate overhead paging was based on staff dissatisfaction with the frequency and disruptive nature of overhead pages that occurred in the previous NICU, as well as concerns related to noise levels experienced by patients and families. These pages were not limited to communication regarding telephone calls but also broader clinical communication including bedside alarms and emergency alerts. For example, notification regarding the need for a neonatal resuscitation team alone generated 60–100 overhead pages per month.

Neonatal ICU physician and nurse leadership determined the communication objectives, while the clinical engineering department was essential in finding technology that would support these communications and provide ongoing support for the chosen technology. Cooperation from the information technology (IT) department was required for supporting Wi-Fi integration.

4. Problem

To enable telephone functionality of our mobile devices the technical team installed Cisco Jabber version 8.4 (Cisco Systems, Inc. San Jose, CA) as the voice-over IP application (voIP). Shortly after implementation staff reported that phone calls were not being successfully transferred from the front desk to individual staff members. Investigating further, the technical team discovered that when a staff member had not used their phone after a period of time the device went into sleep mode, as expected. However, in sleep mode the voIP application also unexpectedly logged off. When the device was taken out of sleep mode by the user the voIP application attempted to launch with an auto-login. The auto-login frequently failed so that the device could not make incoming or outgoing phone calls without manual configuration by a member of the technical team. Unfortunately, users were unaware when a device was in need of such configuration, and the unrecognized issue prohibited phone calls from being received by the user. These phone calls were routed to the secretaries at the front desk phone. Often the secretaries would attempt to transfer the phone call back to the intended receiver's device which was still non-operational, leading to a vicious cycle of call transfers until it was recognized that the voIP application was logged off. Sometimes the secretaries would use alternative methods to notify a recipient of an incoming phone call, such as text messaging or transferring calls to another desk phone nearby the intended recipient. Anecdotally, this created frustration and inefficiency among NICU staff, consultants, patient families, and ancillary support staff.

To estimate the extent of the problem we monitored a convenience sample of phone calls to unit secretaries during 2-h observation periods

Table 1
Pattern of observed unit secretary phone call outcomes.

Call Outcome	Pre-intervention N (%)	Post-intervention N (%)
Successful transfer	813 (47.5)	336 (70.1)
Text/Retransferred	441 (25.8)	53 (11.1)
Unsuccessful	126 (7.3)	7 (1.4)
Not applicable	328 (19.2)	79 (16.6)
Total	1708	475

chi-square 95.6, p < 0.05 for overall groups.

between 9 a.m. and noon. Calls were assigned to one of four categories: successful, text/ retransfer, unsuccessful and not applicable. Calls were considered successful if the call was forwarded by the unit secretary to the intended recipient's device on first attempt. Calls were categorized as text/retransferred if the secretary made more than one attempt to forward a call to the intended recipient's device or if the secretary texted the recipient to inform them of the call. Calls were categorized as unsuccessful if the call did not reach the intended recipient by any mechanism. Calls that did not require forwarding to an individual within the NICU were considered not applicable. To determine the time required to reach a bedside nurse by phone, two phone calls per observation period were made to bedside nurses by a member of the study team. These calls were categorized as successful (the bedside nurse was reached within 180 s) or unsuccessful (disconnected or greater than 180 s to connect). The duration of time to successfully connect to a bedside nurse was measured using a stopwatch application. Data were prospectively collected from 27 May 2016–4 October 2016 (see results for pre-intervention data in Tables 1 and 2).

The technical team suspected that the difficulty with auto-launch was because the voIP application was non-native to the device, meaning the application was not specifically designed for the operating system. Non-native applications are designed to function on a variety of devices and operating systems, however, this flexibility may lead to compromised integration with other applications on the device.[19] Alternatively, native applications are built to function on a specific device or operating system, inherently providing smoother integration between multiple applications on the device. Our goal was to improve telephone communication efficiency by replacing the non-native voIP application with a native application. We hypothesized that the native application would decrease the time required to reach bedside nurses by phone and increase the percent of telephone calls that were made successfully on first attempt. We also anticipated decreased number of calls to the unit secretary desk phone, as fewer unanswered calls would be re-routed back to the secretary.

5. Solution

In December 2016, Jabber was replaced with Workforce Connect (Zebra Technologies), the native voIP of the MC40 device. While the native application was expected to be associated with greater efficiency for communication, committing to the application required additional investment from our institution. Since the telecommunication needs of the NICU were unique and not generalizable across the hospital, the expense was heavily considered by hospital administration. Additional

Table 2
Comparison of applicable unit secretary phone calls.

Outcome	Pre-intervention N (%)	Post-intervention N (%)
Successfully transferred on first attempt	813 (58.9)	336 (84.8)
Not successfully transferred on first attempt	567 (41.1)	60 (15.2)

chi-square 90.6, p < 0.05 for overall groups.

investment in NICU communication technology had broader implications because the administration had not yet committed to supporting our particular smart device across the hospital system. It was unclear how the NICU technology could be adapted across other hospital units and workflows. Ultimately, our data on failed telephone communications among providers (see Tables 1, 2) influenced additional monetary investment in the native application.

To estimate the impact of our solution, we prospectively collected post-intervention data from 26 January 2017–22 March 2017. Normality of the sample was assessed with Kolmogorov-Smirnov test. Continuous data are expressed as median and range. Categorical data are expressed as number (%). Differences between the pre- and post-intervention groups were assessed using independent sample *t*-test and Mann-Whitney *U* tests for non-parametric continuous data and chi-square tests for categorical data. Statistical significance was set at $p < 0.05$. Analysis was completed using Socscistatistics, Physics.cbsju.edu/stats and R Statistical Software.

A total of 2183 observed calls were received by the unit clerk during the study period; 1708 during the pre-intervention period and 475 during the post-intervention period. The overall pattern of phone call categories significantly changed significantly between the pre- and post-intervention period with an increase in the percentage of calls being successfully forwarded; chi square 95.6, $p < 0.05$ (Table 1). Among applicable calls, the percentage that were successfully forwarded to their intended recipient on first attempt significantly increased during the post-intervention period; chi-square 90.6, $p < 0.05$ (Table 2).

The median number of calls per hour to the unit secretary desk phone significantly decreased during the study period; 14 (range 3–26) during the pre-intervention period and 10.5 (range 3–19) during the post-intervention period ($p < 0.05$).

A total of 108 calls were placed by the research team to bedside nurses during the observation period; 70 during the pre-intervention period and 38 during the post-intervention period. The percent of successful phone calls (within 180 s) was unchanged between the pre- and post-intervention periods (88.5% pre- vs 94.7% post-; chi square 1.1, $p = 0.29$). However, the percent of calls that took longer than 60 s to reach the intended recipient significantly decreased during the post-intervention period from 30% to 5.2% (chi square 8.9, $p < 0.05$). Among calls that were successfully placed, there was a 44% reduction in the median duration to reach the intended recipient. (Fig. 1).

6. Unresolved questions and lessons from the field

Hospital-wide implementation of mobile technology is complex and problems with integration can be a source of inefficiencies in healthcare delivery.[20] Technical factors that must be considered prior to implementation include Wi-Fi and cellular infrastructure, data security,

integration with patient monitoring systems and electronic health records, support of personal devices, equipment durability, infection control, battery life, asset management, customer support capabilities, and interoperability of devices and applications.[11,13] Above all, the technology must support the various clinical processes associated with patient care. If any of these technical factors cannot meet the needs of the clinicians' workflow, healthcare delivery and patient outcomes may be adversely impacted.[8,20]

In our case, mobile technology that was meant to support communication resulted in ineffective and inefficient communication processes. The frequent failures of our telephone application were likely caused by application-device incompatibility. The burden imposed on the staff was immediately felt. Clinicians found themselves using workarounds (e.g. texting) and alternative devices (e.g. desk phones) to facilitate communication. Over time our data demonstrated the extent of the communication system's inefficiency, ultimately leading to the implementation of an alternative application for telephony. Following this implementation, we observed a reduction in the number of calls to the unit secretary per hour, an increase in successful call transfer on first attempt, and a reduction in time to reach a bedside nurse by phone. Since telephony is our primary mechanism for communicating with specialty consultants, operating room staff, and our regional neonatal transport team efficient mobile communication has the potential to improve healthcare delivery for our patients. Future study of our communication system on healthcare delivery and patient outcomes is ongoing.

A principle highlighted by this case is the need for close compatibility between software and hardware. While a variety of software applications can serve a similar communication function, each may be markedly different with respect to design, cost, functionality, reliability and user experience.[19] In our case, the difference in reliability between the native and non-native application was important. While in many cases native applications are user-friendly they can be associated with greater expense and/or limited integration with other devices and operating systems.[19] With multiple manufacturers and developers competing for market share in the healthcare sector, it can be difficult for clinicians to know which applications will be most beneficial for workflow needs. Additionally, as in our situation, problems with integration may not be obvious in the pilot stage or even immediately after larger scale deployment. Therefore, we recommend that leadership teams assign professional technical experts to partner with clinicians to understand their needs and assist with decision-making for software and hardware, prior to and following implementation.

Another difficulty that we faced was concern about financial investment in an additional application for telephony. Financial considerations are a common barrier to clinical mobility implementation in hospitals.[12] The cost of mobile telephony not only involves the initial purchase of devices but also annual license fees, any upgrades to the supporting infrastructure, and technical support for users and for systems integration. Data on the long-term benefits of mobile technology investment are limited, making it difficult to weigh against the risks of monetary commitment.[14–16] Helping us overcome that barrier was the ability to provide data on the application failures. The high degree of failure was able to be viewed by everyone as unacceptable, leading to investment in the replacement application.

This experience has emphasized the importance of gathering data on clinical workflows both before, during, and after implementation of any healthcare technology. Outcomes related to clinical processes must be measured to ensure that the deployed technology does not lead to increased work for staff. The promise of mobile technology is efficient connectivity among patients and healthcare providers, while being free of multiple or static devices. Without objective assessment of the technology's impact on communication processes, hospitals risk poorer healthcare delivery and additional strain for clinicians. Engineering and evaluating health information technology systems to optimize patient-centered outcomes was identified as a national goal almost 10 years

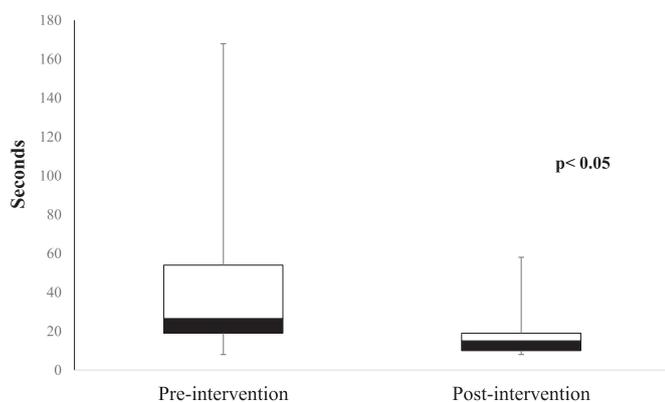Figure 1. Box plot of duration to reach intended recipients

Fig. 1. Box plot of duration to reach intended recipients.

ago; yet, further research on clinical mobility and healthcare delivery outcomes is still needed.[1]

The commitment to support this technology in the NICU led to broader questions about technology use in other areas of the hospital. Whether the current technology can support the clinical workflows of other units and hospitals within our system is a question that remains to be answered. Additionally, who bears the responsibility and ownership of the technology can be difficult to determine for products that are used by clinicians, but require technical integration and, in some cases, clinical engineering. As the devices are used for expanding capabilities (secure texting, photodocumentation, clinical alarm notifications, etc.), the need for close collaboration between these hospital groups is emerging rapidly within our institution. We believe that this collaboration will be an essential characteristic of future success with clinical mobility.

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