Impact of a Hands-free Wireless Communication Device on Communication and Clinical Outcomes in a Pediatric Intensive Care

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Introduction: Timely communication is essential in the intensive care environment. Delays may occur if communication relies on identification of individuals through line of sight, or use of telephones and pagers. We measured communication delays, staff perceptions, and clinical outcomes before and after implementation of a hands-free wireless communication device (HWCD) in a pediatric intensive care unit (PICU). Methods: Single-center study comprising 3 components: observational study of verbal communication among PICU staff; staff survey regarding perceptions of communication delays; analysis of clinical data (length of stay, risk adjusted mortality, emergency events). All components were conducted before and after implementation of the HWCD. Results: Four hundred sixteen hours of staff working time were observed (210 pre- and 206 postimplementation). These data showed significant reduction in communication delays—most notably among roaming staff [median time to response to verbal queries before and after implementation 120 seconds (interquartile range, 6–255) and 9 seconds (interquartile range, 7–30), respectively; P < 0.001]. The results of the staff survey showed significant improvements in staff perceptions of communication delays in all roaming staff groups utilizing the HWCD. The survey response rate was 205/361: 56.8%. There were no differences in clinical outcomes from the routinely collected clinical data. There was a significant reduction in emergency event rate—emergency summoning of assistance to bedside (per 100 bed-days)—before and after implementation, 2.17 and 1.69, respectively: rate ratio = 0.78 (95% confidence interval, 0.63–0.95; P < 0.05). Conclusions: Implementation of a HWCD was associated with significant reduction in communication delays among roaming staff members in PICU.

INTRODUCTION

Timely and precise communication is an essential component of a functional intensive care unit. The majority of communication between coworkers within intensive care comprises verbal transfer of information (eg, handover) and requests for assistance. Much of this communication is time-critical, so communication delays may impact patient care. Verbal communication may take place via face to face interaction, or via devices such as telephones and pagers. An emerging modality for assisting verbal communication is the hands-free wireless communication device (HWCD).1

These devices are typically worn by the user, allowing hands-free verbal communication between colleagues within a specified environment. The user may also receive and initiate telephone calls or pages. HWCD utilize voice over internet protocol over a wireless local area network to transmit audio data between devices.

Previously published reports have shown reduction in time to locate colleagues in acute clinical environments2–4 and reduced nursing interruptions to patient care.5 The impact of HWCD in a pediatric intensive care unit (PICU) has not previously been described.

A HWCD (Vocera communications, San Jose, Calif.) was installed in our institution’s PICU in response to identification of communication delays and expectation of exacerbation of delays due to imminent expansion of the PICU from 20 to 31 beds. Before implementation of a HWCD, verbal communication between colleagues depended on line-of-sight communication. Communication delays were commonly reported as a
result of multiple physical obstructions to line of sight across the unit (eg, structural factors such as walls, pillars, and cubicles). These physical obstructions to line of sight were anticipated to increase significantly as a result of the expansion, as the additional beds were located in the adjacent ward, separated from the original unit by a wall. A further risk to timely communication between colleagues was the associated increase in staffing numbers, which occurred pro-rata with the increased PICU bed capacity. Funding for implementation of the HWCD was obtained by charitable grant. Implementation took place over a 2-week period following completion of expansion of the PICU footprint and enhancement of wireless access points and computer servers. Implementation in the clinical area comprised a training period for all staff who worked in the clinical area. The HWCD units (“badges”) were introduced piecemeal during this period, as staff received training.

This study aimed to answer the following questions:

1. Would the implementation of a HWCD be associated with a reduction in communication delays?
2. Would the implementation of a HWCD be associated with improved staff perceptions of communication delays?
3. Would the implementation of a HCWD be associated with changes in routinely collected clinical metrics (risk-adjusted mortality, length of stay, and rate of emergency events)?

METHODS

This study comprised 3 distinct methodologies: a time and motion study of direct observation of communication between staff members; an anonymous, electronic staff survey; and a retrospective cohort study of routinely collected clinical data. All components of the study were conducted in 2 phases: before and after the implementation of the HWCD. The study took place during a static phase of planned staff expansion—therefore the staffing establishment was unchanged between the pre- and post-implementation phases. NHS Research Ethics Committee approval for this study was not necessary, as this was a service evaluation study of staff metrics and routinely collected anonymous clinical data.

Directly Observed Communication Metrics

A team of research nursing staff conducted an observational study of communication delays in 2 staff groups on PICU: bedside nursing staff and “roaming” staff. Roaming staff were defined as staff members whose role required responsive movement throughout the PICU without allocation to a specific location (eg, junior doctors, consultants, senior nurses, and nursing coordinators). The researchers used stopwatches to measure “time to response to verbal queries” for each episode of communication between the observed staff member and a remote individual. “Time to response” was defined as the time between (1) indication that communication was required; and (2) verbal contact with the colleague. For example, this would include a bedside nurse querying a ventilator adjustment with a junior doctor or a senior nurse attempting to locate a colleague to facilitate a patient transfer. Measurement of this process required direct observation, so blinding was not possible.

Incoming telephone calls were also monitored by members of the research team. Stopwatches were used to measure the time to successful connection to intended recipient.

Both periods of observation were conducted before and after implementation of the HWCD. The observations were conducted over 2 periods of 2 weeks’ duration (2 months preimplementation, and 4 months postimplementation). All observations were recorded during daytime shifts.

Staff Survey

Coinciding with the observational study, an anonymous survey was distributed electronically to all PICU staff before and after implementation of the HWCD. The survey comprised questions in 3 domains, each requiring answers in a 5-point Likert scale: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree. The questions are described in full in the results table and were categorized into 3 domains:

Domain 1: perception of communication delays. Domain 2: perceived delays when locating specific staff groups. Domain 3: support for HWCD in PICU.

Distribution of the Survey and Analysis Methodology

The survey was distributed to all staff in the PICU via e-mail. In the before and after implementation phases, the survey was distributed 4 times; after which the survey was closed. Each response was anonymously labeled to allow identification of responders who contributed to both surveys. To improve validity of the results, the analysis was restricted to respondents who had responded to both before and after surveys.

Cohort Study of Clinical Data

The PICU electronic database was interrogated for routinely collected data on clinical metrics (length of stay, risk-adjusted mortality, and rate of “emergency events”). Emergency events were defined as discrete episodes requiring activation of an emergency alert (emergency “buzzer”) in the PICU, to summon help rapidly for an unexpected deterioration in the patient’s condition. The frequency and characteristics of these events are recorded routinely in the PICU electronic database. The clinical metrics were analyzed in 2 time periods: 12 months before and 12 months after implementation of the HWCD. The cohort period of 12 months was chosen to reduce bias from seasonal variation of clinical diagnoses and activity.
**Statistical Analysis**

Median values of quantitative data for communication times, questionnaire scores (Likert), and clinical metrics were compared in the before and after implementation periods using Wilcoxon signed rank test (for paired data) or Mann-Whitney test. Categorical data (successful connection of incoming telephone calls) were compared using the chi-square test. The emergency event rate was compared using the rate ratio. A P value of < 0.05 was considered statistically significant.

**RESULTS**

**Directly-measured Communication Metrics**

A total of 416 hours of direct observation of verbal communication and telephone calls were made during the 2 study periods (210 hours before and 206 hours after). The majority of observation (300 hours) was conducted with bedside staff. Significant reduction in response times was observed in both roaming and static staff groups. This was more pronounced in the roaming staff group. The time to connect incoming telephone calls to intended recipient was also significantly reduced, see Table 1. A decrease in frequency of incoming telephone calls was also observed in the second study period.

**Staff Survey—Questionnaire Responses**

The response rate to the electronic survey was 56.8% (205/361). The number of overall responses was identical in the before and after surveys. Of the 205 responses, 146 (71.2%) were from responders who had answered both surveys (80 roaming staff and 66 static staff). Analysis was restricted to this smaller sample, as described above. Thus, the overall survey response was 40.4%.

Before and after scores (medians), and magnitude of changes in score, are shown in Table 2.

**Cohort Study of Clinical Data**

Comparison of clinical metrics before and after implementation of the HWCD showed no change in length of stay or adjusted mortality. There was, however, a statistically significant reduction in emergency event rate (defined as frequency of “emergency buzzer activations” in the PICU per 100 occupied bed-days), see Table 3.

**DISCUSSION**

This study has shown a statistically significant improvement in response times to verbal communication and incoming telephone calls after implementation of a HWCD in the PICU. Staff perception of locating roaming staff members also significantly improved. We also found a statistically significant reduction in the emergency event rate, but no significant change in the other clinical metrics.

The greatest benefit of introducing the HWCD was the impact on locating roaming staff. This is not surprising as roaming staff members can often immediately respond to queries without the need for other staff to locate them or having to rely on other communication devices such as pagers. This is consistent with other published studies demonstrating improved response times of roaming staff following the introduction of HWCD. Jacques et al. evaluated the effects of introducing a HWCD in a perioperative environment and found staff members equipped with the device responded to communication queries 4 times faster compared with staff members using pagers. Richardson et al. also found HWCD improved response times compared with relying on pagers alone.

We also described a reduction in the successful connection of incoming telephone calls to the desired recipient in the postimplementation period (Table 1). Despite not meeting criteria for statistical significance (P = 0.06); this difference may reflect a real phenomenon. The number of incoming telephone calls per hour decreased following implementation of the HWCD (4.9 versus 3.0 calls per hour), reflecting a decreased requirement for traditional direct phone connection in the postimplementation period. The remaining incoming calls would include a relatively higher proportion of calls aimed at members of staff not present, or not on the HWCD system. Our study did not capture adequate depth of data to confirm or deny this hypothesis.

The reduction in emergency buzzer activations shown in our study, suggests that timely communication among

| Table 1. Directly Observed Communication Metrics |
|-----------------------------------------------|
| **Metric**                                    | **Pre** | **Post** | **Significance (P)** |
| Observation of bedside staff                  |         |         |                     |
| Hours observed                                |         |         |                     |
| Median time to response to verbal queries (IQR)| 60 s (0–120) | 10 s (5–18) | 0.01*               |
| Observation of roaming staff                  |         |         |                     |
| Hours observed                                | 28      | 52      | < 0.001*            |
| Median time to response (IQR)                 | 120 s (60–255) | 9 s (7–30) |                     |
| Incoming telephone calls                      |         |         |                     |
| Hours observed                                | 13      | 23      |                     |
| Successful connection to intended recipient   | 86.4% (64/74) | 74.1% (69/93) | 0.06†               |
| Median time to connection (IQR)               | 35 s (20–80) | 11 s (6.5–30) | < 0.001†             |

*Mann-Whitney test.  
†Chi-square test.  
IQR, interquartile range.
PICU staff may prevent the need to activate the emergency call. The ability to summon rapidly specific staff members to the bedside (e.g., senior nursing and medical staff members) may allow rapid clinical interventions to prevent acute deterioration. No other published studies have looked at the impact on emergency calls following the installation of a HWCD.

The opinion of staff members using the HWCD has been an important factor in ascertaining its impact in the clinical environment. In our study, the survey responses showed a statistically significant improvement in staff perceptions regarding locating roaming staff members following the installation of a HWCD in a perioperative environment. In this study, the HWCD was noted to positively impact on the timeliness and ease of communication.

We are not aware of any published reports of clinical metrics following the implementation of a HWCD to date. In our study, the significant improvements in communication metrics were not translated into significant changes in clinical outcomes: length of stay and risk-adjusted mortality rates. This raises the question of financial justification of a new system for which there is no direct measurable improvement in clinical outcomes. A formal health economic assessment was out of scope for this project, but we have demonstrated a significant positive impact on staff experience (reduction in measurable and perceived communication delays), which may indirectly improve unmeasured patient experiences. The approximate total cost of implementation (including training and purchase of software and hardware) for this project was equivalent to 75 PICU bed-days.

### Table 2. Staff Survey

| Question | Preimplementation, Median (IQR) | Postimplementation, Median (IQR) | Wilcoxon Signed Rank Test | Change in Survey Response—Pre to Post, Median (IQR) |
|----------|---------------------------------|---------------------------------|---------------------------|-----------------------------------------------|
| **Domain 1: Perception of communication delays** | I commonly encounter delays when trying to locate members of the PICU team | 4 (4–5) | 2 (2–3) | < 0.0001 | 2 (0–3) |
| | Delays in locating members of the PICU team have a negative impact on patient care | 4 (4–5) | 4 (3–4) | 0.0083 | 0 (0–1) |
| **Domain 2: Perceived delays when locating specific staff groups** | I commonly encounter delays when seeking the following individuals on PICU (except in emergency situations): | | | | |
| | Roaming staff groups | | | | |
| | Consultant | 4 (3–4) | 2 (2–3) | < 0.0001 | 2 (1–3) |
| | Junior doctor | 4 (3–4) | 2 (2–3) | < 0.0001 | 2 (1–2) |
| | Nurse in charge | 3 (2–4) | 2 (1.25–2) | < 0.0001 | 1 (0–2) |
| | Team leader nurse | 4 (3–4) | 2 (1.25–2) | < 0.0001 | 2 (1–2) |
| | Pharmacist | 3 (3–4) | 3 (2–3) | < 0.0001 | 1 (0–2) |
| | Tech team member | 4 (3–4) | 2 (1–2) | < 0.0001 | 2 (1–3) |
| | Health care assistant | 4 (3–4) | 2 (2–3) | < 0.0001 | 1 (0–3) |
| | Housekeeper | 3 (3–4) | 2 (2–3) | < 0.0001 | 1 (0–2) |
| **Domain 3: Support for HWCD in PICU** | I support the implementation of such a system in PICU | 5 (4–5) | 5 (4–5) | 0.0238 | 0 (-1 to 0) |
| | It would (has) reduce(d) communication delays in PICU* | 4.5 (4–5) | 4 (4–5) | 0.20 | 0 (-0.75 to 0) |
| | It would (has) improve(d) quality of patient care in PICU* | 4 (4–5) | 4 (3.25–5) | 0.136 | 0 (0–1) |
| | It would (has) provide(d) support to new ways of working, for example, increasing the patient to nurse ratio to 2:1* | 4 (3–5) | 4 (3–4) | 0.016 | 0 (0–1) |

*Subjunctive tense (i.e., “would”) used for preimplementation survey; replaced with past tense (i.e., “has”) in the postimplementation survey.

All survey responses from 5-point Likert scale: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree.

### Table 3. Clinical Metrics

| Metric | Pre- (12 mo Pre) | Post- (12 mo Post) | Significance |
|--------|-----------------|-------------------|--------------|
| No. admissions | 1,292 | 1,385 | ns |
| Standardized mortality ratio (95% CI) | 0.84 (0.66–1.01) | 0.96 (0.78–1.14) | ns (P = 0.13) (Wilcoxon rank sum test) |
| Median length of stay in d (IQR) | 2 (1–6) | 3 (1–7) | ns (P < 0.05) (Wilcoxon rank sum test) |
| Emergency event rate (per 100 occupied bed days) | 2.17 | 1.69 | Rate ratio = 0.78 (95% CI, 0.63–0.95; P < 0.05) |

NS: Not significant.
Our study demonstrated an increase in perceived delays by the “receptionist” group after implementation of the HWCD—the median response to perceived communication delay changed from “disagree” to “neutral.” This is difficult to interpret with the existing data, but may be explained by the fact that the HWCD system was configured to allow calling by name, not by role. The receptionist staff may not have been aware of all clinical staff names during the postimplementation period, given the large workforce (> 300 members of staff).

There are a number of limitations of this study. First, the conclusions are limited by the short periods of observation (2 weeks for each period). The improvements measured by comparison of 2 separate periods of observation before and after installation may not have been solely due to installation of the HWCD, but may have occurred as a result of general improvements in the unit. A continuous improvement methodology approach or more frequent time-point analysis would have been a more robust methodology, but was not deliverable within the study constraints. Second, the study conclusions are also limited by an inability to blind the staff to the measurement and intervention. Apart from measured communication timings, the other metrics used for comparison in this study were all derived from routinely collected data, via the departmental database (length of stay, risk adjusted mortality, and emergency event rate). Third, additional data including medication delays, extubation-readiness, and duration of mechanical ventilation may have added richness and context to the results of the study, but were beyond the scope of our data collection capabilities. The study findings would also have been improved by considering types of call; for example, urgent versus nonurgent. Differential performance of the HWCD by different category of call was not in the scope of this project. Fourth, the overall questionnaire response rate was adequate (56.8%), but not optimal, and was further reduced to 40.4% by restricting analysis to respondents to both pre- and postsurveys. However, all staff groups were represented, indicating that engagement occurred throughout the department. The methodological approach to restrict survey analysis to only include responders from both before and after surveys adds validity to the results, by reducing contamination of data from staff who did not experience working in PICU before and after the change. Fifth, this study did not demonstrate an impact of introducing a HWCD on patient care. As discussed, the implementation of the HWCD did not have any measurable impact on patient length of stay or adjusted mortality; however, there are other metrics which could be assessed in future evaluations such as miscommunication events leading to patient complaints and patient satisfaction of care. It is possible that the HWCD may have altered the signal to noise ratio of unit communications. We did not measure balancing measures such as unintended interruptions, so we cannot comment directly on this. However, the staff survey responses were extremely positive and supportive of the HWCD, suggesting a very low perception of unintended adverse effects.

CONCLUDING STATEMENT

Introduction of a HWCD in PICU was associated with improvement in perceived and measured communication delays among PICU staff, along with a small reduction in emergency event rates. There was no measurable impact on routinely collected clinical outcomes: length of stay and risk-adjusted mortality.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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