Research Article

A time and motion study in a neonatal intensive care unit

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Abstract

Aims This study aimed to quantify and compare doctors' shift activity in 2019 on a neonatal intensive care unit with 2011 data. Differences in 'wasted' time, workflow interruptions and the most time-consuming tasks since the introduction of quality improvement changes to the unit in 2011 were analysed.

Methods The activity of five doctors was monitored in a time and motion study. Each doctor was followed over a 12 hour shift. Observations and interruptions were recorded using an activity pro forma. Distance travelled by doctors, fluid intake and number of toilet trips were also noted.

Results 'Wasted' time, interruptions and distance travelled per shift reduced by 38% (p=0.01), 80% (p=0.0007) and 55% (p=0.0005), respectively, between 2011 and 2019. The largest proportion of shift time was dedicated to direct patient contact in both 2011 (33%) and 2019 (36%). Fluid intake by doctors was inadequate in 2019, averaging 810 ml per shift.

Conclusions This study has not been able to conclude the areas of workflow that have benefitted from the reduction in 'wasted' time. Further monitoring in this field may help clarify wasted time and improve efficiency further.

Introduction

In 2017, there were 3395 admissions to neonatal units in Wales. Of these, 15% were in the University Hospital of Wales (UHW), the most of any Welsh hospital.[1]

In the hospital setting, wasteful activities can have an impact on the time for direct patient contact. A 2011 time and motion study analysed 4320 minutes of doctor activity on the neonatal intensive care unit (NICU) at UHW. This was inspired by the 'Productive Ward' and 'Transforming Care' initiatives of the NHS, which empower ward teams to redesign and streamline work processes.[2,3] Since 2011, several 'quality improvement' processes have been implemented, focussing on efficiency and reducing unnecessary testing. These include:

- changes to the design of the unit
- introduction of the 'handover and huddle' framework
- availability of guidelines on the intranet
- presence of a senior pharmacist on the ward round
- improvements in staff training

Time and motion studies have been shown to be a reliable tool for the assessment of doctors' workflow patterns.[4] We aimed to determine the impact of these changes on doctors' activity by comparing current (2019) activity with 2011 data, with particular emphasis on 'wasted' time and interruptions.

Methods

The methods used in this study (described below) closely follow that of the original 2011 study.[5] Differences of note are as follows:

- The observer was different between the studies (however, the supervisor of both this and the 2011 study was the same so the guidelines followed remained constant);
- There was one less ITU shift observed in this study as compared with the 2011 study;
- The length of interruptions, fluid status and toilet visits were recorded in this study but not in the 2011 study.

UHW NICU is a tertiary centre with 28 cots (eight intensive care, ten high dependency and ten special care). Per neonatal shift, there are two Senior House Officers (SHOs) and one registrar on ICU, with two to three doctors in high dependency. The activity of five NICU doctors (n=3 SHOs and n=2 registrars) was monitored on a minute-by-minute basis in a time and motion observational study.

Verbal consent was obtained to follow each doctor over a 12 hour ICU weekday shift (09:00–21:00 hours), totalling 3600 minutes of activity. The doctor recruitment was random and the days that were monitored were selected at random. All participants were in good health on the day of participation. A standardised activity pro forma (**Appendix 1**) was used to record observations. The distance that doctors travelled while on shift was recorded, and fluid intake and number of toilet trips were noted to gauge hydration status. Participant activity was timed using a digital stopwatch and steps measured with a pedometer mobile phone application (iOS 'Health' application).

'Wasted' time was defined as any unnecessary motion not related to the task being performed. Examples of wasted time included walking to another computer because the nearest one was being used or looking for notes/equipment that were not in the expected location. An 'interruption' was any event that required the participant to stop their current activity. This study did not require ethical approval as patient information was not used and the identity of doctors has been kept confidential.

Results

The absolute time and percentage of the 12 hour shift that each participant spent on a specific category is presented in **Table 1**. The only activity that was statistically different between 2011 and 2019 was 'wasted' time per shift, which was reduced by 38% (p=0.01) between 2011 and 2019. In total, approximately 49 minutes was lost to 'wasted' time in 2019, as compared with 78 minutes in 2011 **(Table 1)**.

In both 2011 and 2019, the top three activities that had the most time dedicated to them were direct patient contact (which included ward round; the largest proportion of shift time was dedicated to this: 33% in 2011 and 36% in 2019), followed by medical documentation and discussion (**Table 1, Figure 1**). Sepsis screens were the most time-consuming clinical procedure, averaging 26 minutes per shift (data not shown). In 2011, the most performed clinical procedure was capillary blood gases (CBGs), taking up an average of 28 minutes per shift, whilst, in 2019, time spent doing CBGs averaged 3 minutes per shift (data not shown).

Table 1. Absolute time and percentage of 12 hour shift participants spent on specific activities in 2011 and 2019

Activity category	$\bar{x}$ time taken (minutes) over 12 hour shift		*p* value
	2011	2019	
'Wasted' time, i.e. unnecessary motion	78.33 ± 17.55	48.60 ± 11.56	0.01
Teaching/training	57.67 ± 52.72	30.00 ± 39.35	0.36
Medical documentation	162.00 ± 60.06	191.10 ± 38.11	0.37
Discussion	107.33 ± 31.55	96.40 ± 56.75	0.69
Personal hygiene	3.17 ± 3.06	6.50 ± 4.82	0.20
Other (including breaks)	72.33 ± 10.09	81.30 ± 24.42	0.43
Direct patient contact (including ward round)	239.17 ± 64.01	256.50 ± 53.84	0.64
Interruptions	ND[a]	9.60 ± 3.80	
Ward round	107.80 ± 29.10	137.80 ± 40.04	0.18

Data is represented as the mean±SD

[a]The 2011 study only recorded the frequency and not the length of each interruption, therefore no data are present

ND, no data

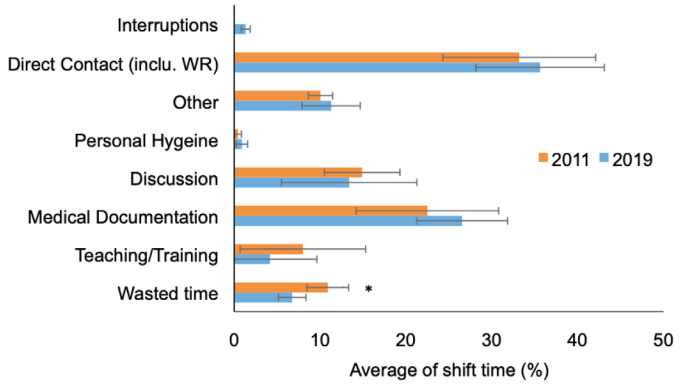

Figure 1. Comparison of the combined average shift activity of NICU doctors in 2011 and 2019. Inclu., including; WR, ward rounds. *$p<0.05$.

Interruptions and distance travelled per shift reduced by 80% ($p=0.0007$) and 55% ($p=0.0005$), respectively, between 2011 and 2019 (**Table 2**). Fluid intake in 2019 was, on average, 810 ml per shift, and participants made one toilet visit.

Table 2. Comparison of participant steps, distance, fluid intake and interruptions between 2011 and 2019.

Variable	$\bar{x}$ over 12 hour shift		*p* value
	2011	2019	
Steps *(n)*	6805 ± 1348	3264 ± 903	0.0007
Distance (km)	5.39 ±1.08	2.41 ± 0.69	0.0005
Amount to drink (ml)	ND	810 ± 286	
Toilet visits *(n)*	ND	1.40 ± 0.89	
Externally prompted interruptions *(n)*	40.67 ± 14.12	8.20 ± 2.28	0.0007
Self-prompted interruptions *(n)*	22.5 ± 10.9	3.2 ± 2.6	0.004

Data is represented as the mean±SD

ND, no data

Interruption frequency was significantly less in 2019, with an average of 8 occurrences over a 12 hour shift, as compared with 41 in 2011 (**Table 2**; $p=0.0007$). A similar pattern was seen in the number of times the doctor interrupted someone else: 23 in 2011 compared to 3 in 2019. In both years, doctors received more interruptions than they initiated. The most common source of interruptions was patient-related queries in both 2011 and 2019 (data not shown).

When comparing activity between registrars and SHOs, two activity categories showed statistical significance: discussion and medical documentation (**Figure 2** and **Appendix 2, Supplementary Table 1**). Registrars spent an additional 91 minutes (21% of shift time) on discussion as compared with SHOs (8% of shift time), whilst SHOs spent 66 more minutes on medical documentation than registrars. Although the percentage of shift time lost to interruptions was similar for both registrar and SHO, the average interruption rate was 9.5 and 7.3 times per shift, respectively (**Appendix 2, Supplementary Table 2**). Furthermore, SHOs interrupted someone else on average five times per shift as compared with registrars (0.5 times; **Appendix 2, Supplementary Table 2**).

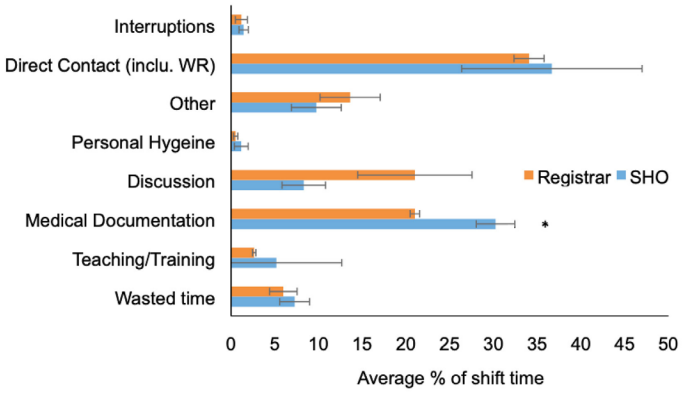

Figure 2. Comparison of the 2019 activity between registrars and SHOs in the NICU. Inclu., including; WR, ward rounds. *$p<0.05$. See **Appendix 2, Supplementary Table 1** for raw data.

Discussion

One potential contributing factor to the reduction in wasted time observed in this study when compared to 2011 was the practical design of the unit investigated. All equipment for clinical procedures was in one location, resulting in less time looking for it (see **Appendix**

3, Supplementary Figure 1a). Moreover, each patient had their own trolley at their bedside containing their notes, making them easy to find (**Appendix 3, Supplementary Figure 1b,c**). Previously, in 2011, all patient notes were stored together, requiring the doctor to leave the bedside to collect them. Furthermore, the introduction of the 'handover and huddle' framework identifies patient safety concerns and increases team members' situational awareness of the management plans for that day.[6] This has led to a culture change on the NICU.

Direct patient contact accounted for 36% of the shift in 2019. In 2011, the most performed clinical procedure was CBGs, taking up an average of 28 minutes per shift. As a result of this, programmes were implemented to reduce the number of CBGs and, consequently, time spent doing CBGs averaged 3 minutes per shift in 2019. This is because they were generally performed alongside phlebotomy or cannula insertion, and not as a separate procedure. The nurse would take the sample to the blood gas analyser for the doctor, thus saving time. Often the nurse did the entire CBG, allowing the doctor to complete other tasks. CBG numbers for 2018 were unavailable at the time of writing, therefore, it is unclear if the time reduction represents a true continued decrease in CBG procedures or if nurses are doing them instead.

Interruption occurrence was significantly less in 2019 than in 2011. Since 2011, training of the NICU staff on not interrupting people was introduced and, consequently, interruptions have halved (unpublished findings). Other changes include the increase in numbers of staff[7] and improvements in training across the deanery.[8] In addition, management guidelines are accessible on the intranet, potentially reducing the need to ask for advice.[9] A senior pharmacist is present on the ward round so any medication-related queries can be addressed during this time.[10] In both years, doctors received more interruptions than they initiated, which agrees with the previous literature.[11]

Registrars spent an average of 21% of shift time in discussion, as compared with 8% by SHOs. This is expected given the greater role registrars play in decision-making, leadership and supporting junior doctors.[12]

On average doctors drank just over 800 ml of fluid and made just one toilet visit during a 12 hour shift in 2019. The European Food Safety Authority (EFSA) recommends a daily water intake of 2.0 litres for females and 2.5 litres for males.[13] Guidance from the UK Health and Safety Executive requires that water is available in sufficient quantities in the workplace.[14] Dehydration by 2% of bodyweight "impairs performance in tasks that require attention, psychomotor, and immediate memory skills".[15] Based on these recommendations, doctors are not drinking enough, increasing the likelihood of errors and potential for patient harm. It is recommended that units install a water dispenser on the ward to improve accessibility and encourage doctors to remain hydrated while on shift.

There are several limitations of this study. For example, the interpretation of activities/interruptions by the observer was subjective, making reproducibility of the data difficult. In addition, the time-consuming nature of the study makes collecting data on large sample sizes highly demanding in terms of resources and impractical. Therefore, the results may not be reflective of all NICU doctors. Moreover, human error in time recording is likely to affect the accuracy of the data. It is also difficult to overcome the Hawthorne effect, in which clinicians may change/improve their behaviour in response to being observed.[16] In addition, the EFSA guidance on water intake is the recommended amount over a whole day; however fluid intake from doctors was only measured over a 12 hour period. Therefore, doctors could have potentially drunk enough each day if the fluid they consumed outside of shift hours was included.

For future studies, a pilot study to train multiple observers and compare their agreement in interpreting activity may be useful. This will ensure uniformity and improve the reliability of the results.[11] It may also be worth considering influencing factors, such as the demographic of the doctor, including age, sex, experience working on the unit and if training was in or outside the UK. To better assess dehydration, researchers could consider performing bioelectrical impedance analysis, which is accepted to be a reliable method of measuring total body water. The values obtained from bioelectrical impedance correlate closely with the values derived using the recognised 'gold standard' for measuring total body water, isotope dilution.[17] It may also be useful to record the number of CBGs carried out by both doctors and nurses to determine if there has been a reduction in the number of procedures performed.

Conclusions 'Wasted' time, interruptions and distance travelled all decreased from 2011 to 2019. Other areas of workflow showed little difference. The observed changes may be the consequence of multiple unit changes and the conscious effort of clinicians to be more efficient in their work. Fluid intake by doctors was inadequate and this may impact their performance. This study has not been able to conclude the specific areas of workflow that have benefitted from the reduction in 'wasted' time. Further monitoring in this field may help clarify wasted time and improve efficiency further.

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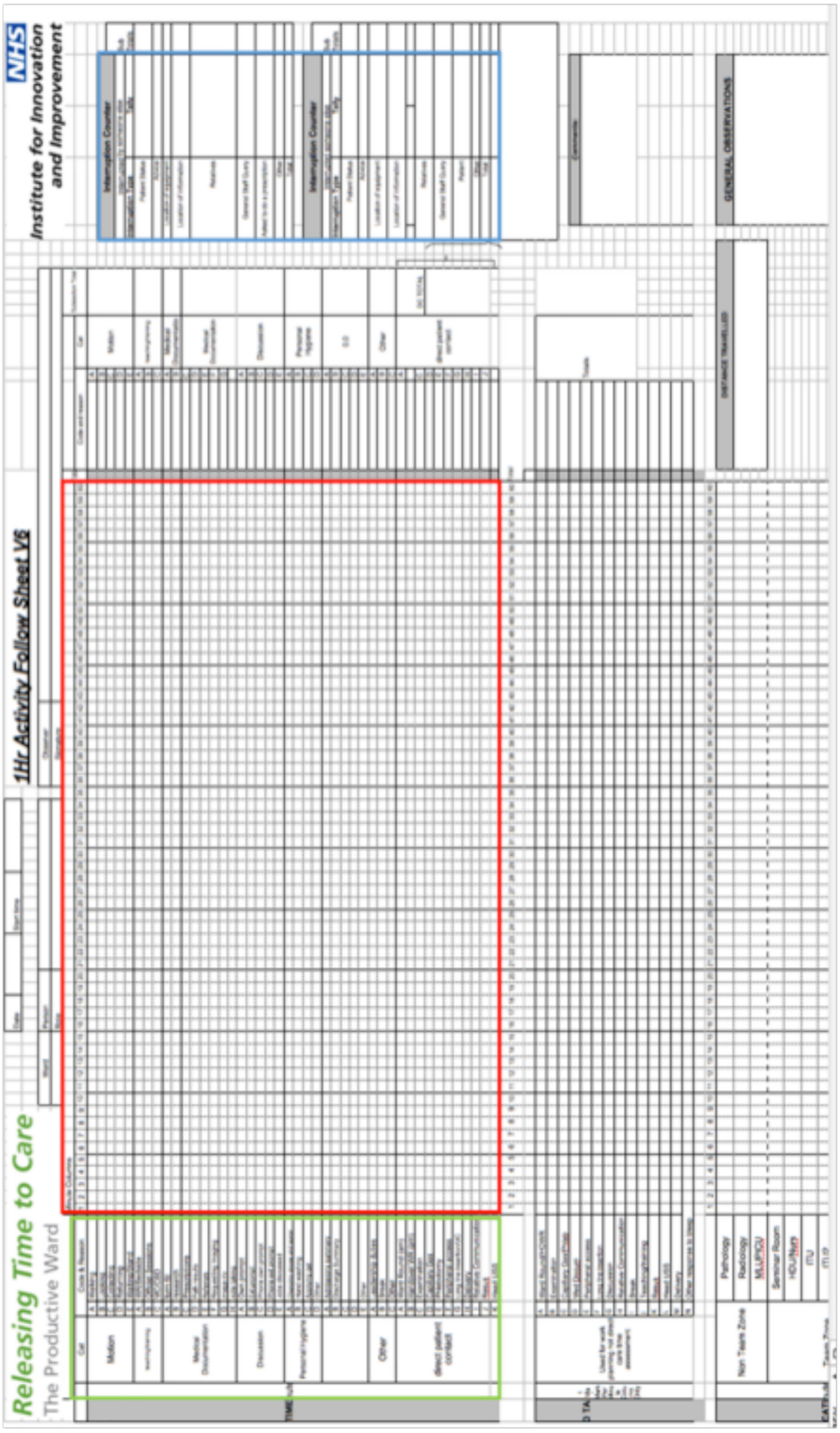
Appendix 1: Standardised 1 hour activity pro forma

Green box: list of main activity categories (e.g. direct patient contact) and their sub-categories (e.g. ward round, examination, phlebotomy etc.); red box: documents the activity occurring at every minute for each hour; blue box: records the number, type and source (external or self-prompted) of each interruption



Appendix 2: Raw data for comparison between registrars and SHOs

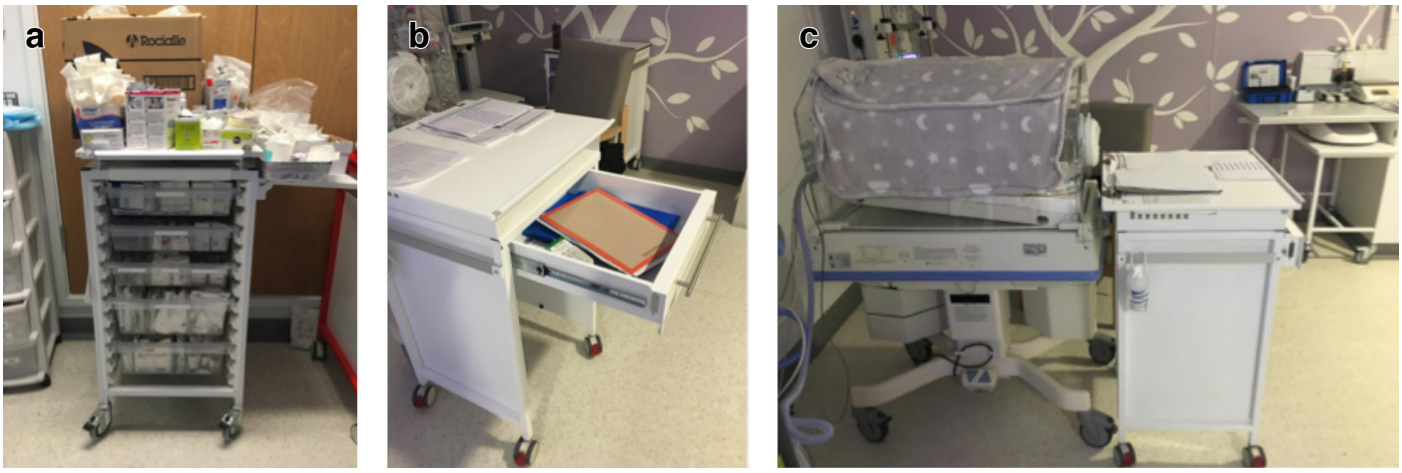
Supplementary Table 1. Comparison of the activity between registrars and SHOs in 2019.

Activity category	$\bar{x}$ time taken (minutes) over 12 hour shift		$\bar{x}$ percentage of 12 hour shift		*p* value
	Registrar	SHO	Registrar	SHO	
'Wasted' time, i.e. unnecessary motion	43.00 ± 11.31	52.33 ± 12.29	5.97 ± 1.57	7.27 ± 1.71	0.46
Teaching/training	19.00 ± 1.41	37.33 ± 53.80	2.64 ± 0.20	5.19 ± 7.47	0.68
Medical documentation	151.25 ± 3.89	217.67 ± 15.83	21.01 ± 0.54	30.23 ± 2.20	0.01
Discussion	151.25 ± 47.02	59.83 ± 17.90	21.01 ± 6.53	8.31 ± 2.49	0.05
Personal hygiene	3.75 ± 1.77	8.33 ± 5.69	0.52 ± 0.25	1.16 ± 0.79	0.37
Other (including breaks)	98.00 ± 24.75	70.17 ± 20.53	13.61 ± 3.44	9.75 ± 2.85	0.26
Direct patient contact (including ward round)	245.25 ± 12.37	264.00 ± 74.23	34.06 ± 1.72	36.67 ± 10.31	0.76
Interruptions	8.50 ± 4.95	10.33 ± 3.82	1.18 ± 0.69	1.44 ± 0.53	0.67

Supplementary Table 2. Comparison of the interruptions to registrars and SHOs in 2019.

	$\bar{x}$ over 12 hour shift 2019		*p* value
	Registrar	SHO	
Externally prompted interruptions	9.50 ± 3.54	7.33 ± 1.15	0.37
Self-prompted interruptions	0.50 ± 0.71	5.00 ± 1.00	0.01

Appendix 3: Images of NICU unit



Supplementary Figure 1. Image showing the practical design of the NICU used in this study to illustrate how this helped to reduce wasted time. (a) All equipment for clinical procedures was stored in one location, resulting in less time looking for it. **(b)** Trolley with medical notes. **(c)** Each patient has their own trolley at the bedside containing their notes, making them easy to find.