NightShift Simulation to Train Newly Qualified Doctors in Non-technical Skills: A Feasibility Study

Running title: nightshift simulation for junior doctors

Abstract

**Background**: There is greater morbidity and mortality in hospitals at night, especially when newly qualified doctors commence work.

**Aim:** To trialled an online simulation of a night shift to improve non-technical skills and clinical outcomes.

**Design:** Randomised feasibility trial of an electronic training simulation.

**Methods:** Medical students at the end of their training followed into initial weeks of working (n=30) at a large teaching hospital.

**Results:** Participants in the intervention group completed their non-urgent tasks more rapidly than the control group though there was a broad range of completion times: mean (SD) time to complete a non-urgent task of 85.1 (50.1) versus 157.6 (90.4) minutes, p=0.027. This difference persisted using linear regression analysis were undertaken using rota and task volume as independent cofactors (p=0.028).

**Conclusions:** This study shows the potential to leverage data routinely collected from newer technologies to develop on-line simulations.

**Keywords:**

Out of Hours Care, Secondary Care, Simulation, Medical Education, Nontechnical skills

Introduction

Hospitals in the United Kingdom are struggling to cope with the demands of ever increasing numbers of admissions. This pressure is felt keenly during the 75% of the year that does not fall between 9am and 5pm Monday to Friday. During this ‘Out of Hours’ (OOH) period staffing levels are generally much lower. This effect is further exacerbated during the 10pm to 9am ‘night shift’ when care is largely provided by a skeleton staff of junior doctors, support workers and nurses.

Over the past decade, reducing length of stay and an increasingly complex range of diagnostic and treatment options mean more interventions and tasks must be co-ordinated in a shorter time, a situation which has shifted care further towards the evenings, nights and weekends. Over the same time period, individual junior doctors’ working hours have fallen by more than 35% to comply with the European Working Time Directive(1). These factors have contributed to increased shift intensity and cross-speciality cover, and to problems of communication between and across shifts (2).

. Failure to perform well may delay patient care and impact on its quality, with well-documented effects on error rate and adverse outcomes (3, 4).There is evidence that this high demand role leads to emotional burnout and poor quality of life(5).

Junior doctors’ awareness and use of best practice for night shift work appears low (6), with many reporting instances of not being able to take breaks during shifts. Objective assessment of the non-technical skills of junior doctors is increasingly possible from routinely collected data from electronic records, ordering and taskflow systems (7, 8). However this is either not captured or not interrogated in most hospitals. We have previously described objective granular data on tasks undertaken by new junior doctors that supports the need for training in task prioritization (9) and route planning(10) and highlighted the gap between senior and junior clinicians in understanding non-technical skills in OOH care (9). Such results relate to recurrently voiced concerns over the preparedness of new junior doctors and may be associated with the significant increase in mortality seen over the month when new doctors start work(11).

In response to this ‘apprenticeship gap’, simulation has become an increasingly common and effective tool in medical education, particularly for invasive or high-risk procedures(e.g.(19, 20)). However, standard clinical simulation techniques are usually resource intensive with limited scope for repeated attempts, particularly if applied to non-technical skills(14). Virtual simulation is an appealing prospect in this regard, as it has the potential to prepare people and improve performance (15). The application of video game technology and methodology is becoming more influential in delivering successful medical education aimed at junior doctors(16) and patients(17).

In this paper we describe the leveraging of existing large and detailed data on junior doctors’ actual activity to develop a serious video game simulating night shift working. We build upon previous focus group and survey results(18), and testing with medical students to evaluate it in a pilot trial in doctors about to start work for the first time. We aimed to trial this intervention using actual work activity as the outcome measure to highlight the potential and challenges in this approach, and so to inform future, multicentre studies.

In this paper we explore the research question: does data driven nightshift simulation have the potential to improve the training of junior doctors in non-technical skills. To this end the investigation had the specific aims:

1. To test the impact of a ‘nightshift’ simulator on task completion times during out of hours working for junior doctors during the first two month after the august handover.
2. To identify the practical considerations for development and deployment of a ‘nightshift’ simulation focused on non-technical skills.

Method

**“NightShift” Simulation development**

The simulation was designed to run on Android (Google, California, USA) enabled tablet PCs. Firstly, wireframe CAD map data on sections of the Nottingham City Hospital were provided to medical contributors to confirm the location of wards and departments. These CAD files were then used as templates to produce an accurate but simplified floor plan. Photographs were taken of the hospital to ensure correct placement and representation of internal aspects of the hospital (e.g. slopes, floor colour, staircases, and so on) and to provide orientation to the user during the simulation. The decision to use a lower fidelity simulation was consistent with the medical simulation literature(2, 3).

We used one calendar year of data (2011) from the NerveCentre on-call task management system (NerveCentre, Wokingham, UK) to inform our simulation. As described elsewhere(4), the NerveCentre system allocates tasks a colour code (red, amber, or green) based on clinical urgency. The taskflow data were summarised overall, by urgency colour code, by task, and per ward by hour of shift (>100,000 OOH task requests in total).

We used the actual activity data to calculate the mean (and SD) time to completion for each specific task type recorded in the NerveCentre data (e.g. “clinical review for chest pain”, “interpret ECG”). Each specific task therefore had its own time distribution in the simulation. The team agreed a list of potential delaying or complicating factors (e.g. unable to find notes, first cannulation failed) with approximate frequencies. These factors could then be displayed to the user when tasks took longer than the minimum time to complete to add to the realism of the simulation. In order to reduce complexity, cardiac arrest calls were the only tasks not included in the simulation.

To reduce usage time to a reasonable duration, simulation time was compressed: Whilst walking time ran 1.5 times faster, and whilst acting it ran 5 times faster. To convey a sense of increasing fatigue, the character in the simulation walked more slowly with time and the screen darkened; this was improved by a visit to the mess or to a vending machine. The simulation was structured to provide summary statistics on performance.

The simulation was initially tested by the research team and volunteers (non-medical researchers the University of Nottingham) who did not have a working knowledge of the layout of the hospital. These sessions also informed the level of the paper gameplay instructions given to each subsequent user, as well as adding to the iterative design process.

A version of the simulation was released for further appraisal amongst final year medical students in Nottingham. This appraisal comprised four sessions where 6-10 students undertook at least one shift in place of a usual one hour formal teaching session.

**Trial of Simulation**

*Setting*

The assessment was undertaken over the course of the junior doctor changeover in August 2013. The setting was the Nottingham City Hospital, a large (around 800 beds) teaching hospital.

*Participants*

Medical students were approached before their “shadowing” fortnight: This phase immediately prior to starting work as a doctor for the first time involves following the existing, outgoing doctor in the role they are about to commence. The simulation was described to all eligible students via a presentation whilst they were assembled for their Trust induction. The first 30 students who expressed an interest were randomly assigned to either standard induction or induction plus serious game training. All participants were given an information sheet and signed a consent form relating to the use of their performance data from both the simulation and the Nerve Centre task tracking system. Free use of the simulation was permitted, and the participants were encouraged to contact a named team member if there was a technical issue preventing their engagement: tablet computers were made freely available for no-cost loan during the study.

**Data Collection and Analysis**

Actual OOH activity for each participant was determined using data from NerveCentre and cardiac arrest logs (cardiac arrests are the only tasks that can be submitted outside the NerveCentre system). Data collection ran from the start of the first shift (8am) on 1st August 2013 to the end of the last shift on 30th September (10am 1st October). The primary outcome for a future efficacy trial was taken to be time taken to complete a non-urgent task (coded “green” by NerveCentre). Secondary outcomes were time taken to complete an urgent task (coded “red” by NerveCentre), and crash calls per shift. Analyses were undertaken in SPSS (IBM, USA); continuous outcome variables were compared using T tests and linear regression.

Feedback from study participants was gathered through a focus group feedback session after the completion of the trial. Non-medical researchers led the session as we believed this would encourage more open reporting of difficulties. We also circulated links to on-line feedback forms to gather comments made directly after shifts and from those who could not attend the focus group.

Ethical approval for the study was obtained through the Ethics Committee of the Department of Engineering of the University of Nottingham

 Results

27 of the 30 individuals who initially volunteered to participate completed the study, and full task level datasets were available for 22 of these as 5 did not undertake night shifts during the study period. 7 (32%) of those with full datasets were male. 9 of the 12 participants randomised to the simulation used it, and 2 individuals used it repeatedly. Table 1 shows the distribution of participants across the medical and surgical rotas.

**Activity Data**

Participants in the intervention group completed their non-urgent tasks more rapidly than the control group though there was a broad range of completion times: mean (SD) time to complete a non-urgent task of 85.1 (SD=50.1, Median=84.5,IQR=71.02) versus 157.6 (SD=90.4,Median=128.3, IQR=128.6) minutes, p=0.027. This difference was also observed using linear regression analysis were undertaken using rota and task volume as independent cofactors (p=0.028). There was no difference in the time to complete urgent tasks (see figure 2). These task completion times and distributions values are comparable to those seen in previous work (10) and are slightly skewed from a normal distribution (see appendix 1).

Standard cardiac arrest logs were complete for all study days. There was no difference in the mean number of cardiac arrest calls attended per shift (0.39 vs 0.45).

**Feedback**

Following the trial, the new junior doctors were clear that they had been overwhelmed by the experience of starting work, and with so many new clinical protocols and systems to learn they had not had time to devote to a simulation. In their focus group, they also raised issues that mirrored those described in feedback forms by the medical students who had undertaken testing:

*Reported short-comings*

A key issue reported by users of the simulation was difficulty in navigation around the virtual hospital using a plan (top-down) view and a static set of pictures relating to what the user would see at that location (see figure 3). Users recognised that hospitals have a plethora of signs, but felt the level of visual information provided tended to be too simple (such as some signs above ward doors not being in place). Users also were frustrated by the “fatigue” element (slower walking pace with gradual darkening of the screen).

*Actual difficulties of working OOH*

The second area of feedback related to realistic aspects of the night shift. The simulation involves a great deal of walking around in comparison to the medical activity undertaken. Although this is realistic (and time was compressed in the simulation) it reduced engagement in the activity. Similarly, students reported it was impossible to attend to multiple urgent tasks that appeared in a short time window. Again, this is representative of actual shifts rather than a game where one can “win”, but highlights an important issue with the representations of real-world tasks within serious games or simulations.

Discussion

This study shows it is feasible to create an educational simulation of on-call shifts with the primary aim of teaching non-technical skills. In the study, those in the simulation group took less time to complete non-urgent tasks whilst on-call. These data, taken with previous studies, suggest an efficacy trial for an intervention of this nature would require junior doctor recruitment at a number of medical schools. Hospital-specific simulations are therefore not likely to be practical for such a study. However, if only small time savings per task in the first weeks of work were realised through this approach, the cumulative effect would be substantial.

**Strengths and Weaknesses of the Study**

This work has strengths in its use of a high-volume of task level data and precise mapping to inform the underlying mechanics of the simulation. However given the practicalities of collecting and integrating such data, it is unclear if this approach should serve as a template for future studies.

The project also focuses on the teaching of non-technical skills for junior doctors, a clear unmet need as discussed previously. It is possible that relatively brief exposure to the simulation could teach the layout of the hospital and increase navigational efficiency, and make the user more aware of the importance of clinical task prioritization, but it seems unlikely there was a major training effect.

A major limitation of the study was the limited engagement of users, with initial enthusiasm not translating into extended use as described above. Our study suggests successful simulations will need significant resources to support preparation, deployment, and debriefing. The suggestion from this experience is that any such interventions are targeted at medical students as part of their curriculum, or that new doctors are provided with protected time in the busy induction period immediately before starting work. It may be most efficient to develop a suite of software with elements that focus on specific skills. The initial candidate would appear to be training in task prioritization skills as it is likely valuable experience could be provided in limited time period without the need to resolve complexities of accurate individual hospital mapping, time compression of full shifts, and making walking round the hospital engaging for the user.

**Conclusions**

This study has highlighted that virtual simulations based on routine clinical data could be developed and deployed as part of medical school training in non-technical tasks. This could potentially partially mitigate the previously reported ‘august effect’ on out of hours care (10).

While apparently effective, our study suggests improvements that could enhance engagement with the system and streamline the development of future systems.

Firstly the use of a ‘top-down’ highly detailed virtual environment was time consuming to develop and the cause of frustration for the participants. We suggest that future work in this area could focus on simulators that target specific skills (task prioritisation, hospital navigation or the management of personal needs) rather than attempting to emulate the entire nightshift experience. More constrained simulation/games such as these could more efficiently deliver training need and would likely require less tailoring to specific sites.

Similarly it is unclear if the ‘fatigue’ feature added sufficiently to the training value of the simulator to justify the development effort required to develop it and the commonly reported participant frustration with it.

**Future Work**

As suggested above future work is needed in developing and testing more focused and engaging simulators in order to provide training as efficiently as possible and with minimum user frustration. Large scale deployments would be required to definitively study a full night shift simulation,, with our data suggesting a efficacy trial would need to include in excess of 800 students to have 80% power to detect a 10 minute difference in task completion time. However the potential benefits of this type of training appear to justify the development and formal testing of more generalizable and focussed tools.

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References

1. Pickersgill T. The European working time directive for doctors in training. Bmj. 2001 Dec 1;323(7324):1266. PubMed PMID: 11731377. Pubmed Central PMCID: 1121739. Epub 2001/12/04. eng.

2. Raduma-Tomas MA, Flin R, Yule S, Williams D. Doctors' handovers in hospitals: a literature review. BMJ Qual Saf. 2011 Feb;20(2):128-33. PubMed PMID: 21209133. Epub 2011/01/07. eng.

3. Aylin P, Yunus A, Bottle A, Majeed A, Bell D. Weekend mortality for emergency admissions. A large, multicentre study. Qual Saf Health Care. 2010 Jun;19(3):213-7. PubMed PMID: 20110288. Epub 2010/01/30. eng.

4. Maggs F, Mallet M. Mortality in out-of-hours emergency medical admissions--more than just a weekend effect. The journal of the Royal College of Physicians of Edinburgh. 2010 Jun;40(2):115-8. PubMed PMID: 21125051.

5. West CP, Shanafelt TD, Kolars JC. Quality of life, burnout, educational debt, and medical knowledge among internal medicine residents. JAMA. 2011 Sep 7;306(9):952-60. PubMed PMID: 21900135. Epub 2011/09/09. eng.

6. Jackson EJ, Moreton A. Safety during night shifts: a cross-sectional survey of junior doctors' preparation and practice. BMJ Open. 2013;3(9):e003567. PubMed PMID: 24056488. Pubmed Central PMCID: 3780329.

7. Blakey JD, Guy D, Simpson C, Fearn A, Cannaby S, Wilson P, et al. Multimodal observational assessment of quality and productivity benefits from the implementation of wireless technology for out of hours working. BMJ Open. 2012;2(2):e000701. PubMed PMID: 22466035. Pubmed Central PMCID: 3317138. Epub 2012/04/03. eng.

8. Herrod PJ, Barclay C, Blakey JD. Can mobile technology improve response times of junior doctors to urgent out-of-hours calls? A prospective observational study. QJM. 2014 Apr;107(4):271-6. PubMed PMID: 24300162.

9. Brown M, Shaw D, Sharples S, et al. A surveybased cross-sectional study of doctors’ expectations and experiences of non-technical skills for Out of Hours work. BMJ Open 2015;5:e006102. doi:10.1136/bmjopen-2014- 006102

10. Blakey JD, Fearn A, Shaw DE. What drives the 'August effect'? A observational study of the effect of junior doctor changeover on out of hours work. JRSM Short Rep. 2013;4(8):2042533313489823. PubMed PMID: 24040495. Pubmed Central PMCID: 3767064.

11. Jen MH, Bottle A, Majeed A, Bell D, Aylin P. Early in-hospital mortality following trainee doctors' first day at work. PLoS One. 2009;4(9):e7103. PubMed PMID: 19774078. Pubmed Central PMCID: 2743809. Epub 2009/09/24. eng.

12. Kennedy CC, Cannon EK, Warner DO, Cook DA. Advanced airway management simulation training in medical education: a systematic review and meta-analysis. Crit Care Med. 2014 Jan;42(1):169-78. PubMed PMID: 24220691. Epub 2013/11/14.

13. Kennedy CC, Maldonado F, Cook DA. Simulation-based bronchoscopy training: systematic review and meta-analysis. Chest. 2013 Jul;144(1):183-92. PubMed PMID: 23370487. Pubmed Central PMCID: 3707173. Epub 2013/02/02.

14. Arriaga AF, Gawande AA, Raemer DB, Jones DB, Smink DS, Weinstock P, et al. Pilot testing of a model for insurer-driven, large-scale multicenter simulation training for operating room teams. Ann Surg. 2014 Mar;259(3):403-10. PubMed PMID: 24263327.

15. Lawson G, Sharples S, Clarke D, Cobb S. Validating a low cost approach for predicting human responses to emergency situations. Applied ergonomics. 2013 Jan;44(1):27-34. PubMed PMID: 22591762. Epub 2012/05/18.

16. Lagro J, van de Pol MH, Laan A, Huijbregts-Verheyden FJ, Fluit LC, Olde Rikkert MG. A Randomized Controlled Trial on Teaching Geriatric Medical Decision Making and Cost Consciousness With the Serious Game GeriatriX. J Am Med Dir Assoc. 2014 Jun 6. PubMed PMID: 24913210. Epub 2014/06/11.

17. Kato PM, Cole SW, Bradlyn AS, Pollock BH. A video game improves behavioral outcomes in adolescents and young adults with cancer: a randomized trial. Pediatrics. 2008 Aug;122(2):e305-17. PubMed PMID: 18676516. Epub 2008/08/05. eng.

18. Brown M, Syrysko P, Sharples S, Shaw D, Jeune IL, Fioratou E, et al. Developing a simulator to help junior doctors deal with night shifts. . In: Anderson M, editor. Contemporary Ergonomics and Human Factors: Taylor and Francis.; 2013.

19. de Giovanni D, Roberts T, Norman G. Relative effectiveness of high- versus low-fidelity simulation in learning heart sounds. Med Educ. 2009 Jul;43(7):661-8. PubMed PMID: 19573189. Epub 2009/07/04.

20. Norman G, Dore K, Grierson L. The minimal relationship between simulation fidelity and transfer of learning. Med Educ. 2012 Jul;46(7):636-47. PubMed PMID: 22616789. Epub 2012/05/24.

21. Cook DA, Hatala R, Brydges R, Zendejas B, Szostek JH, Wang AT, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA. 2011 Sep 7;306(9):978-88. PubMed PMID: 21900138.

22.

Figure Legends

**Figure 1:** Consort diagram of flow of participants in pilot trial of the NightShift simulation.

**Figure 2**: Boxplot of time taken to complete individual tasks by study arm illustrating range, quartiles and median. Red boxes represent urgent tasks, green boxes represent less urgent tasks.

**Figure 3:** Example screenshot of alpha version of digital simulation.

Tables

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| --- | --- | --- | --- |
|  |  | Rota | Total |
|  |  | medicine | surgery |
| Group | Standard | 6 | 4 | 10 |
| Simulator | 5 | 7 | 12 |
| Total | 11 | 11 | 22 |

Table 1: Distribution of participants by study arm and working pattern