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Creating a safe, reliable hospital at night handover: a case study in implementation science

Annette McQuillan,[1] Jane Carthey,[2] Ken Catchpole,[3] Peter McCulloch,[4] Deborah A Ridout,[5] Allan P Goldman[1]

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[1]Cardiothoracic Unit, Great Ormond Street Hospital NHS Foundation Trust, London, UK
[2]Great Ormond Street Hospital NHS Foundation Trust, London, UK
[3]Department of Surgery, Cedars-Sinai Medical Center, Los Angeles, USA
[4]Nuffield Department of Surgical Sciences, University of Oxford, John Radcliffe Hospital, Oxford, UK
[5]Centre for Paediatric Epidemiology and Biostatistics, UCL Institute of Child Health, London, UK

Correspondence to
Dr Jane Carthey, Consulting, 34 Ravensmede Way, London W4 1TF, UK
jcarthey_gosh@yahoo.com

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ABSTRACT

Background We developed protocols to handover patients from day to hospital at night (H@N) teams.

Setting NHS paediatric specialist hospital.

Method We observed four handover protocols (baseline, Phases 1, 2 and 3) over 2 years. A mixed-method study (observation, interviews, task analysis, prospective risk assessment, document and case note review) explored the impact of different protocols on performance.

Intervention In Phase 1, a handover protocol was introduced to resolve problems with the baseline H@N handover. Following this intervention, two further revisions to the handover occurred, driven by staff feedback (Phases 2 and 3).

Results Variations in performance between handover protocols on three process measures, start time efficiency, total length of handover, and number of distractions and interruptions, were identified. Univariate regression analysis showed statistically significant differences between handover protocols on two surrogate outcome measures: number of flagging omissions and the number of out of hours deteriorations (p=0.04 for Phase 3 vs Phase 1 for both measures (CI 1.04 to 4.08; CI 1.03 to 4.33), and for Phase 3 vs Phase 2 (p=0.006 and p=0.001 (CI 1.22 to 5.15; CI 1.62 to 9.0)), respectively). The Phase 1 and 2 handover protocols were effective at identifying patients whose clinical condition warranted review overnight. Performance on both surrogate outcome measures, length of handover and distractions, deteriorated in Phase 3.

Conclusions A carefully designed prioritisation process within the H@N handover can be effective at flagging acutely unwell patients. However, the protocol we introduced was unsustainable. In a complex healthcare system, sustainable implementation of new processes may be threatened by conflicting goals.

INTRODUCTION

Patients admitted to hospital at the weekend have an increased risk of mortality within 30 days of admission[1 2] and hospitals which have the fewest senior doctors available at weekends have the highest hospital standardised mortality ratio rates.[2] Collectively, these and other research findings[3] have raised concerns about the safety of out of hours care in the National Health Service (NHS).

The hospital at night (H@N) care model is an important part of the NHS's strategy to maintain quality of care with reduced staffing overnight.[4–7] Miscommunication of information at handover negatively affects patient safety, quality and efficiency[8–16] and so the H@N handover is arguably one of the most important transitions of care in a hospital. There are numerous studies of healthcare handovers, for example, shift to shift,[17] nurse to nurse,[18] anaesthesia care provider to postanaesthesia care unit,[18 19] operating theatre to intensive care unit,[20] emergency room[21 22] and paramedic to emergency room.[18] There is however little research on the safety of the H@N handover, even though it is a safety critical interface.

The H@N handover takes place sometime between 20:00 and 22:00 and requires all vital inpatient information and clinical responsibility to be handed over from a well-staffed, highly skilled day team to a smaller coordinated night team. While team composition varies, handovers usually involve junior and middle grade doctors and senior nurse(s), known as clinical site practitioners (CSPs). At the study site, staffing scales down from around 200 consultants, 80 middle grade doctors and 200 nurses to

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zero resident consultants, four middle grade doctors (outside of the operating theatre and intensive care units) and 90 nurses. The H@N team is responsible for delivering safe patient care in 84 out of 168 h every week.

METHOD

Setting

This was a mixed-method, time series study conducted at a London Specialist Paediatric Hospital. Over 2 years, observations of four different H@N handover procedures were carried out (see online supplementary appendix table) to evaluate the effects of protocol changes on handover performance.

Baseline phase

The baseline handover protocol in place when the study started involved the day CSPs handing over to the night CSPs from 19:45 to 20:15 in their office. This nurse to nurse handover was followed by the H@N handover at 20:30 in the doctors' mess. This was a 'taxi-rank' handover procedure in which junior doctors from various specialty teams handed over their patients sequentially: The specialty to arrive first handed over first, and once each specialty registrar had handed over their patients, they left the handover. Paper handover sheets were used, the day CSP did not attend, there was no standardised process and the most acutely medically unwell patients were not prioritised. Neither surgery nor cardiothoracic registrars attended.

A 3-month evaluation of this baseline phase handover process was conducted using task analysis,[23] error analysis,[24 25] interviews with CSPs, junior doctors and consultants, and ethnographic observation. Several problems with the baseline handover were identified (see online supplementary appendix table): First, it started after the ward nursing handover had finished, leading to distractions and interruptions during the H@N handover because ward nurses bleeped and phoned the junior doctors and CSPs. Additionally, the most acutely medically unwell patients were not handed over first. Junior doctors used paper handover sheets and handed over to the doctor covering their specialty overnight rather than communicating to the entire H@N team (partly because the design of the doctors' mess did not support projection of paper handover sheets so that all team members had access to patient information).

The start time of H@N handover also meant that for day shift junior doctors, handover was the last task at the end of a 12 h shift. There was also no overlap of day and night shifts meaning there was no opportunity for H@N team members to clarify information after H@N handover had finished. The taxi-rank handover protocol meant that junior doctors left the doctors' mess once they had handed over their patients. Our baseline observations showed that this often led to unclear patient management plans for patients with multiple comorbidities who were being treated by multiple specialties. Another gap was that some specialties (surgery and cardiothoracic) did not attend H@N handover meaning that these patients were not handed over to the H@N team. Finally, interview data identified lack of awareness of the importance of accurate handover, concerns over workload prioritisation and isolation of H@N team members.

We sought to resolve these problems by designing a modified handover protocol based on human factors principles and reviewing handover practice in other high-reliability organisations,[26] including air traffic control (Phase 1). Human factors science was used because it provides a human-centred approach to hospital system improvement and provides approaches to team, task, environment, technology and organisational redesign.

Intervention

Phase 1 handover design

In Phase 1, the H@N handover protocol moved towards a multi-disciplinary team handover model. Senior managers and consultants ensured that only essential workload was handed over from the day team to H@N night team. The doctors' mess was redesigned (including redecoration, new furniture plus an LCD projector to support shared data display) to create an improved handover environment. Paper handover sheets were re-designed using a Situation Background Assessment Recommendation (SBAR) format to support verbal handover. The hospital's Information Technology department developed an electronic handover database.

An induction programme was delivered to junior doctors and nurses on the purpose of the H@N handover (including training on, teamwork, leadership, situational awareness, cognition and cognitive biases, communication, SBAR, read back and safety huddles).

Between 19:45 and 20:00, the day CSPs handed over site and security issues to the night CSP. The H@N handover started at 20:00, coinciding with ward handovers, to reduce distractions and interruptions. Changes in shift patterns allowed day CSPs to hand over directly to the whole H@N team, and created a 1 h overlap between day and night junior doctors' shifts.

To ensure prioritisation of the most clinically at-risk patients, a 'flagging' structure was introduced. Patients who met predefined criteria (see box 1) were handed over first ('flagged patients'). Team members were trained to use SBAR to hand over flagged patients, and CSPs leading the handover were taught to read back key information on them formally to the presenting junior doctor, to verify that the receiver and H@N team had understood key patient information.

Other key changes included introducing a H@N team 'regroup' at the end of the handover to check

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Box 1 List of criteria for 'flagging' a patient at hospital at night handover

- Patients who are acutely medically unwell according to their Children's Early Warning Score (CEWS).
- Patients who are identified as acutely medically unwell, irrespective of their CEWS score (Note that it is important not to rely solely on the CEWS score when deciding whether or not a patient should be flagged).
- Patients who have been discharged from an intensive care area within the last 24 h (PICU, NICU, CICU).
- Postoperative patients considered to be at high risk of complications (eg, patients who returned from theatre late, major spinal surgery, peri-operative haemorrhage, anaesthetic complication patients at risk of neurovascular compromise and/or compartment syndrome. All postoperative patients on invasive monitoring).
- Patients who have been admitted as acute medical/emergency admissions during the day shift.
- Patients who are having surgery overnight (eg, emergency surgery patients, transplant patients).
- Sick patients who are outliers (ie, being treated on wards outside their specialty)—especially complex patients with multiple pathologies.
- Patients who need their treatment plan changed overnight as a result of their laboratory or radiology results.
- Patients who have emerging or known safeguarding issues where there is a cause for concern overnight.
- Referrals from other hospitals (especially patients at high risk of deterioration who may require urgent advice or admission to Great Ormond Street Hospital overnight, eg, suspected malaria, bacterial meningitis, metabolic conditions, oncology patients, acute surgical referrals).
- Any patients who have undergone an interventional radiology procedure where a biopsy or intervention (other than uncomplicated line insertion) has been undertaken and there is a risk of bleeding or other complications.

CICU, Cardiac Intensive Care Unit; NICU, Neonatal Intensive Care Unit; PICU, Paediatric Intensive Care Unit.

and, if necessary, reassign workload. A 'safety huddle' briefing was introduced at around 01:00 to revisit workload management issues and communicate information on emerging patient problems.

Staff feedback on the Phase 1 handover intervention led us to introduce a slightly modified protocol in Phase 2.

Phase 2

The Phase 2 H@N handover protocol was based on the same multi-disciplinary team human factors model as Phase 1. However in Phase 2, the H@N induction was not delivered to the new intake of junior doctors. Day to night CSP handover was extended by 15 min (in response to feedback that the Phase 1 protocol allowed insufficient time to handover site and security issues) and occurred between 19:30 and 20:00. The H@N handover started at 20:15. In contrast to Phase 1, the day CSP did not attend H@N handover (a protocol change made following feedback from the H@N team about the Phase 1 protocol). The hospital's Information Technology department was engaged and an electronic handover database was introduced for some specialties.

Phase 3

In Phase 3, the handover procedure was re-designed by a group of general paediatricians appointed by the hospital. From 19:45 to 20:15, the day CSP handed over to the night CSP in the CSP's office. Simultaneously, between 20:00 and 20:15 the junior doctors handed over housekeeping and non-urgent tasks in the doctors' mess. At 20:15, the multidisciplinary team H@N handover of flagged patients took place, jointly led by the general paediatrician and a night CSP. The general paediatrician left H@N handover after all flagged patients had been discussed. At this point, junior doctors resumed their handover of housekeeping and non-urgent tasks. Phase 3 also introduced staggered arrival times for CSPs and junior doctors from private patients and surgery, to resolve issues with delayed handover start times observed in Phases 1 and 2.

The key elements of the different intervention phases, together with the issues identified in the baseline phase, are shown in the online supplementary appendix table.

Data collection

Observational data were collected by two experienced observers (AM and JC) using a standard pro forma, developed based on baseline observations and refined in Phase 1. Observer 1 was an experienced Paediatric Intensive Care Unit Nurse and Research Nurse and Observer 2 was a human factors specialist with considerable experience in observing team interfaces in healthcare. Process data were collected on efficiency of handover start times per phase, number of distractions and interruptions and mean length of handover. Distractions or interruptions were recorded by the observer when bleeps, phone calls and background conversations occurred during the handover.

To assess the effectiveness of patient prioritisation in Phases 1, 2 and 3, a document review was carried out where the number of flagged patients identified in handover observations was compared with the number of patients reviewed overnight by the CSPs (as recorded in their records). The document review allowed us to identify the number of *appropriate*

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follow-ups: Patients who were clinically reviewed by the H@N team overnight having been identified as flagged patients at the H@N handover. We postulated that appropriate follow-ups are a measure of how well the H@N team prioritise patients overnight. A high percentage of appropriate follow-ups demonstrates that the H@N team focused on patients they had been forewarned about, via the flagging process.

In the next stage of the study, a case note review was conducted for a representative sample of *non-flagged* patients who the document review had identified as requiring review by the H@N team overnight (n=125). The aim was to ascertain if they should have been identified and 'flagged' during the handover. A research nurse (AM) compared the information in all available clinical notes and charts from each sample patient with the predefined flagging criteria (see box 1) and classified patients into two groups:

1. *Out of hours deteriorations*: Patients who required clinical review overnight and who were (correctly) not flagged in the H@N handover because they did not meet the flagging criteria in box 1 during the day shift leading up to the H@N handover.
2. *Flagging omissions*: Patients who required clinical review overnight and who were *not* handed over as flagged patients, but who should have been as the patients met at least one of the flagging criteria during the day shift preceding the H@N handover.

Patients classified in groups 1 and 2 included patients whose clinical condition deteriorated overnight, including cardiac and respiratory arrest calls, patients with severe postoperative bleeds and patients whose Paediatric Early Warning Scores triggered clinical review, as well as patients with pain and cannulation failures. The key distinction between groups 1 and 2 is that patients classified as 'out of hours deteriorations' showed no clinical indication that they should have been flagged at H@N handover, whereas patients classified as 'flagging omissions' did meet the criteria shown in box 1. Hence these were patients that the H@N team could have been forewarned about. We postulated that higher numbers of flagging omissions should be an indicator of poor quality handover because, unlike out of hours deteriorations, the H@N team could have been forewarned about these patients.

One of the problems we sought to resolve was the lack of a prioritisation process during the baseline phase. Therefore, there were no 'flagged patient' data for the baseline period. Rather than compare improvements against the baseline, our analysis explores how different handover protocols affect handover performance.

Statistical analysis

Data for continuous measures are summarised with mean (SD) and for categorical data as number (percentage). Mann–Whitney tests were used to test for differences in the number of distractions and interruptions per phase. Linear regression was used to compare mean durations, and logistic regression was used to compare binary outcomes between phases. We summarise the number of patients flagged per handover session by different staff members and compare these counts between phases using Poisson regression. Results are presented as incidence rate ratios (IRRs). When comparing phases we have accounted for multiple comparisons using a Bonferroni adjustment and present adjusted 95% CI and p values.

Poisson regression was used to investigate the impact of type of handover process on our two main outcomes, the number of out of hours deteriorations and the number of flagging omissions. Univariate analyses explored the impact of three independent variables on outcome, study phase (1, 2 and 3), weekday versus weekend handover and number of distractions during

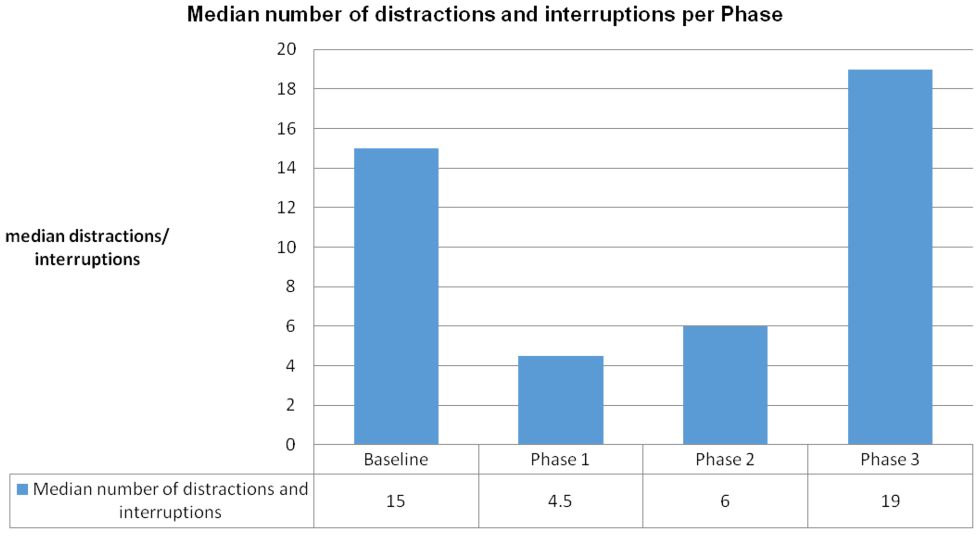


Figure 1 Median number of distractions and interruptions.

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the handover. Fractional polynomials were used to explore any departure from linearity for the relationship between the number of distractions and outcome. To account for a possible effect of variability in exposure between handover sessions, we investigated the inclusion of an exposure offset in the models. We considered as an offset, total number of flagged patients per handover and total length of handover. Comparison of the models with and without an offset, using the Akaike Information Criteria, showed no improvement in the fit of the models with the inclusion of an offset; therefore, we have presented results for models with no offset. Similarly, there was no evidence that accounting for an excess of zeros using a zero inflated model improved the fit. Pearson goodness of fit statistics indicated all final models presented fitted the data well.

Analyses were performed with STATA V.12 (StataCorp, College Station, Texas, USA).

RESULTS

A total of 211 H@N handovers were observed (34 in the baseline phase, 64 in Phase 1, 67 in Phase 2 and 46 in Phase 3).

Process measures

The median number of distractions and interruptions was 15 (baseline), 4.5 (Phase 1), 6 (Phase 2) and 19 (Phase 3) (see figure 1). Phases 1 and 2 had significantly fewer distractions than baseline. There was no statistically significant difference between Phase 3 and the baseline handover (Phases 1 and 2 protocols vs baseline handover; p<0.001: Phase 3 protocol vs baseline; p=0.18). The human factors handover intervention reduced distractions and interruptions, as planned.

Table 1 presents the mean handover duration and percentage of handovers that started at the scheduled start time per phase. Mean length of handover decreased from the baseline (44.3 min) to 34.8 and 36.1 min in Phases 1 and 2, but increased to 56.8 min in Phase 3 (p<0.001). Phase 3 handover performed the best on percentage of handovers starting at the scheduled start time (p<0.001 compared with Phases 1 and 2).

The Phase 1 intervention was based on a single, multi-disciplinary team handover model designed to create a shared vision within the H@N team. However, it depended on all team members being present before the H@N handover could start, and this proved a key difficulty, as shown by the fact that this phase was the least efficient in terms of the percentage of handovers starting at the scheduled start time. The delayed start times ultimately meant that the Phase 1 intervention was unsustainable. H@N handover takes place when staff numbers in the hospital are decreasing, creating increased workload and task prioritisation challenges for junior doctors. The delayed start times in Phase 1 meant that day CSPs

Table 1 Process, measures: timing data

	Baseline phase n=34	Phase 1 n=64	Phase 2 n=67	Phase 3 n=46	Comparing all phases p value	Phase 1 vs baseline phase effect (95% CI) p value	Phase 2 vs Phase 1 effect (95% CI) p value	Phase 3 vs Phase 1 effect (95% CI) p value	Phase 2 vs baseline phase effect (95% CI) p value	Phase 3 vs baseline phase effect (95% CI) p value	Phase 3 vs Phase 2 effect (95% CI) p value
Mean (SD) duration of handover (min)*	44.3 (8.9)	34.8 (8.3)	36.1 (10.9)	56.8 (12.1)	<0.001	−9.5 (−15.2 to −3.7) <0.001	1.3 (−3.4 to 6.0) 0.99	22.0 (16.8 to 27.2) <0.001	−8.2 (−13.9 to −2.5) 0.001	12.5 (6.4 to 18.6) <0.001	20.7 (15.5 to 25.9) <0.001
Number (percentage) of handovers starting at scheduled start time†	10 (29)	10 (16)	14 (21)	25 (57)	<0.001	0.4 (0.1 to 1.7) 0.67	1.4 (0.4 to 4.8) 0.99	7.0 (2.1 to 23.3) <0.001	0.6 (0.2 to 2.3) 0.99	3.1 (0.9 to 11.1) 0.11	4.9 (1.6 to 15.0) 0.001

*Linear regression used to compare phases and difference in means with 95% CIs is presented.
†Logistic regression used to compare phases and ORs with 95% CIs is presented.

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were working over their scheduled shift times which became untenable. Therefore, to maintain staff engagement, this feedback prompted the modified HF-based design implemented in Phase 2 but this did not resolve the start time issue. The Phase 3 protocol, designed by a group of general paediatricians, succeeded in resolving the start time issues, but it also significantly increased mean length of handover.

Document and case note review findings

Document review identified that the appropriate follow-up rate was 100%, indicating that *all* patients flagged at handover were subsequently reviewed by the H@N team overnight. It also identified that the H@N team had reviewed patients overnight who had not been flagged at handover: Between Phases 1, 2 and 3, 1678 patients were seen overnight by the CSPs, of whom 1393 (83%) had been flagged at handover.

Case note review identified 57 (3.4%) out of hours deteriorations, and 68 (4.1%) flagging omissions in total (see figure 2). A further 160 (9.5%) patients were not followed up in the case note review (48 (7.5%), 73 (11.7%) and 39 (9.6%), patients in Phases 1, 2 and 3 respectively). In Phase 1, 3.3% of the patients were flagging omissions, compared with 2.9% in Phase 2 and 7.1% in Phase 3. There were 2.3% out of hours deteriorations in Phase 1, compared with 1.8% in Phase 2 and 6.6% in Phase 3.

The IRR for Phase 3 versus Phase 1 ($p<0.04$) for both flagging omissions and out of hours deteriorations was over 2, that is, these events were more than twice as likely in Phase 3 (see table 2). There was also a statistically significant difference between Phase 3 versus Phase 2 for both outcomes ($p<0.006$ for flagging omissions (IRR 2.51) and $p=0.001$ for out of hours deteriorations (IRR 3.82)). For both outcomes, no statistically significant difference was found between Phases 1 and 2, which is expected given that the handover protocols used during these phases were similar.

No statistically significant effect was found between weekend and weekday handovers, although weekday rates for both outcomes were greater compared with weekend rates. There was evidence that both flagging omission and out of hours deterioration rates increase as the number of distractions increase (IRR=1.03, $p<0.01$; IR=1.04, $p<0.001$, respectively). For every additional distraction the flagging omission rate increased by 1.03. However, our analysis showed the number of distractions varied by phase and if we include both factors together in a multiple model the effects cancel each other out.

DISCUSSION

We re-designed the H@N handover by introducing a protocol to prioritise the most at risk patients that is, 'patient flagging', based on a set of theoretically sound human factors principles (see online supplementary appendix table). The handover protocol introduced in Phase 1 was based on problems identified with the baseline handover. It was based on a single, multi-disciplinary team handover model designed to create a shared vision for the hospital out of hours within the H@N team.

Our results do not demonstrate that the Phase 1 handover was an improvement on the baseline protocol because surrogate outcome data are not available

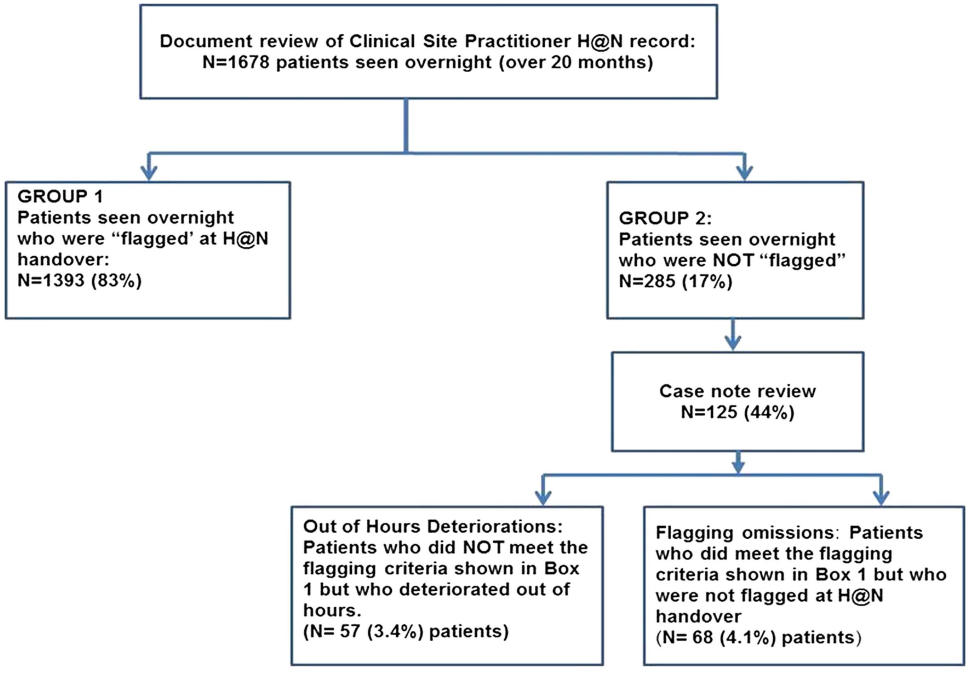


Figure 2 Flow chart showing document and case note review results.

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Table 2 Univariate Poisson regression analysis

	Flagging omissions IRR (95% CI)	Flagging omissions p Value	Out of hours deteriorations IRR (95% CI)	Out of hours deteriorations p Value
Phase 2 vs 1	0.82 (0.38 to 1.77)	0.99	0.55 (0.22 to 1.37)	0.35
Phase 3 vs 1	2.06 (1.04 to 4.08)	0.04	2.12 (1.03 to 4.33)	0.04
Phase 3 vs 2	2.51 (1.22 to 5.15)	0.006	3.82 (1.62 to 9.0)	0.001
Weekday (yes vs no)	1.63 (0.78 to 3.40)	0.20	1.84 (0.79 to 4.29)	0.16
Distractions	1.03 (1.01 to 1.05)	<0.01	1.04 (1.02 to 1.06)	<0.001

IRR, incidence rate ratio.

for the baseline phase. However, the results do show that the Phase 1 handover protocol reduced distractions and interruptions and total length of handover.

The Phase 1 handover protocol depended on all team members being present before the H@N handover could start, and this proved a key difficulty, as shown by the fact that this phase was the least efficient on the start time efficiency measure. Following staff feedback about the delayed start times associated with the Phase 1 handover protocol (which sometimes meant CSPs were working beyond their allotted shifts), and time pressure for the CSPs to handover site and security issues, we modified the Phase 1 handover protocol, introducing an updated protocol in Phase 2. Results showed that the Phase 2 protocol did not erode performance on the two surrogate outcome measures, or the distractions/interruptions and time taken to handover measures (Phase 2 vs Phase 1). The Phase 2 handover protocol resolved the time pressure on CSPs to handover site and security issues but there continued to be issues with delayed handover start times.

The Phase 3 handover protocol used staggered arrival times for some team members to resolve the delayed start time issue. It succeeded in achieving this goal. Commensurately performance deteriorated on other process and surrogate outcome measures.

Our results show that H@N handover designed on human factors principles, implemented in Phases 1 and 2, led to better surrogate outcomes (as measured by the number of flagging omissions and out of hours deteriorations), and that performance on these measures deteriorated in Phase 3. The data demonstrate how different handover protocols vary in the effectiveness with which H@N teams are forewarned about which patients to prioritise overnight. Patient flagging was generally effective for prioritising patient care, and it was possible to measure the reliability of the handover process by comparing expected (flagged patients) with observed (patients requiring attention) events. No other studies have attempted to link a prioritisation system to handover performance.

Case note review showed that the flagging criteria in box 1 were not always appropriately applied given the information available at the time; between 3% and 7% of patients who should have been flagged were not.

Our results demonstrate the trade-offs that occur in a complex system when different models of handover are introduced. They also illustrate the complexity of making and sustaining changes to the handover within an organisation.

Previous research has identified increased risk of mortality for patients admitted at the weekend,[1 2] but with the exception of a link between variations in hospital standardised mortality ratio and staffing levels,[2] the underlying causes of increased out of hours patient safety risk are not well understood. Our results indicate that different handover protocols may be more or less effective in identifying those patients who need to be prioritised out of hours. Our findings did not show a significant effect of weekday versus weekend handovers on outcomes, probably because the staffing model at night is similar to weekends at the study hospital.

Although the Phase 1 and 2 handover interventions were not sustainable, our study has left a legacy of improvement: The hospital now has a structured H@N handover protocol in which our prioritisation process has been sustained. A measure of flagging omissions has now been included into the routine hospital performance data capture process. This identifies how many acutely medically unwell patients are not flagged at H@N handover and which specialty they were being treated under. The hospital also now routinely monitors attendance at H@N handover and information on monthly attendance rates per specialty is reported back to clinical leads.

There are several limitations to this study. First, we did not measure 'false positives' (ie, patients who were handed over as flagged patients but who were medically well). Second, problems accessing patients' notes meant that it was possible to review only a sample of 44% of patients seen overnight but not flagged. This is a limitation experienced in most case note review studies, and reflects the challenges of accessing medical records in NHS hospitals.[27] Third, only one reviewer carried out the case note reviews and no inter-rater reliability measurement was carried out. Fourth, this study was conducted at one specialist paediatric hospital only, and the context for change may be very different in other settings.[28] Finally, although flagging omissions has face validity as a surrogate outcome measure it has not been proven that

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there is a link between flagging omissions and patient outcomes. One might argue that like previous research which has shown that operating theatre teams can cope with a certain number of minor errors before performance deteriorates,[29 30] that H@N teams are able to cope with a certain number of flagging omissions before performance is negatively affected. Further research is needed to explore this issue. We believe however that developing a reliable flagging process for H@N handover is one way to alert a team with limited resources where to focus their attention overnight.

CONCLUSIONS

Different models of handover may be more or less effective in identifying those patients who need to be prioritised out of hours. A carefully designed prioritisation process within the H@N handover system, based on human factors principles, can facilitate prior identification of acutely unwell patients or patients who might potentially deteriorate overnight. However, the challenges of maintaining even demonstrably better handover processes in a healthcare system with conflicting goals and competing priorities cannot be underestimated.

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Contributors AM and JC collected the observational data and carried out the document review. AM carried out the case note review, supervised by JC and APG. JC, AM and DAR carried out the data analysis, with DAR leading the statistical analysis. APG was the clinical lead for the project and secured the engagement of the H@N team and hospital management. KC and PM wrote the original BUPA research proposal (with APG and AM), and provided human factors and research advice throughout the study. All authors have reviewed drafts of the manuscript. APG is the guarantor of the paper.

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Ethics approval The original BUPA research grant application was reviewed by the Institute of Child Health/Great Ormond Street Hospital Research Committee in 2008. The ethics committee decided that the study did not require ethics approval. The Trust's Caldicott Guardian was also informed of the project and data were stored in accordance with Great Ormond Street Hospital NHS Foundation Trust's information governance policy.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement There are no additional data available for sharing from the study: the data in the paper contain the main data analysis.

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