



Using real-time location devices (RTLTD) to quantify off-unit adult intensive care registrar workload: a 1-year tertiary NHS hospital prospective observational study

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Received: 24 April 2019 / Accepted: 28 August 2019
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Abstract

UK national guidelines state deteriorating or at risk hospital ward patients should receive care from trained critical care outreach personnel. In most tertiary hospitals this involves a team led by an Intensive Care Unit (ICU) registrar. The ICU registrar must also review patients referred for possible ICU admission. These two responsibilities require work away from the ICU. To our knowledge the burden of this work has not been described, despite its importance in ICU workforce management and patient safety. A 12-month, prospective, observational study was carried out. The primary outcome measure was ICU registrar time spent on and off-unit. The study participants were senior and junior registrars on the rota of the 16 bed, Adult Intensive Care Unit at the John Radcliffe Hospital in Oxford. To measure their work patterns, this study used AeroScout 'T2' Real Time Location Device (RTLTD) tags (Stanley Healthcare, Swindon). In our hospital, senior and junior ICU registrars spend roughly one-fifth of their time off-unit, half of which is spent in ED. This workload combines to leave the unit unattended at night up to 10% of the time. RTLTDs provide a reliable, automated method for quantifying ICU registrar off-unit work patterns. This method may be adopted for quantifying other clinical staff work patterns in suitably equipped hospital environments.

Keywords Intensive Care Unit · Critical care · Medical workload · Real Time Location Device

Abbreviations

ICU	Intensive Care Unit
ED	Emergency Department
EAU	Emergency Assessment Unit
RRS	Rapid Response System
RTLTD	Real Time Location Device
OUHNSFT	Oxford University Hospitals National Health Service Foundation Trust
NHS	National Health Service

1 Introduction

Current guidelines stipulate that National Health Service (NHS) hospitals must have appropriate Intensive Care Unit (ICU) staffing to ensure safe on-unit and off-unit patient care [1]. The majority of ICU registrar work is generated on-unit through admitting, managing and discharging critically ill patients (a registrar is a junior doctor who has completed foundational training, usually 2 years, and is

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in training in a specialty area of medicine or surgery). However, the United Kingdom (UK) National Outreach Forum Operational Standards and Competencies for Critical Care Outreach Services state deteriorating hospital ward patients should receive care from trained critical care outreach personnel. In most NHS hospitals this involves a team led by an ICU registrar [2]. The ICU registrar must also review ward patients referred for possible ICU admission [3]. These two responsibilities require work away from the ICU. To our knowledge this work has not been quantified in the literature, despite its importance in ICU workforce management and patient safety. This study used an automated method to evaluate the work locations of ICU registrars within a tertiary NHS hospital over a 12-month period.

2 Methods

The 12-month, prospective, observational study was carried out in accordance with the Revised Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0) guidelines [4]. The study ran from April 1st 2017 to March 31st 2018.

2.1 Intervention

Real-time Location Devices (RTLDS) are small portable devices that can communicate with wireless (wifi) data networks. This study used AeroScout ‘T2’ RTLDS, (Stanley Healthcare, Swindon). The RTLDS determine their position by triangulating the signals from wireless access points (WAPs) and pass this information to the AeroScout software. The location of each WAP is premapped into the AeroScout software, so the RTLDS position within the hospital building can be determined. The RTLDS location is updated every 5 min. RTLDS are usually used to determine the location of mobile assets (such as portable physiological monitors). In this study the RTLDS were attached to the “baton” pagers carried by the registrars which are handed on at the end of each shift.

2.2 Measures

The primary outcome measure was ICU registrar time spent on and off the ICU. The study participants were registrars on the senior and junior tiers of the rota for the 16 bed, Adult Intensive Care Unit of the John Radcliffe Hospital, which is part of the Oxford University Hospitals National Health Service Foundation Trust (OUHNHSFT).

2.3 Analysis

Data analysis was carried out using Python version 2.7 (Python Software Foundation, Wilmington, USA).

2.4 Ethical considerations

Informed consent was not required, but all registrars were made aware of the study. Data were collected automatically in real time and securely stored within the hospital’s AeroScout system. Access to the data was granted to JM only.

2.5 Validation

The tags were tested during the study by placing them in predesignated locations and times and cross-referencing these with the location data.

3 Results

Figure 1 shows the results of binary (i.e. on-unit/off-unit) analysis carried out on ICU doctor location during each of the shifts per 24 h. During the day shift (0830–1800) the adult ICU was staffed by both the senior and junior registrars as well as between two and five additional doctors of varying seniority. During the evening shift (1800–2100) and the night shift (2100–0830) the ICU was staffed by only the senior and junior registrars. In the latter two shifts, the ICU was therefore left unattended if both registrars were called off-unit.

Off-unit location analysis showed that during the day shift (0800–1830), on average, the senior and junior registrars spent 7% of their time in the Emergency Department (ED)/Emergency Assessment Unit (EAU) and 8% in the general wards. During the evening shift (1830–2100), on average, both registrars spent 10% in the ED/EAU and 7% in the general wards. During the night shift (2100–0830), on average, both registrars spent 8% in the ED/AEU and 11% in the general wards. Variation in registrar off-unit work load between days of the week was minimal. Results are included in the Appendix (Fig. 3). A detailed description of the locations making up the category ‘general wards’ are included in the Appendix (Fig. 4a, b).

4 Discussion

4.1 Summary

The provision of intensive care in NHS hospitals increasingly involves off-unit registrar work, which is important

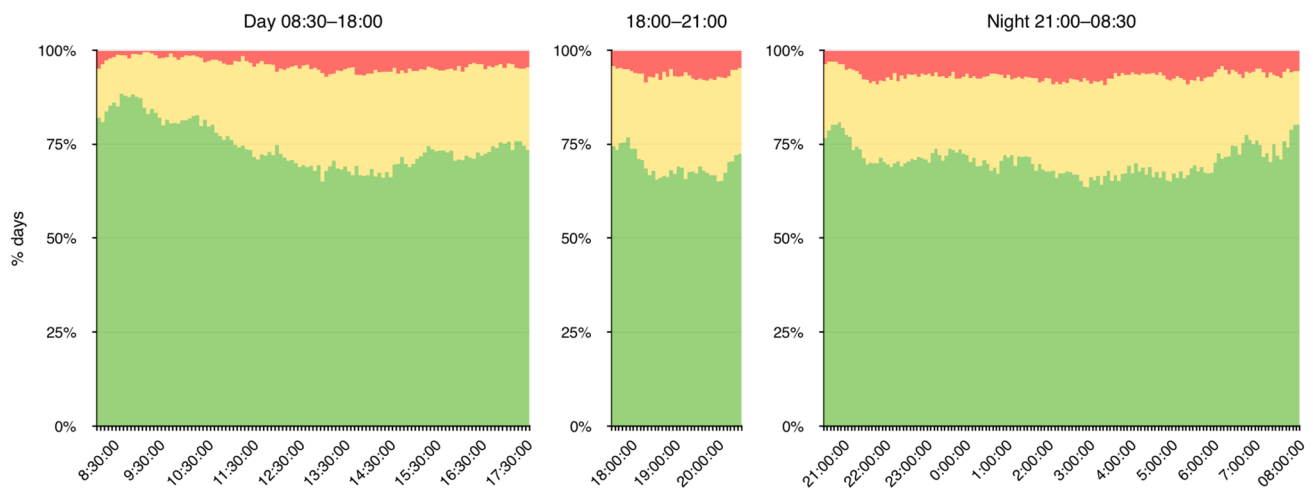


Fig. 1 On-unit/off-unit analysis of ICU doctor location. x-axis: 24 h divided into 5 min increments y-axis: % of days (mean) that the 5 min period had either none (red), one (amber) or both (green) doctors in the ICU (mean standard deviation is shown in the Appendix (Fig. 2))

but time consuming and expensive. We are the first to use RTLDs to quantify this activity. In our hospital, senior and junior ICU registrars spend roughly one-fifth of their time off-unit, half of which is spent in the ED. This workload combines to leave the unit unattended at night up to 10% of the time. This method and these data will help inform decisions about ICU off-unit workload and staffing and may in turn improve patient safety.

4.2 Interpretation

This study established the feasibility of this method to establish staff working locations (both ICU and non-ICU) which could be applied to other hospitals. RTLD tags are already widely used in the NHS to monitor the location of portable medical devices so adapting this method may prove cost effective and efficient in those cases. Generally, a detailed understanding of when, where and how long ICU registrars spend off-unit will assist in customising staffing in ICU and in areas where ICU expertise are required (e.g. the ED). Additionally, being aware of when and how often an ICU is without a registrar with airway expertise (as was the case for up to 10% of the night shift) is of clinical importance. Locally, this data informed staffing decisions.

5 Limitations

The temporal resolution (5 min) of this study was preset by the tracking devices and could not be modified. ‘Floor hopping’, where the RTLD communicates a WAP on the floor

above or below is dependent on WAP layout and occurred roughly 1% of the time. This system requires Aeroscout or similar hardware and software to be installed within the hospital and collaboration with skilled hospital Information Technology technicians. These data give ICU registrar work locations and times but not work type. We made the assumption that ICU registrars were off-unit in response to work demand alone and this may have not always been the case. Likewise, we acknowledge individual doctors will have approached the same workload in different ways. The data was anonymised so individual doctor off-unit workload patterns were not evaluated and this may have introduced bias into the results.

6 Conclusions

RTLDs provide a reliable, automated method for quantifying ICU registrar off-unit work patterns. This method may be adopted for quantifying other clinical staff work patterns in suitably equipped hospital environments.

Acknowledgements JM would like to acknowledge the University of Adelaide, Department of Acute Medicine, who are administering his PhD.

Author contributions JM and GB designed the study and undertook the methodological planning. JM led the writing. DM led the data analysis. DY, GL and PW assisted in study design, contributed to data interpretation, and commented on successive drafts of the manuscript. All authors read and approved the final manuscript.

Funding No funding was required for this study.

Data availability The datasets generated and analysed during the current study will not be publicly available as they can be linked to the treatment of specific individuals. Aggregated data are available from the corresponding author on reasonable request.

Compliance with ethical standards

Competing interests The authors declare that they have no competing interests. PW is Chief Medical Officer for Sensyne Health and holds shares in the company.

Ethics approval and consent Health Research Authority (South Central – Oxford C, Research Ethics Committee (REC), nrescommittee.southcentral-oxfordc@nhs.net) approval was sought but not required as the study was deemed a quality improvement project. All documents and data were stored securely and only accessible by study staff and authorised personnel. The study complied with the Data Protection Act.

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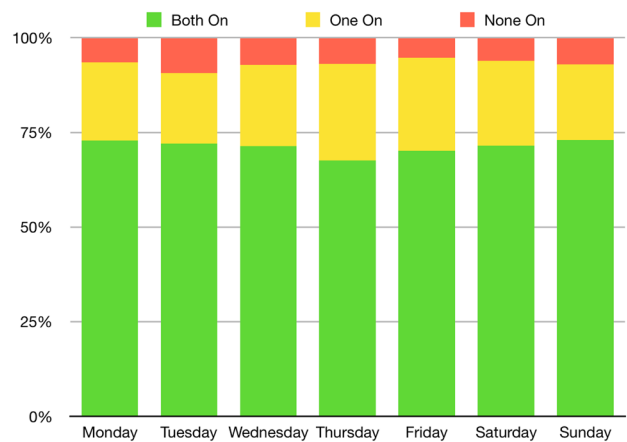


Fig. 3 Tracker location variation between days of the week

Appendix

See Figs. 2, 3, and 4.

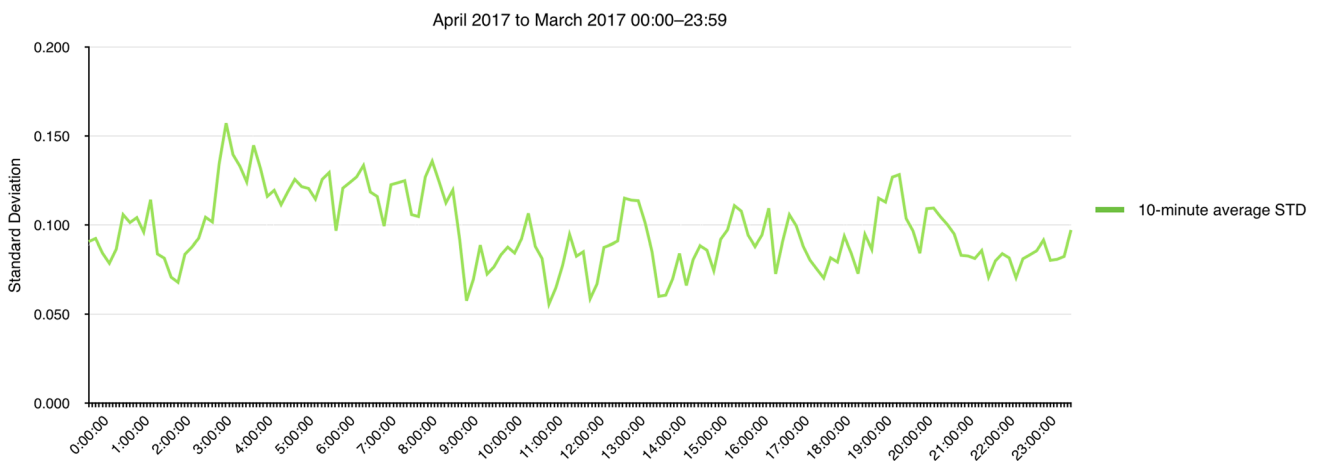


Fig. 2 Variation (standard deviation) of the mean percentages of time spent on or off-unit. The least variability is seen around handover times (0830)

Tracker Locations April 2017–March 2018

	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
AICU	82%	82%	79%	79%	81%	80%	83%	84%	88%	92%	89%	86%	84%	82%	80%	83%	83%	85%	83%	81%	81%	86%	81%	81%
ED/EAU	9%	9%	9%	9%	8%	8%	6%	6%	5%	3%	5%	6%	7%	8%	9%	9%	9%	8%	7%	9%	11%	8%	11%	11%
Theatres	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Radiology	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Trauma	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Changing Rooms	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Maternity	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Level 2	1%	0%	1%	1%	1%	1%	1%	2%	1%	1%	0%	1%	1%	2%	1%	1%	1%	1%	2%	1%	1%	1%	1%	1%
Level 4	1%	1%	1%	0%	0%	1%	1%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	1%
Level 5	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Level 6	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	2%
Level 7	1%	1%	1%	1%	1%	0%	1%	1%	1%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	1%
Level 8	0%	1%	3%	5%	5%	5%	3%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
West Wing	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%	1%	1%	1%	0%	0%	1%	0%	0%	1%	0%	0%
Other	1%	1%	2%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	2%	2%	1%	1%	1%	1%
Null	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%

Fig. 4 a Tracker locations (total). **b** Tracker locations (as a % of time off-unit). Level 2: a mix of corridors, shops and outpatient departments, Levels 4 and 5: specialty wards, Level 6: surgical wards, Level

7: medical wards, Level 8: the on-call room for the Tier 2 registrars. West Wing: neurosurgical, plastics and ear, nose and throat surgical wards, null/data error: ‘floor hopped’ data

Tracker Off-Unit Locations April 2017–March 2018

	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
ED/EAU	52%	52%	50%	53%	46%	46%	36%	35%	29%	16%	28%	36%	41%	44%	51%	52%	53%	44%	40%	52%	65%	45%	42%	62%
Theatres	4%	6%	4%	4%	7%	4%	7%	5%	4%	3%	2%	2%	3%	4%	8%	7%	5%	4%	6%	5%	3%	3%	2%	5%
Radiology	0%	1%	1%	1%	1%	1%	0%	1%	0%	1%	2%	3%	2%	3%	3%	2%	2%	2%	2%	2%	2%	0%	0%	1%
Trauma	2%	0%	0%	0%	1%	1%	0%	0%	0%	1%	1%	2%	1%	1%	1%	0%	0%	0%	0%	1%	1%	0%	1%	0%
Changing Rooms	0%	0%	1%	2%	2%	2%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Maternity	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Level 2	5%	2%	4%	4%	3%	6%	7%	11%	8%	6%	3%	5%	8%	11%	8%	7%	6%	7%	9%	8%	6%	4%	3%	6%
Level 4	4%	3%	3%	2%	2%	3%	3%	3%	2%	2%	2%	3%	4%	8%	6%	5%	5%	4%	5%	4%	3%	2%	1%	3%
Level 5	2%	3%	3%	1%	0%	2%	1%	2%	1%	1%	3%	2%	1%	2%	3%	1%	1%	3%	2%	2%	2%	2%	3%	3%
Level 6	7%	8%	7%	8%	5%	7%	6%	4%	5%	4%	4%	7%	8%	6%	6%	4%	3%	5%	6%	8%	5%	4%	6%	7%
Level 7	8%	4%	7%	4%	3%	3%	5%	8%	4%	3%	2%	4%	8%	5%	5%	3%	6%	4%	7%	8%	5%	2%	2%	5%
Level 8	2%	8%	20%	26%	27%	26%	19%	4%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
West Wing	3%	1%	2%	1%	1%	1%	1%	3%	1%	1%	2%	3%	3%	4%	3%	4%	3%	2%	4%	3%	2%	3%	2%	2%
Other	5%	7%	10%	7%	5%	6%	6%	7%	4%	4%	6%	8%	8%	10%	11%	7%	8%	6%	9%	12%	8%	6%	5%	6%
Data Error	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	3%	5%

Fig. 4 (continued)

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