The association of nurses’ shift characteristics, missed vital signs observations and sickness absence. Retrospective observational study using routinely collected data

by

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When organising shift work, healthcare managers are required to cover the service across 24 hours in a way that maximises job performance – which includes minimising sickness absence related to work, and creating conditions that allow nursing staff to perform their scheduled tasks.

This study aimed to investigate the association between characteristics of shift work in acute hospital wards and nursing staff job performance, in terms of sickness absence and compliance with vital signs observations. This was a retrospective longitudinal observational study using routinely collected data on nursing staff shifts, missed vital signs observations and sickness absence. The study took place in all acute inpatient general wards at a large teaching hospital in the South of England over a three years period. Shift and sickness data were extracted from the electronic shift system and overtime shifts datasets, which are both linked to the hospital payroll. These contain individual records of shifts worked, dates, start and end time, ward and grade for all nurses employed by the hospital. Vital signs observations data were extracted from a database of records made using the VitalPAC™ system. Generalised linear mixed models were used to model the association between shift work characteristics, sickness absence episodes and compliance with vital signs observations.

This doctoral research provides new knowledge regarding the association of shift characteristics and job performance outcomes. It found that working high proportions of 12 hours or more shifts is associated with higher sickness absence, regardless of how many days nursing staff had worked in the previous seven days. An association between working 12 hours or more shifts and delaying vital signs observations was found for health care assistants. Drawing on a large and diverse sample size and using objective data, this study is the first in nursing to demonstrate that there is an association between long shifts and job performance.
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I, Chiara Dall’Ora

declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

“The association of nurses’ shift characteristics, missed vital signs observations and sickness absence. Retrospective observational study using routinely collected data”

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. Parts of this work have been published as:

Signed: ...............................................................................................................................

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Definitions and Abbreviations

Definitions

**Agency shifts**: shifts covered by staff who are supplied to a Trust by a private agency. Staff covering agency shifts are not part of a Trust bank.

**Agenda for change**: the current National Health Service (NHS) grading and pay system for NHS staff.

**Bank shifts**: shifts worked by the hospital nursing staff who sign up to work additional hours at their Trust. Bank shifts are worked on a voluntary basis and employees can sign up for bank shifts in advance. Bank shifts are paid to the employee at Agenda for Change pay structures for the assignment undertaken.

**Common-method variance**: a form of bias that could occur because respondents to a survey tend to provide answers that are consistent in their point of view, leading to halo effects or effects of social desirability.

**Compressed working week**: a type of work schedule in which the hours worked per day are extended, whilst the days worked are reduced, so that the standard number of weekly hours are worked in fewer days.

**Cost-effectiveness**: The measure of the cost of achieving a benefit by different means. The benefits are expressed in non-monetary terms related to health.

**E-Roster**: electronic rostering system. It brings together management information on shift patterns (including individuals' preferred shift patterns), annual leave, sickness absence, staff skill mix and movement of staff between wards. This enables managers to build rotas and employees are able to access the system to check their rotas and make personal requests.

**Job performance**: observable behaviours/actions that an employee is expected to perform.

**Missed nursing care**: any aspect of care that is omitted or delayed, in part or in whole. It has been conceptualised as an error of omission.

**Nursing staff**: in this study the word “nursing staff” refers to both registered nurses (RN or RNs), covering from band 5 upwards and healthcare assistants (HCA) covering from band 1 to band 4. Registered nurses are fully qualified nurses trained and registered with the Nursing and Midwifery Council. Healthcare assistants provide much ‘hands on’ care and
Definitions

do not undergo any formal training before starting the job. HCAs are variously titled: health care support workers; nurses’ aides and nursing assistants

**Overtime bookings:** the dataset containing all bank and agency shifts worked within the Trust by nursing staff

**QALY:** Quality Adjusted Life Years. A measure of the state of health of a person or group in which the benefits, in terms of length of life, are adjusted to reflect the quality of life. One QALY is equal to 1 year of life in perfect health. QALYS are often measured in terms of the person’s ability to carry out the activities of daily life, and freedom from pain and mental disturbance

**Shift work:** a work activity scheduled outside standard daytime hours, where there may be a handover of duty from one individual or work group to another; a pattern of work where one employee replaces another on the same job within a 24-hour period. Examples of shift work are evening, night, weekend work; extended work periods of 12 hours or more; overtime and rotating hours of work

**Trust:** legal entity, set up by order of the Secretary of State under section 25 of, and Schedule 4 to, the National Health Service Act 2006, to provide goods and services for the purposes of the health service

**VitalPAC™:** the Trust’s patient clinical monitoring system, which alerts users if the patient’s vital signs are outside acceptable limits. Vital signs are usually observed and recorded by the nursing staff

**Wellbeing:** positive outcome that indicates that people perceive that their lives are healthy and going well

**Whole time equivalent:** an estimated measurement of the staff resource available, taking into account full and part-time working
Abbreviations

AIC: Akaike Information Criterion
aOR: Adjusted Odds Ratio
BIC: Bayesian Information Criterion
ERGO: Ethics and Research Governance Online
HCA: Healthcare Assistant
HCA-HPPD: Healthcare Assistants Hours Per Patient Day
HS&DR: Health Services and Delivery Research Programme
HSE: Health and Safety Executive
ICC: Intraclass Correlation Coefficient
ILO: International Labour Organisation
IQR: Inter Quartile Range
MBI: Maslach Burnout Inventory
NEWS: National Early Warning Score
NEXT: Nurses’ Early Exit Study
NHPPD: Nursing Hours Per Patient Day
NHS: National Health Service
NICE: The National Institute for Health and Clinical Excellence
NRES: National Research Ethics Service
OFER: Occupational Fatigue Exhaustion/Recovery Scale
OR: Odds Ratio
QALY: Quality Adjusted Life Years
RCN: Royal College of Nursing
RN: Registered Nurse
Abbreviations

RN4CAST: Registered Nurse Forecasting in Europe Study

RN-HPPD: Registered Nurse Hours Per Patient Day

RR: Rate Ratio

UK: United Kingdom

US: United States of America

VIF: Variance Inflation Factor

95% CI: 95% Confidence Interval
Chapter 1 Introduction to the study

1.1 Introduction

In broad terms, this research explores how an aspect of work organisation - shift work - may impact on employee job performance.

The idea for this research originated while undertaking a cross-sectional study that explored the association between registered nurses’ shift length and outcomes such as quality of care and job satisfaction. The analysis was motivated by the move of many UK hospitals to shifts of 12 hours or longer as a strategy to reduce costs while maintaining nurses’ job performance (NHS Evidence 2010; Griffiths et al. 2014; Harris et al. 2015). These longer shifts offer a compressed week, fitting the workweek into fewer days by extending daily hours. Dividing the day into two 12-hour shifts reduces time spent in handovers and thus time spent where shifts overlap; moreover, 12-hour shifts are reported to be preferred by many nurses, because they can benefit from more days off work and improved work-life balance (Stone et al. 2006).

However, the introduction of 12-hour shifts raised concerns: long working hours have been correlated with fatigue and decreased levels of alertness, potentially resulting in jeopardised job performance (Trinkoff et al. 2011; Geiger-Brown et al. 2012). The RN4CAST study, one of the largest nursing workforce planning studies ever conducted in Europe (Sermeus et al. 2011), provided an opportunity to examine the characteristics of nursing work in relation to a number of nurse reported outcomes, such as job satisfaction and burnout. The cross-sectional study covered more than 33,000 registered nurses (RNs) from 488 hospitals across 12 European countries and its main aim was to investigate the relationship between nursing workforce characteristics and nurse and patient outcomes. It included data on the last shift worked, length of shift, presence of overtime, and time of day (i.e. early, late and night). The work I undertook based on the RN4CAST data resulted in publications on two international peer-reviewed journals (Griffiths et al. 2014; Dall’Ora et al. 2015), which are attached as Appendix A and Appendix B.

The RN4CAST study was based on a large and diverse sample with a nested data structure, which enabled multilevel analysis to be conducted, controlling for several confounding variables other than shift length, while simultaneously taking into account country, hospital and ward effects. The study had a cross-sectional design and both shift work characteristics (e.g. shift length, overtime, time of the day last shift had taken place and whether nurses were working full or part time) and outcomes (such as quality of care
provided by nurses, patient safety, care left undone, burnout, job satisfaction and intention to leave the job due to job dissatisfaction) were self-reported by RNs. This motivated me to review the relevant literature and then to plan my doctoral research, where the aim is to investigate the association between shift work undertaken by nursing staff in acute hospital wards and job performance, as indicated by sickness absence and delayed/missed vital signs observations.

1.2 Background: work organisation, shift work and job performance

Concerns about quality and safety in health care and the connections between nursing work organisation and patient outcomes were surfaced in England’s NHS recently (Francis 2013; Keogh 2013). Several international studies and reviews have highlighted the link between poor working conditions, including negative working environments, and inadequate staffing levels and compromised patient outcomes (Aiken et al. 2014; Griffiths et al. 2016).

A key work factor that has been studied in relation to the ability of the nursing workforce to maintain quality and safety in hospitals is shift work (Wagstaff and Sigstad Lie 2011; Bae and Fabry 2014). Shift work is a work activity scheduled outside standard daytime hours, where there may be a handover of duty from one individual or work group to another; a pattern of work where one employee replaces another on the same job within a 24 hour period (Health and Safety Executive 2006).

Research describing potential adverse consequences of shift work on employees is mounting, with recent evidence of shift work being associated with impaired cognitive function (Marquie et al. 2015) and reports of a plausible correlation with higher risk of employee death (Knutsson 2017). The potential of shift work to affect cognitive function has implications for employees’ performance, which is likely to be jeopardised.

Given the known adverse effects associated with shift work, in an ideal world, shift work would be avoided. However, in common with several occupational sectors, many nursing services must be provided in a continuous manner, across 24 hours, seven days a week, so that resorting to shift work is a necessity. When organising shift work, healthcare managers are required to cover the service across 24 hours in a way that maximises job

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1 The term “nursing staff” in this thesis refers to both registered nurses (RNs) and healthcare assistants (HCAs).
performance – which includes minimising sickness absence related to work, and creating conditions that allow nursing staff to perform their scheduled tasks.

Job performance has been studied and conceptualised in several ways in the literature (Koopmans et al. 2011). Despite different nuances and theoretical standpoints of these definitions, the common feature that embraces the job performance construct is an observable behaviour/action that an employee is expected to perform (Campbell et al. 1990; Viswesvaran and Ones 2000; Motowidlo 2003).

Extensive work carried out by Michie and West corroborated the relationship between how healthcare employees are managed, their behaviour and their job performance. They found links between organisational context, including resources; people management, including job design, workload and teamwork, employee involvement and control over work, leadership and support; psychological consequences for employees, which include health and stress, satisfaction and commitment, knowledge, skills and motivation; employee behaviour, which includes absenteeism and turnover, task and contextual performance and organisational performance (Michie and West 2004). Their framework, which can be found in Appendix C, highlighted that different ways of designing a job and managing people have different impacts on employees’ psychological and physical well-being, their attitudes to work and the organization, and their performance and behaviour at work – one aspect being their presence or absence at work due to sickness (Michie and West 2004).

Shift work is among the aspects that healthcare managers consider when organising their workforce and it is a practice that is adopted by several occupational sectors. The next sections explore shift work from a general standpoint. However, references to and applications of shift work in nursing are provided where possible.

### 1.3 Defining shift work

Shift work refers to a wide variety of work time arrangements, and broadly could be described as “all working hours that are outside the normal daytime ones” (Knutsson 2004). However, this statement raises a further question as to what can be labelled as “normal daytime hours”.

The attempt to identify “working hours outside the normal ones” has produced different definitions of shift work; the UK Health and Safety Executive (HSE) have defined normal daytime hours as “a work schedule involving an activity during the day, commonly for a period of eight hours between 7 am and 7 pm. There are usually two periods of work, one
in the morning, and the other in the afternoon, separated by a lunch-time break” (Health and Safety Executive 2006).

The HSE guidance provides examples of what could be considered as shift work. It states: “a work activity scheduled outside standard daytime hours, where there may be a handover of duty from one individual or work group to another; a pattern of work where one employee replaces another on the same job within a 24 hour period […] Examples of this may be evening, night, weekend work; extended work periods of 12 hours or more; overtime and rotating hours of work” (Health and Safety Executive 2006).

The International Labour Office reports that shift work is “a method of organization of working time in which workers succeed one another at the workplace so that the establishment can operate longer than the hours of work of individual workers” at different daily and night hours (International Labour Office 2004). This definition, despite being very comprehensive, does not refer to any specific features that could be used to describe shift work.

As regards the literature, studies have defined shift work in a variety of ways: “a shift worker is anyone who works extended-duration shifts and other variable and nonstandard hours, including workers who work late into the night or start working very early in the morning” (Barger et al. 2009); “work schedules outside of 6 am–7 pm Monday through Friday” (Saksvik-Lehouillier et al. 2013).

In another study, workers were classified as undertaking shift work if their work schedules “involved rotating shift work (e.g., alternating morning, afternoon and night shifts), or did not allow them to go to bed before midnight, or resulted in them having to get up before 5 am, or prevented them sleeping during the night (night work)” (Marquie et al. 2015). These are just a few of the several different definitions of shift work that can be accessed from the scientific literature; such different descriptions may lead to an equivocal shift work exposure assessment, which makes studies in the field difficult to compare.

In this study, shift work is defined according to the UK Health and Safety criteria, as these are more comprehensive, not limiting shift work to a start and end time range only, but at the same time offering clear boundaries of what could be classified as shift work. The next sections describe the history of shift working before reporting on shift working in Europe, UK and more specifically within the NHS.

**1.4 A historical perspective of shift work**

It could be argued that shift work has to some extent always existed as an aspect of work organisation (e.g. military watchmen, soldiers), but the introduction of modern shift work...
can be traced to the industrial revolution (Harrington 2001). In the first decades of the 19th century, technology progressed extensively, and a surge in productivity demand was observed. This led to several industries adopting shift work, so that production could be maintained throughout 24 hours, seven days out of seven (Pati et al. 2001). This drive for increased productivity meant that employees' working hours had to be extended, so that it was common to observe working days of 10-16 hours.

Amongst the first efforts of improving employees' working conditions, emerges that of social reformer Robert Owen, who in early 19th century started advocating for “Eight hours labour, eight hours leisure and eight hours rest” (Owen 1825). He argued that allowing employees to have adequate rest and time off from work would not only lead to increased recreation – what we would nowadays refer to as work-life balance (Bambra et al. 2008) – but would also boost productivity and efficiency. His arguments were largely dismissed, as they were clashing with the practices and standards of the time (Clayton 1908).

However, in 1919, the International Labour Organisation (ILO) was established and its first Convention was entitled: “Limiting the Hours of Work in Industrial Undertakings to Eight in the Day and Forty-eight in the Week”. This convention clearly stated the necessity for industries to resort to 8-hour shifts and to put a cap on weekly hours; from then onwards, 48 hours was the maximum threshold (International Labour Organization 1919). Since then, the 8-hour shift requirement has been abolished; however, some elements of the ILO convention have been embedded in the European Working Time Directive in 2003 (The European Parliament and the Council of the European Union 2003). This directive requires EU countries to guarantee to all workers:

- a limit to weekly working hours, which must not exceed 48 hours on average, including any overtime
- a minimum daily rest period of 11 consecutive hours in every 24
- a rest break during working hours if the worker is on duty for longer than 6 hours
- a minimum weekly rest period of 24 uninterrupted hours for each 7-day period, in addition to the 11 hours' daily rest
- paid annual leave of at least 4 weeks per year
- extra protection for night work, specifying that:
  - average working hours must not exceed 8 hours per 24-hour period,
  - night workers must not perform heavy or dangerous work for longer than 8 hours in any 24-hour period
  - night workers have the right to free health assessments and, under certain circumstances, to transfer to day work (The European Parliament and the Council of the European Union 2003)
1.5 Shift work in Europe, the UK and the NHS

The proportion of staff undertaking shift work in Europe has increased from 17% to 21% in the past five years. Of these, 48% are on a rotating schedule. By sector, shift work is most common in health (41%), transport (33%), and commerce and hospitality (28% for both sectors). The survey reports that 19% of the EU workforce had worked at least one night shift and 32% had covered at least a 10 hours or more shift in the month prior to the survey (European Foundation for the Improvement of Living and Working Conditions 2016).

According to the Health Survey for England - 2013, England mirrors the European picture, with 18% of the British workforce being engaged in shift operations, constituting an increase from 2009 when the proportion of shift workers was 14% (The Health and Social Care Information Centre 2014).

For nurses, shift work is far more common. The Royal College of Nursing (RCN) surveyed 4845 RNs in 2009 and found that 60% of the NHS nursing workforce was engaged in shift work; of those, 65% worked rotating shifts, 27% worked fixed day shifts and 8% worked permanent night shifts. Permanent night shifts were more prevalent among bank and agency nurses2 (Ball and Pike 2009).

The higher proportion of nursing staff working shifts in the NHS, compared to the national average (60% vs 18%) is not surprising, since a vast number of nursing activities are structured around 24 h operations. After having defined shift work and having scoped the breadth of its usage in different contexts, next section explores the complexity of organising shift work.

1.6 Shift work as a complex component of work organisation

Shift work is often conceptualised as a dichotomous variable (i.e. employees working shifts vs employees not working shifts), but in reality it is characterised by several different components. These different components and their interactions have influence on job performance outcomes. The implementation of different shift systems within an organisation can be due to managerial decisions, to the organisations’ policies or to the requirements and demands of the job. An organisation may have adopted a policy that allows the employees to self-schedule or to resort to flexible working.

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2 Bank nurses are those who sign up to work additional hours at their Trust. Bank shifts are worked on a voluntary basis and nurses can sign up for bank shifts in advance. Agency nurses are staff who are supplied to a Trust by a private agency and who are not part of a Trust bank
Overall, when employers organise and plan shift work in the UK, they are currently required to comply with general duties under the Health and Safety at Work (Health and Safety Executive 2003) and the European work time directive (The European Parliament and the Council of the European Union 2003). Some professions are allowed to opt-out of the 48-hours week (European Foundation for the Improvement of Living and Working Conditions 2015). Some professions, such as aviators and railway workers may have some further legislation in place regarding working time arrangements.

There are several factors that employers need to consider when organising shift patterns for their workforce. Firstly, shift work can be organized around fixed or rotating patterns. If fixed, the employee works morning, evenings or nights on a continuing basis. If rotating, the employee may alternate between morning, evening and night shifts, or they may rotate between evening and nights because the day shift is an exclusive fixed arrangement for some workers (Perrucci et al. 2007).

In addition, speed of rotation is a further element that must be considered: a schedule is defined as fast rotating when employees work up to five consecutive shift types (i.e. three early shifts, followed by two night shifts). A slow rotation involves more than five consecutive shifts at the same timing of the day (i.e. six late shifts, followed by six night shifts) (Knauth 1993). There are contrasting results reported on the efficacy and safety of fast rotating and slow rotating schedules. There is evidence that fast rotating schedules do not allow the employee to adapt; this suggests that, while performance on night shifts may be disrupted, the employee is likely to resynchronise with natural circadian rhythms quickly (Iskra-Golec et al. 2017). Nurses in the UK mainly work on fast rotating systems. Slow rotating systems are not common and frequently implemented in England; therefore, this aspect of shift rotation will not be further investigated in this doctoral research.

Furthermore, the direction of rotation is a key factor in determining job performance outcomes. Evidence indicate that forwards rotating shift patterns, also referred to as clockwise rotating shifts, are preferable to backwards rotating shift patterns because they follow natural circadian rhythms (Ryan et al. 2008).

The number of hours on duty (i.e. shift length) is a further variable characteristic of shift work. Shifts are usually eight or 12 hours in duration, but sometimes can stretch to 24 hours. Three 8-hour or two 12-hour shifts in 24 hours are common in nursing, and they are often referred to as, respectively, a three-shift system and a two-shift system. Working a 24-hour shift is common in firefighting and in medicine. However, schedules in occupational sectors like medicine and firefighting are designed to make expertise available to respond to intermittent demand, rather than continuous work. Common shift systems in other settings such as police are rotating shifts with lengths varying between eight and 12 hours (International Labour Office 2004).
Chapter 1

Depending on how long shifts are, the number and position of rest days and opportunities are going to differ between shift systems. If staff work the compressed working week (i.e. an alternative work schedule in which the hours worked per day are increased, whilst the days worked are decreased in order to work the standard number of weekly hours in less than five days) they usually work three 12-hour shifts followed by three to four consecutive days off. Conversely, if employees are assigned to 8-hour shifts schedules, they normally will have one or two consecutive days off (Bambra et al. 2008).

The effect of shift characteristics on employees’ job performance are explored in Chapter 2, which is the literature review that informed the development of the research questions.

Before moving to the literature review, the main outcomes of this doctoral research – sickness absence and missed/delayed vital signs observations - are introduced in section 1.7.

1.7 Job performance

A short and concise definition of job performance refers to the measure of how well someone performs given tasks at their place of work (MeSH 2016). There is an extensive body of literature on job performance within organisational/industrial psychology, which is the field where the job performance construct was first theorised. In the literature, several conceptual frameworks of job performance have been reported (Koopmans et al. 2011). The main feature that embraces the job performance construct is an observable behaviour/action that an employee is expected to perform.

1.7.1 Job performance: sickness absence

Sickness absence refers to any day of absence from work that is attributed to sickness by the employee and accepted as such by the employer (Whitaker 2001). From an employee point of view, sickness absence has been found to have negative consequences for health, such as higher likelihood of experiencing long term absence spells (i.e. seven or more days of sickness absence) (Vahtera et al. 2004). Sickness absence can accurately capture employees’ wellbeing in terms of physical and social functioning (Kivimaki et al. 2003).

A recent report undertaken by NHS Employers highlighted that “mental health issues” such as stress, fatigue and burnout were in the top three most reported reasons for sickness absence in several trusts, outnumbering by far musculoskeletal diseases (NHS Employers 2014). This reverses the trend of healthcare professionals traditionally reporting a higher percentage of musculoskeletal diseases than mental health issues as a
reason for absence. Furthermore, this suggests that sickness absence is more likely to reflect employees' wellbeing rather than health status. Among the predictors of sickness absence in the NHS, there are the nature of the work, high workload and high work demand (e.g. long hours), lack of control over work, and poor support from managers (Michie and Williams 2003).

From an organisational psychology perspective, sickness absence is regarded as an employee behaviour and an attribute of job performance, prompted by low psychological wellbeing, which is characterised by health impairments, stress, job dissatisfaction and low motivation (Michie and West 2004). There is evidence that employees may be absent because they want to avoid challenging work environments (Schaufeli et al. 2009). Furthermore, there are reports of absenteeism being adopted as a coping mechanism to deal with stressful job demands and not merely as a reaction to job dissatisfaction (Kristensen 1991). Conceptualising sickness absence as an aspect of job performance applies to nursing: a fundamental requirement of being a registered nurse or health care assistant working on hospital wards is to be present during the scheduled shifts. Missing a scheduled shift will, therefore, have an impact on job performance.

Whilst different conceptualisations of absence were found within the organisational psychology literature, their common feature is the notion of sickness absence being an employee behaviour and an attribute of job performance. This brings sickness absence in the domain of job performance, which was defined as a series of visible behaviours and actions that an employee is expected to perform.

From a research standpoint, data on absence constitute a reliable and cost-effective indicator of employees' wellbeing and performance, since they are often collected routinely by workplaces; this minimises potential recall and response biases attributable to self-reported indicators of health and it reduces costs of data collection.

1.7.2 Job performance: delayed and missed vital signs observations

The direct study of shift systems' performance is challenging (Folkard and Tucker 2003). Several studies in healthcare attempted to measure the impact of shift work organisation on employees' performance, however, most of these suffered from lack of objective in-shift measures of performance.

Where studies have used in-shift indicators of performance, these data were self-reported (Gander et al. 2000; Rogers et al. 2004), or reported by researchers who were observing employees (Landrigan et al. 2004). This section aims to describe delayed/missed vital
signs observations as outcomes that could provide a valid measure of in-shift job performance in healthcare.

Nurses are required to perform many actions during a shift, but they are likely to miss some care tasks. Data from a cross-sectional study of 33,659 nurses highlighted that nurses reported leaving on average 3.6 care tasks undone during their most recent shift. The authors observed a high degree of variation in care left undone between countries, with nurses working in England reporting a slightly higher average of care left undone than the European one (Ausserhofer et al. 2014). Furthermore, 35% of the nurses in England reported leaving patient surveillance activities undone during their last shift (Ball et al. 2014). Missed care – and missed surveillance specifically – has been described as a mechanism that explains the often observed relationship between increased workload and patient outcomes such as mortality (Ball et al. 2017a).

One missed nursing care task that has been consistently associated with adverse outcomes, including mortality, is the failure to perform and record vital signs observations. The need to identify and respond to clinical and physiological patient deterioration is now internationally recognised as pivotal in order to provide high quality and safe care (Cardona-Morrell et al. 2016), as vital signs have shown to be accurate predictors of clinical deterioration (Churpek et al. 2016). Hospitalised patients suffering from adverse events such as cardiac arrest and unanticipated ICU admission often exhibit physiological deterioration before the events (Smith et al. 2006; Smith et al. 2013); abnormalities of pulse rate, blood pressure, temperature, occur before 79% of in-hospital cardiac arrests and in 54% of in-hospital deaths and emergency ICU admissions (Kause et al. 2004).

Vital signs monitoring activities are mainly performed by registered nurses and healthcare assistants; they play a crucial role in detecting a deteriorating clinical situation, and the actions that follow may have an immediate impact on patient outcomes (Yeung et al. 2012). Missing signs of deterioration can result in a failure to rescue patients from subsequent poorer outcomes (Osborne et al. 2015).

In addition, NICE enlisted ‘patient vital signs not assessed or recorded as outlined in the care plan’ as one of the nursing red flags (National Institute for Health and Clinical Excellence 2014); these are events that, if they occur, should prompt an immediate escalation response by the registered nurse in charge.

The monitoring and recording of vital signs has sometimes proved to be either not regarded as important by nurses (Mok et al. 2015) or to be inadequately documented (Watson et al. 2014; Mok et al. 2015; Odell 2015; Cardona-Morrell et al. 2016). However, if nurses fail to monitor patients closely and do not record their vital signs, there may be delays in detection and treatment of serious complications, therefore resulting in adverse
outcomes. This suggests that missed vital signs observations are a useful indicator of job performance, specifically of task performance (Michie and West 2004) and a potential risk factor for lapses in patient safety.

1.8 Chapter summary

This chapter introduced the background to this thesis, by identifying the challenge of organising shift work so that employees' performance is maintained. Furthermore, this chapter highlighted how shift work stands as a complex component of the work organisation, being composed of several variables, including length of the shift, whether shift work includes rotation, and rest opportunities that employees can benefit from. The outcomes of this thesis were introduced in this chapter: these are sickness absence and delayed/missed vital signs observations. This doctoral research sets out to measure the association between shift work undertaken by nursing staff and their job performance. The next chapter explores and summarises the literature around the effect of shift work patterns and outcomes of employees' job performance.
Chapter 2  A literature review of the effect of shift work on employees’ performance

2.1 Introduction

In this chapter, the evidence around shift work and employees’ performance is explored in depth within different work contexts. The process of accessing, summarising and appraising the evidence is reported in this chapter. Gaps in the literature were identified and these informed the development of the research questions.

As described in section 1.3, shift work refers to a work activity scheduled outside standard daytime hours; a pattern of work where one employee replaces another on the same job within a 24 hour period (Health and Safety Executive 2006). Shift work can be organised in different ways, depending on how several components are set, including shift length, rest breaks and rotation status (Folkard et al. 2007), which may consequently lead to a different impact on employees’ job performance.

The variability in the organisation of shift work in nursing specifically has been described in large European studies, including the RN4CAST (Griffiths et al. 2014) and NEXT (Estryn-Behar et al. 2012) studies. A limited number of literature reviews aimed to study the effect of different shift work characteristics on employees’ outcomes of job performance.

Wagstaff and Sigstad Lie (2011) reviewed 14 studies in search for evidence of a relationship between safety and shift work (i.e. long working hours and night work). They concluded that shifts longer than 8 hours led to an increased risk of accidents, while fixed night work could be a strategy to improve safety, due to its resynchronising effect (Wagstaff and Sigstad Lie 2011).

Merkus and colleagues’ systematic review examined the effect of shift work on sickness absence within different populations. This synthesis of 24 studies suggested there is evidence of the association between evening work in female healthcare professionals and sick leave, while the link with rotating shifts, fixed night work, and 8-hour and 12-hour shifts could not be established (Merkus et al. 2012). As regards outcomes of employees’ job satisfaction and burnout, a recent integrative review of 37 studies found no evidence of an association of shift work and nurses’ psychological well-being (Tahghighi et al. 2017).
Further reviews considered the effect of single shift characteristics on adverse outcomes, including the effect of 12-hour shifts on patient outcomes such as quality of care and risk of making errors (Bae and Fabry 2014; Clendon and Gibbons 2015; Harris et al. 2015), job satisfaction (Estabrooks et al. 2009) and the association of extended hours and fatigue (Smith et al. 1998; Harrington 2001).

Baltet and colleagues performed a meta-analysis of the effects of the compressed working week on job performance, job satisfaction and absenteeism (Baltes et al. 1999). They found that working on a compressed workweek (CWW) schedule improved job satisfaction, but did not affect absenteeism (Baltes et al. 1999). A more recent systematic review by Bambra and colleagues concluded that working the compressed workweek had a low risk to impact negatively organisational outcomes of job performance, while it could improve work-life balance (Bambra et al. 2008).

These reviews have largely contributed to expand the evidence on individual components of shift work, however, up to date no synthesis of all these shift characteristics has been produced. Therefore, the aim of this review is to identify evidence for the characteristics of shift work that have an effect on employees’ performance. This review draws on literature from all sectors. A version of this review of the literature has been published in May 2016 in the International Journal of Nursing Studies (Dall'Ora et al. 2016) and it is attached as an appendix (see Appendix D).

### 2.2 Literature review design

A scoping review is a useful technique to map the key concepts underpinning a research area and the main sources and types of evidence available, especially where an area is complex or has not been reviewed comprehensively yet (Arksey and O'Malley 2005).

Because the review question is broad, and it is likely that several different study designs may be applicable, a scoping review was undertaken. To supplement the scoping review and help inform the design of this research study, a critical review of the quality of previous research was undertaken.

### 2.3 Literature review search strategy

The following databases were searched: Medline (Ovid), CINAHL Plus with Full Text (EBSCOhost), PsycINFO (EBSCOhost) and Scopus using the following terms (title, abstract, key words): “shift work”, “work schedule”, “shift pattern” “shift length”, “shift or schedule”, “safety”, “error”, “satisfaction”, burnout”, “quality”, “performance”, “efficiency”,

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“stress”, “sickness absence”. Related index terms were also searched (see Appendix E for the complete search strategy).

The main literature search was performed between January 2015 and January 2016 and was then updated in December 2017. Several occupational sectors beyond healthcare involve shift work; therefore, to achieve a comprehensive understanding of the topic, this review encompassed occupational contexts beyond healthcare.

The outcome measures of interest in this review are indicators of employee’s performance.

Studies published in the English language were included provided that they met all the following criteria:

- participants aged >18
- participants are or have been working shifts or serve as control group for others working shifts
- the study is a primary study with quantitative design
- the study explores the association of characteristics of shift work and at least one outcome of employee performance

Reviews, editorials, notes, letters, and case reports were not included. No limits were put on the date of included studies, in order to ensure that the review of research was as comprehensive as possible.

For every study included in the review, the following information was extracted and recorded in Excel:

- author(s)
- year of publication
- design of the study
- sample size
- participants’ occupational setting
- studied shift characteristic(s)
- outcome(s) and how it was measured
- results

Meaningful parameters indicating the size of effect were extracted; where these were not available, only statistical significance is reported (with exact p value if given).
2.4 Results

Overall, 24,013 records were retrieved from the database searches. After a rapid deduplication performed with the reference management software (i.e. EndNote X7), the titles and abstracts were screened. This led to rapidly exclude 23,696 studies, while 317 papers were identified as potentially relevant, (i.e. directly addressing the effect of shift work on one or more relevant outcomes) and the full text was accessed.

References of the 317 papers were checked to identify any additional articles: this resulted in the addition of three further papers. After reading the full text of the 320 records, 266 papers were excluded, due to lack of explicit methodology. One was excluded due to an unclear categorisation of work hours (the correspondent author was contacted to ask information but never replied) and 53 papers were included in the final review. Figure 2.1 reports the flow chart of the study selection.

Figure 2.1 Study selection flowchart
The 53 studies were published between 1988 and 2017. The majority of the studies (n = 38) were published in the last decade, with 15 published more than one decade ago. Most of the studies were conducted in the United States/Canada region (n=28), nine in Northern Europe, six in Central/Southern Europe, five in Asia, three in the United Kingdom, and two in Australia.

The majority of the studies related to the healthcare sector (n=35), predominantly in nursing (n=27); other industries were chemical/electrical (n=5), police (n=3), mining (n=1), transport (n=2), automotive (n=1), manufacturing (n=1) and five studies covered multiple occupational contexts.

The majority of the studies had a cross-sectional design (n=38), while four were experimental. Two studies were case control in design, two were before and after, one was retrospective observational, five were longitudinal and one was descriptive exploratory. The studies’ sample size ranged from 12 to 31,627.

The studies explored a variety of shift-work characteristics, including shift length, weekly hours and compressed working week, overtime working, night work and fixed/rotating shifts, rest and break opportunity as organisational characteristics of shift work that have an impact on employee performance.

Results are reported by shift work characteristics and their association with the selected outcomes, namely: job performance, productivity, safety, quality of care delivered, errors, adverse events and client satisfaction, burnout, job satisfaction, sickness absence, intention to leave the job. All studies are summarised in evidence tables. For each shift work characteristic an evidence table was created.

### 2.4.1 Shift length

Overall, nineteen studies regarding the association of shift length and outcomes of interest were found. The shift work studies are summarised in Table 2.1.
Table 2.1 Summary of studies analysing the association between shift length and employee performance

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Design</th>
<th>Participants and setting</th>
<th>Shift factor</th>
<th>Outcome (measurement)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Baker et al. 1994)</td>
<td>Retrospective Observational</td>
<td>104 nuclear power workers, USA</td>
<td>Shift length (8 vs 12 hours)</td>
<td>Number of Operator Errors (cause-coded Licensee Event Reports)</td>
<td>Working 12-hour shifts is correlated with operator error (p&lt; 0.05)</td>
</tr>
</tbody>
</table>
| (Barker and Nussbaum 2011) | Cross-sectional | 745 nurses, USA | Shift length (8 vs 9-12 hours) | a) Physical fatigue (Fatigue-Related Symptoms Questionnaire (F-RSQ))
                b) Acute fatigue, (Occupational Fatigue Exhaustion Recovery (OFER)) | a) Higher levels of physical fatigue for nurses working 9-12 hour shifts (p< 0.001)
b) Higher levels of acute fatigue for nurses working 9-12 hour shifts (p< 0.001) |
| (Dall’Ora et al. 2015) | Cross-sectional | 31,627 nurses, Europe | Shift length (≤8; 8.1-10; 10.1 – 11.9; ≥12 hours) | a) Job satisfaction (RN4CAST nurse survey)
                b) Satisfaction with work schedule flexibility (RN4CAST nurse survey)
                c) Burnout (Maslach Burnout Inventory (MBI), consisting of 3 subscales: high scores on emotional exhaustion (EE) and depersonalisation (DEP); low scores on personal accomplishment (PA))
                d) Intention to leave the job (RN4CAST nurse survey) | a) All shifts longer than 8 hours were associated with increases in job dissatisfaction. The highest odds were found for nurses working ≥12 hour shifts (OR= 1.40; 95% CI: 1.20-1.62)
b) ≥12 hour shifts were associated with increased dissatisfaction with work schedule flexibility (OR= 1.15; 95% CI: 1.00-1.35)
c) ≥12 hour shifts were associated with higher levels of burnout (for EE: OR= 1.26; 95% CI: 1.09-1.46; DEP: OR= 1.21; 95% CI: 1.01-1.47; PA: OR= 1.39; 95% CI: 1.20-1.62)
d) ≥12 hour shifts were associated with increased intention to leave the job (OR= 1.29; 95% CI: 1.12-1.48) |
<table>
<thead>
<tr>
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</tr>
</thead>
</table>
| (Dwyer et al. 2007) | Descriptive exploratory study (Evaluation 3 months after intervention was introduced) | 12 nurses (in 3 groups: nurses choosing to work 12 hour shifts, nurses working 8 hour shifts and nurse managers), Australia | Shift length (introduction of 12 hour shifts) | a) Nurses’ belief on delivered quality of care (study questionnaire)  
b) Nurses’ preference (study questionnaire) | a) Six nurses (50%) expressed no change; six nurses (50%) agreed or strongly agreed it had improved  
b) 92% of nurses agreed or strongly agreed that they were more satisfied with the 12 hour roster |
| (Duchon et al. 1994) | Before and After Study (Evaluation 10 months after intervention was introduced) | 41 miners, Canada | Shift length (introduction of 12 hour shifts replacing 8 hour shifts) | a) Job performance (Behavioural Performance Battery)  
b) Satisfaction with schedule (Shiftwork Survey questionnaire) | a) No significant differences  
b) 80% of the sample reported preferring 12 hour shifts to 8 hour shifts |
| (Estryn-Behar et al. 2012) | Cross-sectional | 25,924 nurses, Europe | Shift length (8 vs 12 hours) | Burnout (Copenhagen Burnout Inventory) | Working 12 hour shifts is associated with higher burnout scores (OR= 1.34; 95% CI: 1.00-1.78) |
| (Griffiths et al. 2014) | Cross-sectional | 31,627 nurses, Europe | Shift length (≤8; 8.1-10; 10.1 – 11.9; ≥12 hours) | a) Nurse reported quality of care (RN4CAST nurse survey)  
b) Nurse reported patient safety (RN4CAST nurse survey)  
c) Rates of care left undone (RN4CAST nurse survey) | a) 12 hour shifts were associated with poor quality of care reports (OR= 1.30; 95% CI: 1.10–1.53)  
b) 12 hour shifts were associated with poor patient safety reports (OR= 1.41; 95% CI: 1.13–1.76)  
c) All shifts >8 hours were associated with statistically significant increases in the rate of care left undone (p< 05). 12 hour shifts had the highest rate ratio for care left undone |
<table>
<thead>
<tr>
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<th>Results</th>
</tr>
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<tbody>
<tr>
<td>(Guyette et al. 2013)</td>
<td>Cross-sectional</td>
<td>34 air medical providers, USA</td>
<td>Shift length (12 vs 24 hours)</td>
<td>Cognitive performance (Paced Auditory Serial Addition Test (PASAT), University of Southern California Repeatable Episodic Memory Test (USC-REMT), TrailMaking Test (TMT), and the Stroop Color and Color–Word Tests at the end of shift)</td>
<td>undone (RR= 1.13; 95% CI: 1.16–1.19)</td>
</tr>
</tbody>
</table>
| (Mitchell and Williamson 2000) | Case control study      | 27 Electrical workers, Australia | Shift length (8 vs 12 hours) | a) Job performance (Processing and Performance Test System) 
   b) Preference (Standard Shiftwork Index (SSI)) | a) 30% increase in mean number of errors made after a 12-hour day shift, compared to an eight-hour day shift; 50% increase in mean number of errors made after a 12-hour night shift, compared to an eight-hour night shift (p< 0.02) 
   b) 12 hour shifts were preferred by the majority of workers (no percentages or mean differences reported)                                                                 |
| (Rogers et al. 2004) | Cross-sectional study   | 393 nurses, USA          | Shift length | Medication error rates (self-reported on study logbooks)                               | Working ≥12.5 hours was associated with making a medication error (OR= 3.29, p< 0.001)                                                                                                     |
| (Scott et al. 2006) | Descriptive exploratory study, cross-sectional | 502 nurses, USA          | Shift length (8 vs 12 hours) | a) Subjective alertness (self-reported on study logbooks) 
   b) Error rates (self-reported on study logbooks) | a) Working ≥ 12.5 hours was associated with struggling to stay awake (OR= 1.5, p= 0.007) 
   b) The risk for making an error almost doubled when nurses worked ≥ 12.5 hours (OR= 1.94, p= 0.03)                                                                                      |
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<tbody>
<tr>
<td>(Stimpfel and Aiken 2013)</td>
<td>Cross-sectional study</td>
<td>22,275 nurses, USA</td>
<td>Shift length (8-9, 12, &gt;13 hours)</td>
<td>a) Reported quality of nursing care (Multi-State Nursing Care and Patient Safety Study (nurse survey))&lt;br&gt;b) Reported hospital patient safety (nurse survey)</td>
<td>a) All shifts longer than 9 hours were associated with poor quality of care (highest ORs for &gt;13 hours: OR= 2.43; 95% CI: 2.04-2.89)&lt;br&gt;b) All shifts longer than 9 hours were associated with poor hospital patient safety grade (highest ORs for &gt;13 hours: OR= 2.25; 95% CI: 1.89-2.68)</td>
</tr>
<tr>
<td>(Stimpfel et al. 2013)</td>
<td>Cross-sectional study</td>
<td>3,710 nurses, USA</td>
<td>Shift length (8, 12, &gt;13 hours)</td>
<td>a) Reported quality of care (nurse survey)&lt;br&gt;b) Reported hospital patient safety (nurse survey)&lt;br&gt;c) Intention to leave (nurse survey)&lt;br&gt;d) Burnout (MBI)&lt;br&gt;e) Job dissatisfaction (nurse survey)</td>
<td>a) &gt;13 hour shifts are associated with poorer quality of care (OR= 2.76; 95% CI: 1.63-4.70)&lt;br&gt;b) &gt;13 hour shifts are associated with poorer patient safety (OR= 3.14; 95% CI: 2.1-4.68)&lt;br&gt;c) &gt;13 hour shifts are associated with higher likelihood of intending to leave job (OR= 2.70; 95% CI: 1.58-4.61)&lt;br&gt;d) &gt;13 hour shifts are associated with higher likelihood of reporting burnout (OR= 2.73; 95% CI: 1.86-2.40)&lt;br&gt;e) &gt;13 hour shifts are associated with greater likelihood of reporting job dissatisfaction (OR= 1.22; 95% CI: 1.32-1.39)</td>
</tr>
<tr>
<td>(Stimpfel et al. 2012)</td>
<td>Cross-sectional study</td>
<td>22,275 nurses, USA</td>
<td>Shift length (8-9, 12, &gt;13 hours)</td>
<td>a) Job satisfaction (nurse survey)&lt;br&gt;b) Burnout (MBI)&lt;br&gt;c) Intention to leave the job (nurse survey)</td>
<td>a) The longer the shift, the lowest was job satisfaction (highest odds for &gt;13 hours OR= 2.38; 95% CI: 2.24-2.79)</td>
</tr>
<tr>
<td>Author, Year</td>
<td>Design</td>
<td>Participants and setting</td>
<td>Shift factor</td>
<td>Outcome (measurement)</td>
<td>Results</td>
</tr>
<tr>
<td>-------------</td>
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<td>b) The longer the shift, the highest level of burnout (highest odds for &gt;13 hours OR= 2.70; 95% CI: 2.32-3.15) c) The longer the shift, the higher the intention to leave the job (highest odds for &gt; 13 hours OR= 2.57; 95% CI: 2.10-3.15)</td>
</tr>
<tr>
<td>(Stone et al. 2006)</td>
<td>Cross-sectional study</td>
<td>805 nurses, USA</td>
<td>Shift length (8 vs 12 hours)</td>
<td>a) Job satisfaction (study survey) b) Burnout (MBI) c) Absenteeism (Administrative data) d) Perceived quality of care (study survey)</td>
<td>a) Nurses working 12 hours were on average more satisfied with their job (p= 0.025) b) Working 12 hours was associated with a reduction of 5.9 points on the emotional exhaustion scale (p&lt; 0.001) c) Working 12 hour shifts was associated with fewer missed shifts (OR= 0.42; 95% CI: 0.29-0.60) d) No significant difference (OR= 1.35; 95% CI: 0.79-2.29)</td>
</tr>
<tr>
<td>(Todd et al. 1993)</td>
<td>Before and after study (Evaluation 6 months after intervention was introduced)</td>
<td>320 nurses, UK</td>
<td>Shift length (introduction of 12 hour shifts)</td>
<td>Job satisfaction (study questionnaire)</td>
<td>Nurses were more dissatisfied with their job under the 12 hour shift system (p ≤ 0001)</td>
</tr>
<tr>
<td>(Tucker et al. 1996)</td>
<td>Cross-sectional study</td>
<td>162 chemical workers, UK</td>
<td>Shift length (8 vs 12 hours)</td>
<td>a) Wellbeing (i.e. fatigue) (SSI) b) Alertness (SSI)</td>
<td>a) No significant difference b) No significant difference</td>
</tr>
<tr>
<td>Author, Year</td>
<td>Design</td>
<td>Participants and setting</td>
<td>Shift factor</td>
<td>Outcome (measurement)</td>
<td>Results</td>
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<tr>
<td>(Virtanen et al. 2009)</td>
<td>Cross-sectional study</td>
<td>1159 healthcare workers, Northern Europe</td>
<td>Shift length (≤8.45 vs &gt;8.45 hours)</td>
<td>Risk of hospital-associated infection (derived by medical records)</td>
<td>A mean level-ward shift length of &gt;8 hours and 45 minutes per day was associated with higher risk of infection (OR= 2.74; 95% CI: 1.07-7.04)</td>
</tr>
<tr>
<td>(Weaver et al. 2015)</td>
<td>Cross-sectional study</td>
<td>4382 healthcare employees, USA</td>
<td>Shift length (8, 12, 16 and 24 hours)</td>
<td>Work-related injury or illness (recorded on the agency form)</td>
<td>≥12 h shifts increased the risk of occupational injury or illness by 49% (RR= 1.49; 95% CI 1.18-1.88), compared to 8 h shifts. For every additional hour of shift length, the risk of injury or illness increased by 4% (RR= 1.04; 95% CI: 1.02-1.06)</td>
</tr>
</tbody>
</table>
Several studies exploring the effect of shift length on job performance within all occupational sectors focussed on the comparison between 8 and 12 hour shifts. None of the studies found an improvement in job performance after the introduction of 12-hour shifts or when employees work 12-hour shifts, compared to those working 8-hour shifts.

A single before and after study found no statistically significant impact on job performance measured with the Behavioural Performance Battery, following the introduction of 12-hour shifts among 41 underground miners in Canada (mean differences not reported) (Duchon et al. 1994). A study from the USA aimed to identify changes in cognitive performance due to different shift lengths working either 12 or 24-hours shifts. This cross-sectional study was carried out within 34 air medical providers and the results indicated no difference (mean differences not reported) in cognitive performance; however, air medical providers working 24-hour shifts were able to sleep on average 6.8 hours during the shift, whereas those working 12-hour shifts slept on average 1 hour on shift (Guyette et al. 2013).

A cross-sectional study carried out with 745 nurses from different nursing organisations found a link between shift length and fatigue, and between fatigue and job performance. Nurses' shifts of 9-12 hours were associated with higher levels of physical fatigue ($p<0.001$), and higher levels of acute fatigue ($p<0.001$), and fatigue levels were negatively correlated with performance (Barker and Nussbaum 2011).

Two studies aimed specifically to evaluate the association between shift length and alertness, vigilance and fatigue. One reported no significant change (Tucker et al. 1996), whilst the other found a reduction in alertness when employees were working 12-hour shifts (Scott et al. 2006). A cross-sectional study of 162 chemical workers, reported that when employees worked 12-hour shifts, their fatigue and mean alertness levels did not differ significantly from employees working 8-hour shifts (Tucker et al. 1996).

Scott and colleagues performed a cross-sectional study on 502 critical care nurses, recruited randomly from the American Association of Critical Care Nurses, in order to explore whether long hours affect nurses’ vigilance. Nurses who worked more than 12.5 hours were more likely to struggle to stay awake at work ($OR=1.5, p=0.007$), and were twice as likely to report risking to make an error ($OR=1.94, p=0.03$) compared to those who worked 8-hour shifts (Scott et al. 2006).

The evidence regarding the association of shift length and safety and errors/adverse events is consistent as regards the detrimental effect that long shifts have. 104 employees working either 8 or 12-hour shifts at different nuclear power plants were included in a retrospective observational study, and were tested for several safety outcome measures:
no difference was found in safety system failures, but a significant increase in operator error was reported \( (p < 0.05) \) (Baker et al. 1994).

Similarly, a study in an electrical plant reported an increase in the mean number of errors on a standardised test following the introduction of 12-hour shifts. Authors reported a 30% increase in errors made after a 12-hour day shift, compared to an 8-hour day shift and a 50% increase after a 12-hour night shift, compared to an 8-hour night shift \( (p < 0.02) \). A possible explanation provided for the increased error rate was an increase in fatigue experienced by the employee at the end of the working day (Mitchell and Williamson 2000).

A study performed in the healthcare sector, comprising 1092 patient records and 1159 staff, reported a similar association: a mean ward-level working hours of more than 8 hours and 45 minutes was associated with nearly three times higher infection risk, compared to a mean ward-level working of \( \leq 8 \) hours and 45 minutes \( \text{OR} = 2.74; 95\% \text{ CI: 1.07-7.04} \) (Virtanen et al. 2009). Lastly, when 393 nurses from a single hospital, sampled for a cross-sectional study, worked 12.5 hours or more, they were more likely to report making a medication error, when compared to their peers working 8-hour shifts \( \text{OR} = 3.29, p = 0.001 \) (Rogers et al. 2004).

As far as quality of care is concerned, contrasting results were derived from four nursing studies. A single small descriptive exploratory study sought to evaluate the nurses’ perceptions in a hospital unit after the introduction of 12-hour shifts. Twelve nurses agreed to participate in the study, six of which expressed no perceived change in the quality of nursing care they provided, while six nurses agreed or strongly agreed it had improved (Dwyer et al. 2007). However, the questionnaire to evaluate 12-hour shifts was distributed at a single point in time, just three months after the new shift pattern had been implemented, and the small sample size prevents any generalizability.

A further cross-sectional study of 805 nurses from 13 hospitals found no difference in nurse reported quality of care for nurses working 8 and 12-hour shifts \( \text{OR} = 1.35; 95\% \text{ CI: 0.79-2.29} \) (Stone et al. 2006). By contrast, a study performed in 12 European countries on a large sample of hospital nurses \( n = 31,627 \) concluded that 12-hour shifts are detrimental for quality of care, patient safety and missed care, as reported by nurses. A full report of ORs and 95% CIs for these associations is available at Table 2.1; however, the odds of nurses working 12 or more hours and reporting adverse patient outcomes were increased in a range of 30-41%, in comparison with nurses working 8 hours or less (Griffiths et al. 2014).

Three large studies from the US (sample size ranging from 3,710 to 22,275 nurses), performed in different hospitals and settings, explored the association between long shifts...
Chapter 2

and quality of care, patient safety and patient dissatisfaction. They concluded that all these outcomes were negatively affected when nurses worked shifts of 13 hours or longer (ORs and 95% CIs are available at Table 2.1) (Stimpfel et al. 2012; Stimpfel and Aiken 2013; Stimpfel et al. 2013).

The evidence regarding the impact of length of shifts on employee outcomes, including job satisfaction, burnout, and intention to leave the job, satisfaction with schedule, work-related illness and employee morale is mixed.

Working 12 or 8-hour shifts did not appear to influence 162 chemical plant employees’ psychological wellbeing, in terms of job satisfaction and attitudes towards shift work (Tucker et al. 1996). Studies of small samples of workers (sample size ranging from 12 to 41) testing the impact of the introduction of 12-hour shifts on employees’ satisfaction with schedule concluded that staff largely prefer longer shifts and wanted to retain them (Duchon et al. 1994; Tucker et al. 1996; Mitchell and Williamson 2000; Dwyer et al. 2007).

However, a similar study with 162 nurses reported the opposite result, namely, after the introduction of 12-hour shifts, nurses were more dissatisfied with their job (p< 0.0001) (Todd et al. 1993). A further cross-sectional study of 805 nurses from 13 hospitals, comparing job satisfaction and burnout among nurses working 8 or 12-hour shifts, reported that those working 12-hour shifts were more likely to be satisfied with their job (p= 0.025) and to experience less burnout, with a reduction of 5.9 points on the emotional exhaustion scale (p< 0.001) (Stone et al. 2006). However, a large-scale study from Europe (n = 25,924 nurses) indicated that working 12-hour shifts was associated with higher burnout scores (OR= 1.34; 95% CI: 1.00-1.78), in comparison with working 8 hours or less (Estryn-Behar et al. 2012).

Two large cross-sectional studies (sample size respectively 22,275 nurses and 3,710 nurses) from the US indicated that when nurses are working 13-hour shifts or longer, the odds for them reporting job dissatisfaction and burnout were higher than for those working 8 hours, with ORs ranging from 1.22 to 2.73 (full reports of ORs and 95% CIs are available in Table 2.1) (Stimpfel et al. 2012; Stimpfel et al. 2013).

A more recent cross-sectional study, comprising of a sample of 31,627 registered nurses from 12 European countries, concluded that working 12-hour shifts or longer is associated with increased reports of job dissatisfaction and intention to leave the job and higher burnout scores (i.e. higher scores on the Emotional Exhaustion and Depersonalisation subscales and lower scores on the Personal Accomplishment subscale of the Maslach Burnout Inventory). Additionally, all shifts longer than 8 hours were associated with job dissatisfaction, and a linear relationship was observed, so that the longer the shift, the
higher the level of dissatisfaction with the job (Dall'Ora et al. 2015). All the ORs and 95% CIs are reported in Table 2.1.

Four studies explored intention to leave with conflicting results. Stone and colleagues reported that long shifts did not affect intention to leave in a sample of 805 registered nurses. In contrast, three multi-country large cross-sectional studies (sample size ranging between 3,710 and 31,627 RNs), indicated that nurses were more likely to report intention to leave when they worked ≥ 12-hour shifts (Stimpfel et al. 2012; Stimpfel et al. 2013; Dall'Ora et al. 2015).

Stone and colleagues reported that nurses working 12-hour shifts were less likely to report missing shifts, compared to nurses working 8-hour shifts (OR = 0.42; 95% CI: 0.29-0.60) (Stone et al. 2006). An observational retrospective study of 4382 healthcare employees in the USA gained access to 3 years of shift schedules and occupational injury and illness reports from 14 large emergency services agencies. The analysis of these routinely collected data indicated that 12 hours or more shifts increased the risk of occupational injury or illness by 49% (RR = 1.49; 95% CI: 1.18-1.88), compared to 8-hour shifts. For every additional hour of shift length, the risk of injury or illness increased by 4% (RR = 1.14; 95% CI: 1.12-1.16) (Weaver et al. 2015).

In summary, there is insufficient evidence to conclusively say that 12-hour shifts are safe and lead to more productivity. Large multi-site healthcare studies report that working 12-hour shifts are associated with decreased quality of care, patient safety and increased rates of errors. Results are conflicting as regards employees' job satisfaction and wellbeing, with some small-scale studies reporting increased job satisfaction for employees working 12-hour shifts; these results are contrasted by larger studies, which conclude that 12-hour shifts are associated with higher rates of burnout, job dissatisfaction and intention to leave.

2.4.2 Weekly hours of work

Three recent cross-sectional studies regarding the effect of weekly hours of work and job performance were included. These studies were summarised in Table 2.2. Olds and colleagues' work aimed at examining the relationship between nurses' weekly work hours and self-reported adverse events and errors. Overall, 11,516 nurses from the US were included in the sample. The results indicate that the likelihood of observing or experiencing occasional or frequent (versus never or rare) adverse events such as patient falls with injury, nosocomial infections and medication errors was increased respectively by 17%, 14% and 28% when nurses worked 40 or more hours per week, compared to working less than 40 hours per week (Olds and Clarke 2010).
After fitting multiple regression models separated by sex of a large sample deriving from a health survey, comprising overall 7,103 workers, Artazcoz and colleagues concluded that in men, working 51-60 hours per week was associated with job dissatisfaction (aOR= 2.05; 95% CI: 1.49-2.82), in comparison with those working 30-40 hours per week (Artazcoz et al. 2009).

A study of 1524 nurses in Thailand sought to identify associations between weekly work hours and four nurse-reported safety outcomes. All weekly hours longer than 56 were associated with nurses reporting patient identification errors, nurses who worked 57-64 hours per week had the highest odds to report patient identification errors (OR= 1.76; 95%CI: 1.24-2.49). All weekly hours longer than 56 were associated with nurses reporting communication errors, with the highest odds for nurses working 65-72 hours (OR= 1.53; 95% CI: 1.04–2.23). Nurses working 65-72 hours per week were more likely to report patient complaints (OR= 2.33; 95% CI: 1.57-3.46). Nurses working 73-80 hours per week were more likely to report the development of a pressure ulcer in patients (OR= 1.77; 95% CI: 1.23-2.54) (Kunaviktikul et al. 2015).
Table 2.2 Summary of studies analysing the association between weekly hours of work and employee performance

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Design</th>
<th>Participants and setting</th>
<th>Shift factor</th>
<th>Outcome (measurement)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Artazcoz et al. 2009)</td>
<td>Cross-sectional</td>
<td>7103 workers, surveyed for the 2006 Catalanian Health Survey, Central Europe</td>
<td>Weekly hours of work (20-40 hours vs 51-60 hours)</td>
<td>Job dissatisfaction (study survey)</td>
<td>For men, working 51-60 was associated with job dissatisfaction (OR= 2.05; 95% CI: 1.49-2.82)</td>
</tr>
</tbody>
</table>
| (Kunaviktikul et al. 2015) | Cross-sectional study | 1524 nurses, Asia | Weekly hours (≤48 hours; 49-56; 57-64; 65-72; 73-80 hours per week) | a) Patient identification errors  
b) Communication error  
c) Patient complaints  
d) Development of a pressure ulcer  
All outcomes are nurse reported | a) All weekly hours longer than 56 were associated with nurses reporting patient identification errors; nurses who worked 57-64 hours per week had the highest odds to report patient identification errors (OR= 1.76; 95%CI: 1.24-2.49)  
b) All weekly hours longer than 56 were associated with nurses reporting communication errors, with the highest odds for nurses working 65-72 hours (OR= 1.53; 95% CI: 1.04–2.23)  
c) Nurses working 65-72 hours per week were more likely to report patient complaints (OR= 2.33; 95% CI: 1.57-3.46)  
d) Nurses working 73-80 hours per week were more likely to report the development of a pressure ulcer (OR= 1.77; 95% CI: 1.23-2.54) |
| (Olds and Clarke 2010)     | Cross-sectional study | 11,516 nurses, USA | Weekly hours of work | a) Adverse events (nurse reported) (needle sticks, patient falls with injury, nosocomial infections) | When nurses worked >40 hours per week they were more likely to experience occasional or frequent: |
|                           |                  |                          |                                                   |                                               |                                                                                                                                          |
### Chapter 2

<table>
<thead>
<tr>
<th></th>
<th>a) Patient falls with injuries (OR= 1.17; 95% CI: 1.02-1.36)</th>
<th>Nosocomial infections (OR= 1.14; 95% CI: 1.02-1.28)</th>
</tr>
</thead>
<tbody>
<tr>
<td>b) Medication errors (nurse reported)</td>
<td>a) Patient falls with injuries (OR= 1.17; 95% CI: 1.02-1.36)</td>
<td>Nosocomial infections (OR= 1.14; 95% CI: 1.02-1.28)</td>
</tr>
<tr>
<td></td>
<td>b) Medication errors (OR= 1.28; 95% CI: 1.10-1.49)</td>
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In summary, there is limited evidence on the association of weekly hours and job performance; however, the reviewed studies concluded that more than 51 weekly hours of shift work might have a negative impact on employee’s performance and job satisfaction.

2.4.3 Compressed working week

The compressed working week is a type of work schedule in which the hours worked per day are extended, whilst the days worked are reduced, so that the standard number of weekly hours are worked in fewer days (Bambra et al. 2008). This shift organisation links together two features that have already been presented in this review: shift length and weekly hours.

Long shift lengths themselves might not lead to negative consequences, while detrimental outcomes might start to emerge only when long shifts are worked and weekly hours are increased. The vast majority of studies described focussed on either shift length or weekly hours; few looked at both characteristics simultaneously, making it difficult to discern whether there is an interaction between the two. The only exception was a study that included full time/part time status as a control variable, which takes some account of the weekly hours worked (Griffiths et al. 2014). This led the literature to be fundamentally confounded with the long shift phenomenon (and vice versa).

Three studies regarding compressed working week were identified, two of which were performed as experiments within the police sector. These studies are summarised in Table 2.3.
Table 2.3 Summary of studies analysing the association between the compressed working week and employee performance

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Design</th>
<th>Participants and setting</th>
<th>Shift factor</th>
<th>Outcome (measurement)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Amendola et al. 2011)</td>
<td>Randomised block experimental</td>
<td>231 police officers, USA</td>
<td>Compressed working week (CWW) of 12 h/day vs 10 h/day and 8 h/day</td>
<td>a) Job performance (Behavioral Personnel Assessment Device; STISM Driving Simulator; Psychomotor Vigilance Test; MILO/Range 3000 Shooting Simulator) b) Fatigue (Fitness for Duty Impairment Screener) c) Alertness (self-reports and sleep diaries)</td>
<td>a) No significant differences b) No significant differences c) When working the 12 hours shift, police officers were more likely to report a significantly lower average level of alertness (mean= 6.11) than the average alertness levels among officers on the 8 hour (mean= 6.74, p= 0.012), but not the 10 hour (mean= 6.31, p= ns) shift</td>
</tr>
<tr>
<td>(Havlovic et al. 2002)</td>
<td>Cross-sectional study</td>
<td>520 nurses, USA</td>
<td>Compressed working week (CWW) of 3-day or 4-day 11 hrs per week vs 5-day–7.5 hour shifts</td>
<td>Perceived quality of care (study survey)</td>
<td>CWW was associated with poor quality of care only when nurses worked rotating shifts (p&lt; 0.01). CWW was associated with dissatisfaction with schedule only when nurses worked on rotating shifts (p&lt; 0.01)</td>
</tr>
<tr>
<td>(Vega and Gilbert 1997)</td>
<td>Experimental</td>
<td>103 police patrol officers, USA</td>
<td>CWW of 3-day 13 hour and 20 minutes shifts per week vs 5-day 8 hour shifts</td>
<td>Productivity (self-reported and derived from Department data on number and type of arrests, response and handling time → doing more work in less time)</td>
<td>Officers perceived the CWW as beneficial for them, but objective measures of productivity showed no change before and after the implementation of CWW</td>
</tr>
</tbody>
</table>
The oldest study, comprising a sample of 105 patrol officers, sought to describe the attitudinal and productivity effects of using a ‘three 13 hour shifts per week’ schedule. Patrol officers perceived the compressed working week as beneficial for them, in terms of personal life and work performance; however, objective measures found that there was no change in productivity after the introduction of the compressed working week (Vega and Gilbert 1997).

A similar study, a randomised block experimental study on 231 police officers, evaluated the impact of different work schedule organisations (8 hours/5 days’ vs 10 hours/4 days’ vs 12 hours/3 days + 18-hour day every other week) on performance and fatigue and reported no significant differences. However, when police officers worked the 12-hour shift/3 days schedule, they were more likely to report a significantly lower average level of alertness (mean=6.11) than the average alertness levels among officers on the 8-hour shift/5 days schedule (mean=6.74, p= 0.012) (Amendola et al. 2011).

In the nursing sector, a cross-sectional study of 520 subjects, sampled through a nursing association, analysed the effect of the compressed working week (either 3 or 4 11 hour shifts per week compared to 5 days of 7.5 hour shifts) on the perceived quality of care provided to hospital patients and dissatisfaction with schedules, noting that negative associations were found only when the compressed working week was performed with rotating shifts (p< 0.01) (Havlovic et al. 2002). A rotating schedule indicates that the employee rotates between day and night shifts.

Overall, these studies on the effects of the compressed working week provide mixed results. In terms of job performance, there do not seem to be any objective improvements after introducing the compressed working week, while some decrements in alertness have been reported.

2.4.4 Overtime

Working overtime is a shift characteristic intertwined with both shift length and weekly hours. For this reason, a frequent shortcoming in previous research has been the inability to analyse separately overtime working and long shifts, leading to uncertain results as to whether negative effects should be attributed to scheduled long hours or long hours resulting from overtime.

Overall, seven studies have reported an effect for overtime working and job performance and they are reported in Table 2.4.
Table 2.4  Summary of studies analysing the association between overtime and employee performance

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Design</th>
<th>Participants and setting</th>
<th>Shift factor</th>
<th>Outcome (measurement)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Berney and Needleman 2006)</td>
<td>Longitudinal study</td>
<td>161 Hospitals, USA</td>
<td>Overtime</td>
<td>Patient mortality (administrative data on staffing and discharge)</td>
<td>Increased overtime is associated with a decrease in patient mortality (p&lt;0.05)</td>
</tr>
<tr>
<td>(Cho et al. 2016)</td>
<td>Cross-sectional survey</td>
<td>3037 nurses, Asia</td>
<td>Overtime</td>
<td>a) Nurse reported quality of care (nurse survey) b) Nurse reported patient safety (nurse survey) c) Care left undone (nurse survey)</td>
<td>a) RNs working overtime reported an 88% increase in failing or poor patient safety (OR= 1.88, 95% CI: 1.40–2.52) b) A 45% increase in poor quality of nursing care (OR = 1.45; 95% CI: 1.17–1.80) c) An 86% increase in care left undone (OR= 1.86; 95% CI: 1.48–2.35)</td>
</tr>
<tr>
<td>(Griffiths et al. 2014)</td>
<td>Cross-sectional survey</td>
<td>31,627 nurses, Europe</td>
<td>Overtime</td>
<td>a) Nurse reported quality of care (RN4CAST nurse survey) b) Nurse reported patient safety (RN4CAST nurse survey) c) Rates of care left undone (RN4CAST nurse survey)</td>
<td>a) Overtime was associated with reports of poor/fair quality of nursing care (OR= 1.32; 95% CI: 1.23–1.42) b) Overtime associated with reports of poor/failing patient safety (OR= 1.67; 95% CI: 1.51–1.86) c) Overtime associated with higher rates of care left undone (RR= 1.29; 95% CI, 1.27–1.31)</td>
</tr>
<tr>
<td>(Olds and Clarke 2010)</td>
<td>Cross-sectional survey</td>
<td>11,516 nurses, USA</td>
<td>Overtime</td>
<td>Medication errors (nurse reported)</td>
<td>Voluntary paid overtime was associated with medication errors (OR= 1.30; 95% CI: 1.11-1.53)</td>
</tr>
<tr>
<td>(Proctor et al. 1996)</td>
<td>Cross-sectional study</td>
<td>206 automotive workers, USA</td>
<td>Overtime</td>
<td>Cognitive function (neurobehavioral test performance)</td>
<td>Overtime work resulted in an impaired test performance in the areas of attention and executive function (p&lt;0.05)</td>
</tr>
<tr>
<td>Study (Year)</td>
<td>Study Design</td>
<td>Participants</td>
<td>Overtime</td>
<td>Medication Error Rates (Self-Reported on Study Logbooks)</td>
<td>Working Overtime Effect</td>
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<tr>
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<tr>
<td>Rogers et al. (2004)</td>
<td>Cross-sectional study</td>
<td>393 nurses, USA</td>
<td>Overtime</td>
<td>Medication error rates (self-reported on study logbooks)</td>
<td>Working overtime increased the odds of making at least a medication error (OR = 2.06, p &lt; 0.0005)</td>
</tr>
</tbody>
</table>
b) Pressure ulcers  
c) Central line associated bloodstream infection | a) Overtime was associated with higher likelihood of catheter-associated urinary tract infections (OR = 4.72; 95% CI: 2.21-10.05)  
b) Overtime was associated with higher likelihood of pressure ulcers (OR = 1.91; 95% CI: 1.17-3.11)  
c) Overtime was associated with lower likelihood of central line associated bloodstream infection (OR = 0.33; 95% CI: 0.15-0.72) |
A large cross-sectional study of 31,627 nurses from 12 European countries found an association between working overtime on a shift and increased likelihood of nurses reporting poor quality of care (OR=1.32; 95% CI: 1.23-1.42); poor patient safety (OR = 1.67; 95% CI: 1.51-1.86); and higher rates of missed care (tasks not completed during last shift due to lack of time) (RR = 1.29; 95% CI: 1.27-1.31) (Griffiths et al. 2014).

A similar methodology was adopted by Cho and colleagues in South Korea, where they surveyed 3037 registered nurses to evaluate the effect of working overtime on various nurse reported outcomes. They found that when nurses were working high proportions of overtime, they reported an 88% increase in failing or poor patient safety (OR= 1.88, 95% CI: 1.40–2.52); a 45% increase in poor quality of nursing care (OR = 1.45; 95% CI: 1.17–1.80); an 86% increase in care left undone (OR= 1.86: 95% CI: 1.48–2.35) (Cho et al. 2016).

Three further studies exploring the impact of overtime on quality of care and patient safety outcomes were produced within the nursing field. The cross-sectional study from Rogers and colleagues reported increased odds of making at least one error when the 393 nurses were working overtime (OR=2.06, p <0005) (Rogers et al. 2004). Results from a further study, using a cross-sectional design on 11,516 nurses, highlight that voluntary paid overtime was associated with self-reported medication errors both as a linear trend and with a cut point of regular voluntary paid overtime of 4 hours or more in the average work week (OR= 1.30; 95% CI: 1.11-1.53) (Olds and Clarke 2010).

In a large cross-sectional study, Stone and colleagues found adverse effects of overtime on two outcomes, catheter-associated urinary tract infections (OR= 4.72; 95% CI: 2.21-10.05) and pressure ulcers (OR= 1.91; 95% CI: 1.17-3.11), while working overtime was associated with a reduced likelihood of central line associated bloodstream infection (OR= 0.33; 95% CI: 0.15-0.72) (Stone et al. 2007). In a large study across 161 US hospitals, Berney and Needleman found a positive effect of overtime on patient mortality: in hospitals where there were higher proportions of nursing hours per patient day worked as overtime, patients were less likely to die (p<0.05) (Berney and Needleman 2006).

A cross-sectional study of 206 automotive workers found that overtime work resulted in decreased cognitive function, measured by a set of neuropsychological tests, in the areas of attention and executive function (p< 0.05) (Proctor et al. 1996).

In summary, studies indicate that there is a relationship between overtime working and increased likelihood of making errors, of expressing reduced cognitive function and of reporting poor quality of care, patient safety and higher rates of missed care. However,
this did not apply to patient mortality, which was decreased in hospitals where employees
work higher proportions of overtime.

2.4.5 Night work and fixed/rotating schedules

Results for night work and fixed/rotating shifts are reported together because these two
shift characteristics are linked to one another: studies in the literature come to different
conclusions regarding night work, according to the presence or absence of rotation. It
appears that the majority of the studies produced so far have not investigated night work
per se; the focus is more often on the interaction between time of the day, and whether
night work is undertaken as part of a fixed schedule or if the employee rotates between
day and night shifts. The rationale for this association is mainly that adaptation to night
work tends to happen within one or two weeks of continuous night work (Fossum et al.
2013), leading to resynchronisation (Wagstaff and Sigstad Lie 2011).

Nineteen studies investigating night work and/or fixed/rotating shifts were included and
they are summarised in Table 2.5.
Table 2.5  Summary of studies analysing the association between night work and fixed/rotating schedules and employee performance

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Design</th>
<th>Participants and setting</th>
<th>Shift factor</th>
<th>Outcome (measurement)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Bourbonnais et al. 1992)</td>
<td>Cross-sectional study</td>
<td>1349 nurses, Canada</td>
<td>Fixed evening, fixed night, rotating shifts vs day shifts</td>
<td>Sickness absence (database of certified sick leave spells)</td>
<td>Working a permanent night shifts schedule was associated with a higher likelihood of experiencing sickness absence (aOR=1.96; 95% CI: 1.14-3.36). Being on a fixed evening shifts schedule was associated with a higher likelihood of experiencing sickness absence (aOR=1.67; 95% CI: 1.02-2.75). Rotating shift schedules were not significantly associated with sickness absence</td>
</tr>
<tr>
<td>(Burch et al. 2009)</td>
<td>Cross-sectional survey</td>
<td>376 healthcare workers, USA</td>
<td>Permanent night shifts</td>
<td>a) Job dissatisfaction (study questionnaire) b) Absenteeism (study questionnaire)</td>
<td>a) Permanent night workers reported more job dissatisfaction than day workers (p&lt; 0.05) b) Permanent night workers reported higher rates of absenteeism than day workers (p&lt; 0.05)</td>
</tr>
<tr>
<td>(Catano and Bissonnette 2014)</td>
<td>Cross-sectional survey</td>
<td>26,000 employees, Canada</td>
<td>Night vs day shifts</td>
<td>Sickness absence (number of absence spells and length of absence spells through study survey)</td>
<td>Working rotating shifts was associated with a higher number of sickness absence days (β = 0.08, p&lt;0.001)</td>
</tr>
<tr>
<td>(Chang et al. 2011)</td>
<td>Experimental study</td>
<td>62 nurses, Asia</td>
<td>Night shifts (2, 3 or 4 consecutive)</td>
<td>Cognitive performance (State-Trait Anxiety Inventory, Stanford Sleepiness Scale, Wisconsin Card Sorting Test, Taiwan University Attention Test, Digit Symbol Substitution)</td>
<td>Working 2 consecutive night shifts was associated with perceptual and motor ability, when compared to those working 4 consecutive nights (p&lt; 0.05)</td>
</tr>
<tr>
<td>Author, Year</td>
<td>Design</td>
<td>Participants and setting</td>
<td>Shift factor</td>
<td>Outcome (measurement)</td>
<td>Results</td>
</tr>
<tr>
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<tr>
<td>coffey et al. 1988</td>
<td>Cross-sectional study</td>
<td>463 nurses, usa</td>
<td>fixed vs rotating shifts</td>
<td>job performance (six-dimension scale of nursing performance)</td>
<td>job performance was lowest for nurses working rotating shifts (p&lt;0.0001)</td>
</tr>
<tr>
<td>(Fekedulegn et al. 2013)</td>
<td>Cross-sectional study</td>
<td>464 police officers, usa</td>
<td>permanent night schedules vs day shifts</td>
<td>sickness absence (no absence spells vs absence spells of 3 days or longer; derived from work history dataset obtained from police payroll)</td>
<td>adjusted incidence rates were higher for police officers on the night shift compared with those on the day shift (IRR=2.04; 95% CI: 1.56-2.68)</td>
</tr>
<tr>
<td>(Hanna et al. 2017)</td>
<td>Cross-sectional survey</td>
<td>327 healthcare workers, usa</td>
<td>night vs day shifts</td>
<td>job satisfaction (nurse reported on survey)</td>
<td>radiologists working ≥120 night shifts per year had a higher likelihood to report job dissatisfaction (OR= 2.21; 95% CI: 1.05-4.66)</td>
</tr>
<tr>
<td>(Kleiven et al. 1998)</td>
<td>Cross-sectional study</td>
<td>3581 chemical plant employees, Northern Europe</td>
<td>rotating shifts, permanent night shifts vs permanent day shifts</td>
<td>sickness absence &gt; 3 days (administrative records of employees sickness cases)</td>
<td>no significant associations were found</td>
</tr>
<tr>
<td>(Johnson et al. 2014)</td>
<td>Cross-sectional study</td>
<td>289 Nurses, usa</td>
<td>night shift (sleep deprivation)</td>
<td>patient errors (nurse reported)</td>
<td>sleep-deprived nurses reported a higher mean number of patient care errors than non sleep-deprived nurses (p=0.005); an increase of 1 hour of sleep reduces the estimated odds for 1 or more patient care errors by 25%</td>
</tr>
<tr>
<td>(Natti et al. 2014)</td>
<td>Longitudinal study</td>
<td>3101 employees from different occupational</td>
<td>rotating schedules vs fixed day shifts</td>
<td>long-term sickness absence: &gt;10 days absence (register data)</td>
<td>shift work was associated with a higher IRR of sickness absence only when the employee had low work time control (IRR=1.74; 95% CI: 1.30-2.32)</td>
</tr>
<tr>
<td>Author, Year</td>
<td>Design</td>
<td>Participants and setting</td>
<td>Shift factor</td>
<td>Outcome (measurement)</td>
<td>Results</td>
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<tr>
<td>(Niedhammer et al. 2013)</td>
<td>Cross-sectional survey</td>
<td>sectors, Northern Europe</td>
<td>Rotating shifts, fixed night shifts vs day shifts</td>
<td>Sickness absence: if experienced in the past 12 months; if yes, how many days of absence (study survey)</td>
<td>Working on permanent night shifts did not increase the likelihood of experiencing sickness absence. Working rotating shifts increased the likelihood of experiencing sickness absence only for women (OR = 1.23, 95% CI: 1.06-1.43)</td>
</tr>
<tr>
<td>(Niu et al. 2013)</td>
<td>Prospective, randomized study with parallel group comparisons</td>
<td>29,680 employees, Europe</td>
<td>Fixed day shifts vs rotating shifts</td>
<td>Errors (d2 test)</td>
<td>Error rate for night shift workers in the rotating shift group was 44% higher (p&lt; 0.001) than that of fixed day shift workers</td>
</tr>
<tr>
<td>(Norder et al. 2015)</td>
<td>Longitudinal study</td>
<td>5826 male production workers, Central Europe</td>
<td>Rotating schedules vs fixed day shifts</td>
<td>Mental health sickness absence (Occupational Health Service register)</td>
<td>No association was found between working rotating shifts and the risk of recurrent mental health sickness absence</td>
</tr>
<tr>
<td>(Han et al. 2014)</td>
<td>Cross-sectional study</td>
<td>58 nurses, USA</td>
<td>Consecutive rotating vs fixed shifts</td>
<td>Fatigue (OFER scale)</td>
<td>More nurses working rotating shifts had higher levels of acute fatigue compared to those working fixed shifts (p&lt; 0.04).</td>
</tr>
<tr>
<td>(Smith-Coggins et al. 2014)</td>
<td>Longitudinal study</td>
<td>819 Emergency Medicine workers, USA</td>
<td>Perception of night shift work</td>
<td>a) Job satisfaction (self-reported) b) Intention to leave (self-reported) c) Fatigue (self-reported)</td>
<td>a) 58% indicated night shift negatively influences job satisfaction b) 43% indicated night shifts had caused them to think about leaving Emergency Medicine c) 36% were feeling fatigued because of night shifts</td>
</tr>
<tr>
<td>(Saksvik-Lehouillier et al. 2013)</td>
<td>Cross-sectional study</td>
<td>749 nurses, Northern Europe</td>
<td>Working night shifts for less than 1 year vs</td>
<td>Shift work tolerance (Dispositional Resilience Scale-Revised (DRS-15-R)</td>
<td>Shift work experience played no role in determining shift work tolerance</td>
</tr>
</tbody>
</table>

40
<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Design</th>
<th>Participants and setting</th>
<th>Shift factor</th>
<th>Outcome (measurement)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Tüchsen et al. 2008)</td>
<td>Cross-sectional survey</td>
<td>5627 carers of older people, Northern Europe</td>
<td>Fixed night, fixed evening, rotating shifts vs day shifts</td>
<td>Sickness absence: short term ≥ 2 weeks absence; long term: ≥ 8 weeks absence (Study survey)</td>
<td>Working on a fixed evening shift was associated with an increased rate ratio for ≥2 weeks sickness absence (RR = 1.29; 95% CI: 1.10-1.52). No association was found for fixed night work and sickness absence, nor for rotating shifts and sickness absence.</td>
</tr>
<tr>
<td>(van Drongelen et al. 2017)</td>
<td>Cross-sectional study</td>
<td>7652 ground staff employees, Northern Europe</td>
<td>Number of night shifts</td>
<td>Sickness absence (calendar days of the registered sickness absence episodes derived from occupational health records)</td>
<td>Night shift exposure was not significantly associated with long term sickness absence, but working &gt;110 night shifts was associated with a decreased number of sickness episodes (OR = 0.93; 95% CI=0.88-0.98)</td>
</tr>
<tr>
<td>(Vedaa et al. 2017)</td>
<td>Cross-sectional study</td>
<td>1538 nurses, Northern Europe</td>
<td>Night working</td>
<td>Sickness absence days Sickness absence spells (hospital registry data)</td>
<td>Working night shifts did not impact sickness absence</td>
</tr>
</tbody>
</table>
An experimental study carried out on 62 nurses in a single hospital in Taiwan explored the effect of schedules that involved consecutive night shifts; nurses were randomly assigned to groups working two, three or four consecutive night shifts, with the purpose to test cognitive performance at the end of each shift. Subjects working two consecutive nights had poorer perceptual and motor ability (components of cognitive performance), when compared to those working four consecutive nights (p< 0.05) (Chang et al. 2011).

When 463 nurses were surveyed to assess the relationship between type of schedule and job performance, measured with the Six-Dimension Scale of Nursing Performance, the results indicated that job performance was highest for nurses working fixed day shifts, while it was worst for those working rotating shifts (p< 0.0001) (Coffey et al. 1988). Similar results are reported from a randomised prospective study of 62 nurses in a medical centre: the error rate on a standard test for night shift workers in the rotating shift group was 44% higher (p < 001) than that of fixed day shift workers (Niu et al. 2013).

A cross-sectional study explored the interaction between being sleep deprived (defined by a nurse reporting needing more continuous sleep to feel rested than obtained during the past 24 hours) and working the night shift and the effect this has on patient errors. The results indicate that 56% of 289 nurses in the sample were sleep deprived. Sleep-deprived nurses reported a higher mean number of patient care errors than non-sleep-deprived nurses did (p= 0.005); moreover, an increase of 1 hour of sleep reduced the estimated odds for 1 or more patient care errors by 25% (Johnson et al. 2014).

As regards fatigue, the results from a cross-sectional study of 58 nurses working 3 consecutive 12-hour shifts, either on fixed nights (41%) or routinely rotating shifts (23%), highlight that nurses on rotating shifts had higher levels of acute fatigue (measured through the OFER scale) compared to those on fixed shifts (p<0.04) (Han et al. 2014). A secondary analysis of data from 819 emergency medics who were asked to report the status of night shift work and the effects they believed it had on fatigue shows that 36% of the sample believed that night work had an impact on their fatigue levels (Smith-Coggins et al. 2014).

The number of years of night shift work does not seem to have had an effect on shift work tolerance (the ability to adapt to shift work without adverse consequences). When 749 nurses were divided in two groups, one who had worked night shifts for less than a year and one who had worked night shifts for more than 6 years, no differences in shift work tolerance, described as the ability to work shifts without experiencing negative consequences thereof, including fatigue, were found (Saksvik-Lehouillier et al. 2013).
A study involving a sample of 376 healthcare workers highlights that permanent night workers (19% of the sample) were the most likely to report job dissatisfaction, compared to all other workers (p< 0.05) (Burch et al. 2009). A more recent study aiming to explore the association between night work and job satisfaction was conducted by Hanna and colleagues, who sampled 327 radiologists and performed a cross-sectional survey (Hanna et al. 2017). However, this study was not able to discern permanent vs fixed night work, limiting itself to conclude that working ≥ 120 night shifts per year was associated with job dissatisfaction (OR = 2.21; 95% CI:1.05-4.66), while not knowing if such night shifts were worked as part of a fixed or rotating schedule.

Eleven studies investigated the effect of night work on sickness absence and results are contrasting. Among these, three found that working on a rotating shift schedule was associated with an increased risk of reporting sickness absence. Catano and Bissonnette surveyed 26,000 employees from different occupational sectors in Canada, who were found to be more likely to report a higher number of sickness episodes if they were working as part of a rotating schedule, compared to employees working day shifts only (p<0.001) (Catano and Bissonnette 2014). Niedhammer and colleagues conducted a large survey in 31 European countries, aiming to capture work factors that influence sickness absence across a range of different occupational sectors. They found that working on permanent night shifts did not increase the likelihood of reporting sickness absence, while working on a rotating schedule did, but only for women (OR= 1.23; 95% CI: 1.06-1.43) (Niedhammer et al. 2013). In a longitudinal study of 3101 employees from different occupational sectors, Natti and colleagues found that working on rotating schedules was associated with a higher rate of long-term sickness absence (i.e. >10 days of absence), compared to staff on day shifts only, but only when employees had low work time control (IRR= 1.74; 95% CI: 1.30-2.32) (Natti et al. 2014).

Contrarily to these studies’ findings, one study of 7652 ground staff employees found that working a high number of night shifts was not associated with long-term sickness absence (i.e. >7 days absence), but that working a high number of night shifts (i.e. >110) was associated with a decreased number of sickness episodes (OR= 0.93; 95% CI: 0.88-0.98). Working on a rotating schedule was associated with a reduced likelihood of experiencing sickness absence, compared to working on day shifts only (OR= 0.82; 95% CI: 0.76-0.88) (van Drongelen et al. 2017).

Three studies reported a negative effect of permanent night shift schedules on sickness absence. When Fekedulegn and colleagues investigated sickness absence in police officers with a cross-sectional study, they found that, among the 464 participants, those working on permanent night shifts were more likely to take sick leave (IRR =1.65; 95% CI: 1.17–2.31), compared to those working day shifts only (Fekedulegn et al. 2013). Burch
and colleagues carried out a cross-sectional survey of healthcare workers, and they found that those working on permanent night shift rotas were more likely to report absenteeism \((p<0.05)\) (Burch et al. 2009). Bourbonnais and colleagues used databases of certified sickness episodes to assess whether different shift schedules were associated with sickness absence in a sample of 1349 nurses. They found that when nurses were working on a permanent night shift schedule, they had a higher likelihood of experiencing sickness absence \((aOR= 1.96; 95\% CI: 1.14-3.36)\), compared to nurses working day shifts only. However, no effect was observed for rotating shifts (Bourbonnais et al. 1992).

Four studies found no effect of night work on sickness absence. Kleiven and colleagues performed a cross-sectional study of 3581 chemical workers using administrative records of employees’ sickness cases, and found that employees working permanent night or rotating shift schedules did not have a higher likelihood of experiencing sickness episodes lasting more than 3 days, compared to fixed day schedules (Kleiven et al. 1998). A cross-sectional survey of over 5600 female carers of older people by Tuchsen and colleagues, did not find any difference in the odds of experiencing both short-term \((\geq 2\) weeks sickness absence) and long-term \((\geq 8\) weeks sickness absence) for carers working on fixed night or rotating schedules, compared to those working fixed day shifts (Tüchsen et al. 2008). More recently, Norder and colleagues surveyed a large sample of male production workers \((i.e. 5826\) employees). They found no association between working on rotating shift schedules and the risk of recurrent mental health sickness absence (Norder et al. 2015). Verdaa and colleagues used hospital registry data of 1538 nurses in Northern Europe and found no effect of night work on sickness absence in terms of lost days due to sickness and sickness spells (Vedaa et al. 2017).

In summary, it can be concluded that the evidence regarding the effect of rotating and permanent night schedules on job performance outcomes is mixed.

### 2.4.6 Rest and break opportunities

Five studies from diverse occupational groups reported on rest opportunities, mainly between shifts but also within shifts as significant characteristics affecting fatigue and accidents. These studies are reported in Table 2.6.
<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Design</th>
<th>Participants and setting</th>
<th>Shift factor</th>
<th>Outcome (measurement)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Chen and Xie 2014)</td>
<td>Case-control</td>
<td>407 observation (136 crashes; 271 non crashes) of truck drivers, USA</td>
<td>Off-duty time prior to a shift Rest breaks during trip</td>
<td>Truck crashes (study dataset)</td>
<td>Having long off-duty times was not effective in reducing crash risk. In a 10 hour trip, taking 1 or 2 breaks of 30 minutes reduced accident risk</td>
</tr>
<tr>
<td>(Flo et al. 2014)</td>
<td>Longitudinal study</td>
<td>1224 nurses, Northern Europe</td>
<td>Quick returns (shifts separated by &lt;11 hours)</td>
<td>Pathological fatigue (Chalder Fatigue Scale)</td>
<td>The annual number of quick returns at T1 predicted the occurrence of pathological fatigue (OR= 1.01; 95% CI: 1.00-1.01) at T2</td>
</tr>
<tr>
<td>(Tucker et al. 1999)</td>
<td>Cross-sectional</td>
<td>183 manufacturing workers, UK</td>
<td>Rest days</td>
<td>a) Alertness (SSI) b) Fatigue (SSI)</td>
<td>a) Having &gt;24 hour breaks between shifts was associated with higher means of alertness (unadjusted means: 6.40 for breaks of &gt;24 hours and 6.15 for no breaks) compared to having no breaks b) Having &gt;24 hour breaks between shifts was associated with lower means of fatigue (unadjusted means: 2.62 for breaks of &gt;24 hours and 2.75 for no breaks) compared to having no breaks</td>
</tr>
<tr>
<td>(van de Ven et al. 2016)</td>
<td>Cross-sectional</td>
<td>491 employees, Northern Europe</td>
<td>Rest days</td>
<td>Performance (assessed with the Dutch version of the Work Role Functioning Questionnaire (WRFQ-DV))</td>
<td>No significant association was found between rest days and performance</td>
</tr>
<tr>
<td>(Wisetborisut et al. 2014)</td>
<td>Cross-sectional</td>
<td>2772 nurses, Asia</td>
<td>Days off per month</td>
<td>Burnout (MBI)</td>
<td>Having at least 8 days off per month was associated with lower odds of burnout (aOR= 0.60; 95% CI: 0.50-0.80)</td>
</tr>
</tbody>
</table>
A case-control study compared 136 concerning crash cases and 271 non-crash cases among truck drivers. These two groups were compared to assess whether they had different exposure to number of rest breaks and rest-break duration. Results indicated that in a 10-hour trip, taking 1 or 2 breaks of 30 minutes reduced accident risk; having long off-duty times (>11 hours) before undertaking a trip was not effective in reducing crash risk (Chen and Xie 2014).

Similarly, a cross-sectional study of 491 employees in the Netherlands found that benefiting from at least one day off before a night shift was not associated with improved job performance (measured with the Work Role Functioning Questionnaire) (van de Ven et al. 2016). However, a cross-sectional study in the manufacturing sector investigated the same association using more specific job performance related outcomes. This study found that introducing a >24 hour off-duty time between blocks of day and night shifts could have a beneficial effect on fatigue and alertness. Results indicate that having such time off within shifts was associated with higher means of alertness (unadjusted means: 6.40 for off-duty time of >24 hours and 6.15 for no off-duty time) and lower means of fatigue (unadjusted means: 2.62 for off-duty time of >24 hours and 2.75 for no off-duty time) than having no such off-duty time (Tucker et al. 1999).

A longitudinal study of 1224 nurses explored the impact of having quick returns (<11 hours between shifts) on fatigue levels at baseline (T1) and after one year (T2): the annual number of quick returns at T1 predicted the occurrence of pathological fatigue (OR=1.01; 95% CI 1.00 to 1.01) at T2 (Flo et al. 2014). Wisetborisut and colleagues aimed to explore the association between burnout and number of days off within a sample of 2,772 healthcare workers in a single hospital. They indicate that having at least 8 days off per month is associated with lower odds of burnout, compared to having fewer than 8 days off per month (OR = 0.60; 95% CI: 0.50-0.80) (Wisetborisut et al. 2014).

Overall, these studies of relationships between rest opportunities and outcomes suggest that taking breaks can impact positively on employee fatigue and alertness.

2.5 Discussion

This scoping review, set out to identify the characteristics of shift work that have an effect on employees’ performance, included 53 papers overall. There is evidence of the association of six shift characteristics and employees’ job performance: shift length; weekly work hours; the compressed working week; overtime; night work/rotating or fixed shifts; and rest opportunities.
Shift length appears to be widely studied across occupational sectors, with some conflicting results reported. These studies were undertaken primarily through cross-sectional design. Overall, large scale and multi centre studies performed in the healthcare sector tend to report a negative effect of long shifts (i.e. shifts of 12 hours or more) on employees’ performance and satisfaction, although some smaller studies report no difference in performance, but increased job satisfaction. However, studies reporting favourable findings for 12-hour shifts schedules included in this review were performed after a few months of introducing these long shifts; it may be worthwhile evaluating whether employees’ attitudes change in the longer term.

Despite limited evidence regarding weekly hours, reviewed studies concluded that more than 51 weekly hours of shift work may have a negative impact on employee’s performance and job satisfaction, suggesting a yet untested but plausible link between long weekly hours and increased fatigue, and between fatigue and adverse events/errors.

The studies on the effects of the compressed working week provided mixed results. However, every study included in the review provided a different definition of compressed working week, in terms of different number of hours and different number of days worked per week in each study, which may partially explain the different results. Due to European legislations, which set an upper limit to weekly working hours (The European Parliament and the Council of the European Union 2003), most of the studies on shift length probably also included a compressed working week. This would imply that when employees were working 12-hour shifts, they were also reducing the number of work days in the week, in order to maintain a set number of weekly hours. Nonetheless, only the three studies included in the review mentioned explicitly the compressed working week.

The majority of studies on overtime reported an association between overtime working and impairments of job performance, in terms of increased likelihood of making errors, of having reduced cognitive function and of reporting poor quality of care, patient safety and higher rates of missed care. However, one study found that in hospitals where employees were working higher proportions of overtime, patient mortality was lower (Berney and Needleman 2006). This finding is similar to Stone et al’s finding that increased overtime is associated with lower central line associated bloodstream infection (Stone et al. 2007). This apparent contradiction in the results could be explained by the adoption of different methodologies: the majority of the studies that found a negative association between overtime and outcomes recurred to employee-reported data. This could have led to the common-methods variance, a bias that occurs when responses vary systematically because of the use of a single data source (Antonakis et al. 2010). Furthermore, the majority of the studies were unable to report on the type of overtime; whether overtime was paid and voluntary or unpaid and mandatory. This aspect could have influenced the
results, especially if responses are employee-reported: if employees had no choice and control regarding the amount of extra work and if they were unpaid when working beyond contracted hours, they may have been more dissatisfied and more inclined to report negative responses (Beckers et al. 2008).

There is conflicting evidence about the effect of night work on job performance, safety indicators and sickness absence. A number of studies found that working rotating night shifts had a negative effect on sickness absence, errors and fatigue, while other studies found that being on a permanent night schedule was associated with higher sickness absence. A small proportion of studies found no effect of night work on job performance outcomes.

Whether employees should work fixed or rotating shifts represents a controversial case as regards the balance between employee productivity, wellbeing and satisfaction. Given the negative impact of permanent night shifts on job satisfaction (Perrucci et al. 2007; Burch et al. 2009), these types of schedules are unlikely to lead to improved job performance outcomes. Furthermore, a literature review of 6 studies concluded that only a minority (<3%) of permanent night workers adjust completely to night work (Folkard 2008). The author then suggests that the benefits of permanent night shift systems are unclear, as they are unlikely to result in sufficient employee circadian adjustment.

As regards sickness absence, it is not possible to strongly conclude that shift work is consistently associated with higher sickness absence. Studies yielded contrasting results, but the emerging picture indicates that working night shifts is not necessarily associated with increased sickness; in one case, employees working a higher number of night shifts and on rotating schedules were less likely to experience sickness absence, compared to employees working on day shifts only (van Drongelen et al. 2017). However, these studies were different in terms of variables measured, instruments and occupational sectors. There was variation regarding how sickness absence was defined. One study looked at a specific type of absence, e.g. mental health sickness absence (Norder et al. 2015); a number of studies focused on number of sickness spells; some on total number of sickness days; and some studies took episodes' length into account.

In this regard, studies reported different thresholds for long-term and short-term sickness absence. One study classified all episodes involving ≥2 weeks of absence as short-term sickness absence and all episodes lasting ≥8 weeks as long-term sickness absence (Tuchsen et al. 2008). A further study categorised sickness absence episodes as long-term if they were lasting more than 10 days (Natti et al. 2014). A study recorded sickness episodes as long-term when they lasted more than seven days (van Drongelen et al. 2017). Two studies labelled an absence episode as sickness related only if it was lasting
more than three days (Kleiven et al. 1998; Fekedulegn et al. 2013). These differences were largely due to enforced legislations in the studies' countries: all thresholds were adopted based on the maximum number of absence days that employees can benefit from without being required to provide any fitness to work statement signed by a doctor.

Schaufeli and colleagues argue that absence length is an appropriate aspect to discriminate between “voluntary” and “involuntary” sickness absence (Schaufeli et al. 2009). According to them, involuntary sickness absence episodes represent a reaction to distress caused by high job demands or ill health, and reflect an actual inability to attend work. They argued that this involuntary sickness absence process is characterised by longer absence episodes (Schaufeli et al. 2009).

Studies regarding rest opportunities, deriving from both the health sector and other occupational sectors, suggest that timely breaks can impact positively on employee fatigue and alertness, and quick returns between shifts appear to be detrimental for pathologic fatigue. However, none of these studies was able to capture the quality of the rest breaks, in terms of activities performed when having a break or a day off. This could be a crucial factor in determining fatigue levels (Folkard et al. 2007; Wendsche et al. 2017). Furthermore, none of these studies considered interactions of rest breaks with other shift characteristics.

This review highlighted that fatigue is a potential mediator between shift length and adverse outcomes (i.e. impairments in job performance and safety). For example, Baker and Nussbaum concluded that long working hours were associated with fatigue and that fatigue was associated with decreased job performance (Barker and Nussbaum 2011). This plausible link between shift work and fatigue and fatigue and decreased performance remains untested.

Although some authors suggest that the impact of shift work characteristics on the outcomes is likely to be occupation specific (Ferguson and Dawson 2012), our results suggest that there is not a systematic difference by occupational sector. In this respect, associations of shift characteristics and outcomes in the healthcare sector were similar to those found in other occupational sectors. For example, the detrimental effect of shifts of 12 hours or longer on making errors was found both in the healthcare and in the nuclear sector. After the introduction of 12-hour shifts, job satisfaction appeared to increase in some of the nursing studies and in the electrical sector studies, while some nursing studies report that 12-hour shifts are associated with job dissatisfaction. However, the absence of industry specific effects may be due to the small number of studies from industries other than healthcare included in the review. Whilst overall associations may be
similar regardless of occupational sector, it remains possible that there are different thresholds for the effect of long shifts on performance that are occupation specific.

Furthermore, it is possible that different definitions of the same variable (e.g. each of the three studies on compressed working week defined “compressed working week” in a different way) and different outcome measurements explain partly the variability in the findings.

There is also a paucity of studies that examined or controlled for more than one shift characteristic at a time; no studies provided a comprehensive examination of all shift factors. However, shift work is better conceptualised as a complex interaction of factors, rather than a combination of linear characteristics (Ferguson and Dawson 2012). A more multivariate examination that takes account of the complex interplay of shift characteristics is needed to embrace entirely the complexity of shift work, in which the role of moderating/mediating factors remains unexplored.

2.6 Narrative critique of the studies’ quality

A recent scoping review of 12-hour shifts in nursing, possibly the largest and the most comprehensive to date, concludes that the evidence on 12-hour shifts and their effect on nurse and patient outcomes is mixed and inconclusive (Harris et al. 2015). However, mixed results do not equal the inability to draw conclusions on a topic. An example of this can be found in the apparently inconsistent relationship between shift length and nurse/patient outcomes, or employee/client outcomes, if looking at the topic from a broader occupational perspective; however, there are substantial differences in the studies’ design, methodologies and sample sizes that should be noted.

Six studies with large samples, utilising multi-country and complex multilevel designs, all report associations of shifts of 12 hours or more and poorer outcomes. These studies’ data were obtained from the RN4CAST study (Griffiths et al. 2014; Dall'Ora et al. 2015), the Multi-State Nursing Care and Patient Safety Study (Stimpfel et al. 2012; Stimpfel and Aiken 2013; Stimpfel et al. 2013) and the NEXT study (Estryn-Behar et al. 2012). These studies’ aim was to assess the impact of different characteristics of the workforce organisation on a number of nurse and patient outcomes.

The RN4CAST study encompassed a large number of registered nurses (i.e. 31,627 RNs) in 480 hospitals in 12 European countries (Belgium, England, Finland, Germany, Greece, Ireland, Norway, Poland, Spain, Sweden, Switzerland, and The Netherlands) (Sermeus et al. 2011). The Multi-State Nursing Care and Patient Safety Study comprised an analytic sample of 22,275 RNs from 577 non-federal acute care hospitals in four states (California,
New Jersey, Pennsylvania, and Florida) (Aiken et al. 2011). The NEXT study collected data from 25,924 RNs in 408 healthcare organisations in 10 European countries (Belgium, Finland, France, Germany, Great Britain, Italy, The Netherlands, Poland, Slovakia, Sweden) (Estryn-Behar et al. 2012).

The design of these six studies allowed complex multilevel analysis to be performed. This enabled researchers to take into account the natural hierarchical structure of the data (i.e. nurses in hospitals, hospitals in countries; or nurses in units, units in hospitals, hospitals in countries), while controlling for potential confounders of the association of shift length and nurse and patient outcomes.

Limitations of these studies include subjective and self-reported measurements of the outcomes and work hours (e.g. derived from surveys where participants had been asked: “how do you rate the quality of care in your unit on a scale from poor to excellent?”) and cross-sectional study design; this design does not allow to make any cause/effect inference. These are recurring limitations of shift work research that has been conducted and published up to date (Harma et al. 2015).

When exploring studies which conclude that 12-hour shifts were associated with improved or not jeopardised client/employee outcomes, the validity of the results is questionable. Samples of these studies ranged from 12 to 805 nurses, and some were conducted in a single site, whereas one was carried out within 13 hospitals in the same city.

As regards the design, one study was described as “descriptive exploratory” (Dwyer et al. 2007), one as cross-sectional (Stone et al. 2006) and one as a before and after study (Duchon et al. 1994). The design of the latter may suggest a somehow more robust methodology; however, the effect of 12-hour shifts in replacement of 8-hour shifts was evaluated 10 months after the new work schedule was introduced, with no further follow up. Moreover, the sample comprised 41 miners and results do not show any difference in job performance, while reporting that 80% of the workers preferred longer shifts. Furthermore, employees had previously agreed on the introduction of 12-hour shifts; this may lead to the so-called “honeymoon effect” (Peacock et al. 1983).

Smith and colleagues argue that if employees are inclined to adopt 12-hour shifts, they will try to accommodate these shifts and conceal any possible detrimental effects of increased fatigue (Smith et al. 1998). Studies reporting favourable findings for 12-hour shifts schedules included in this review were performed after a few months of introducing these long shifts; it may be worthwhile evaluating whether employees’ attitudes change in the longer term once the “honeymoon effect” is over. The study with the largest sample size (n = 805 RNs, 13 hospitals) reported that nurses working 12-hour shifts were more likely to be satisfied with their job and to experience less burnout; however, no differences
were observed for the association of shift length and objectively recorded patient outcomes and staffing costs.

The evidence that 12-hour shift patterns improve outcomes is weak, while evidence of an association between 12-hour shifts and negative effects on outcomes, despite having significant limitations, is stronger. However, despite the relative strength of these studies they remain limited by their cross-sectional designs and general reliance on self-report.

2.7 Limitations

Six different shift characteristics were identified as associated with employee’s performance; however, none of the included studies was able to control for all of these characteristics simultaneously.

The ability to draw firm conclusions about the effect of individual factors is also limited, owing to contrasting results; different measurements of outcomes and shift work factors; diverse populations and sample sizes.

Despite having developed a comprehensive search strategy and having drawn upon databases that were not specific to healthcare (e.g. SCOPUS), the majority of the studies found were in the healthcare sector. This limited exploring the impact of shift work characteristics across different industries. However, it is unlikely that additional searching would reveal a large body of evidence that contradicts the picture presented here.

Although this was a scoping review without a formal approach to appraising the quality of the evidence, the findings point to significant limitations in the research that has been used to support many conclusions about the impact of shift work in both healthcare and other industries.
2.8 Chapter summary

This literature review identified the complexity of shift work and the numerous characteristics that are associated with difference in employee performance. While there is a large number of studies investigating the association of shift work characteristics and employee performance, research gaps have emerged.

A number of studies that give an indication that subjective job performance might be affected by working long shifts and rotating night shifts were found, but none of these resorted to any objective measure of possible consequences for employees or employers. In this regard, sickness absence could serve as an objective indicator of employee behaviour and performance. While nurse reported quality measures suggest negative impacts associated with longer shifts and there is evidence of adverse patient outcomes, no objective measures of job performance were adopted, although results from one study suggest that missed care is an aspect of job performance that is worth exploring (Griffiths et al. 2014).

Furthermore, the majority of the reviewed studies are cross-sectional in nature, meaning that the effect of shift characteristics cannot be assessed in terms of temporality, according to the Bradford Hill criteria for causation (Hill 1965). Temporality implies that the effect has to occur after the cause; studies that rigorously fulfilled this criterion could not be found. A further bias that should be addressed is the common-method variance, meaning that correlations tend to emerge when self-reported instruments are used to measure several variables (Antonakis et al. 2010).

The current shift work research has significant limitations and this study aims to address some of these limitations, in particular the temporality aspect and the common-method variance. Next chapter reports the methodology I chose to adopt to address some of the research gaps that have emerged from the literature, after the provision of the conceptual framework that guides this study and the statement of the aims and objectives.
Chapter 3  Methods

3.1  Introduction

The aim of this chapter is to describe the methodology that has been developed to address the research questions.

First, a conceptual framework that encompasses all the variables and outcomes of the study is presented. This conceptual framework underlies the research questions, which, subsequently, determine the methodology that this study adopts. Approaches to the designs, settings, data collection, sample size calculation and data analysis are reported, alongside with considerations on ethics and resources needed for the study.

3.2  Conceptual framework

Research in shift work has been characterised by limited conceptual frameworks which systematically describe the concepts, assumptions, hypotheses and theories that support and inform studies (Creswell 2014). Some shift work studies adopted psychology theories’ framework (i.e. the effort-recovery model) (Josten et al. 2003), while some studies formulated their own frameworks (Griffiths et al. 2014).

A conceptual framework is developed for this study, based on the literature review results (see 2.4) and on the algorithms proposed by Harma and colleagues to measure and analyse working time patterns in epidemiologic studies that use register-based exposure assessment of working hours (Harma et al. 2015). Harma’s algorithms are based on 14.5 million shifts worked by 12,391 nurses and physicians, constituting a similar population to that of the present study (Harma et al. 2015).

Furthermore, this study’s conceptual framework draws on the seminal work carried out by Michie and West on the relationship between how healthcare employees are managed, their behaviour and the overall organisational performance. Michie and West’s framework links organisational context (i.e. resources, including staffing), people management (job design, workload and teamwork; employee involvement and control over work; leadership and support), psychological consequences for employees (health and stress; satisfaction and commitment; knowledge, skills and motivation) employee behaviour (absenteeism and turnover; task and contextual performance) and organisational performance (Michie and West 2004).
Chapter 3

Their framework highlights that different ways of designing a job and managing people have different impacts on employees’ emotional and physical well-being, their attitudes to work and the organization, and their performance and behaviour at work – one aspect being their presence or absence at work due to sickness (Michie and West 2004). Figure 3.1 represents Michie and West’s framework domains and subdomains that are investigated in this doctoral research. The adopted variables were circled. It assumes shift work is an aspect of the job design construct and sickness absence and task performance are employee behaviours.

This study’s conceptual framework is represented in Figure 3.2. The literature presented in Chapter 2 found evidence of the association of the following shift characteristics and employees’ job performance: shift length; weekly work hours; overtime; night work/rotating or fixed shifts; and rest opportunities (see 2.4).

According to the domains described by Harma et al (Harma et al. 2015), these shift work variables are grouped within 3 major areas:
1. characteristics of working hours, including how long the shift is, how many hours per week are worked and whether overtime is present (paid or unpaid)
2. time of day / rotation, grouping variables which comprise of night work and whether the shifts are organised on a fixed or rotating pattern
3. shift intensity, including the number of shifts and how much time off is present.

Sickness absence and delayed/missed vital signs observations are used as measures of employee job performance. It should be acknowledged that the choice of outcomes was restrained by what was available from the parent study (see 3.5); however, these outcomes are valid indicators of job performance and an extended description of these can be found at 1.7.1 (sickness absence) and 1.7.2 (delayed/missed vital signs observations). According to Michie and West framework, sickness absence is regarded as an employee behaviour which influences directly job performance (Michie and West 2004). In a previous study (Griffiths et al. 2014), 12-hour shift working was shown to be associated with job performance, albeit using a subjective measure of missed care. Vital signs observations are among the tasks that nursing staff are required to perform during their shift, and failing to perform this task on time or at all represents a failure in job performance.
Figure 3.1 Domains and subdomains from the Michie and West (2004) Framework to be investigated in the present study
Figure 3.2  Study conceptual framework

**PEOPLE MANAGEMENT**

- **Length of working hours**
  1. Shift length
  2. Weekly hours
  3. Overtime

- **Time of day**
  1. Day/night shift
  2. Fixed/rotating schedule

- **Shift intensity**
  1. Number of shifts
  2. Days off

**EMPLOYEE BEHAVIOURS**

- Sickness Absence
- Delayed/Missed Vital Signs Observations
3.3 Aims and objectives

The aim of this research is to measure the association between nurses’ shift work characteristics and job performance, as captured though sickness absence and delayed/missed vital signs observations.

The study objectives are to:

- explore and describe the ward nurses’ shift work characteristics in the hospital, in terms of shift length, night shifts, overtime shifts
- measure the association between ward nurses’ shift work characteristics and sickness absence
- determine the association between ward nurses’ shift work characteristics and delayed/missed vital signs observations

Within NHS hospitals, the “nursing” workforce is composed of registered nurses (RN) who are fully qualified nurses trained for a minimum of three years and registered with the Nursing and Midwifery Council, and variously titled health care assistants or health care support workers (HCA) who provide ‘hands on’ care. Examples of HCA duties are washing and dressing patients; serving meals and helping to feed patients; toileting and making beds.

For brevity, the term “nursing staff” in this study refers to both registered nurses (RNs) and healthcare assistants (HCA). A detailed operative description of sickness absence is provided in 1.7.1. For an extensive explanation of delayed/missed vital signs observations, please see section 1.7.2.

3.4 Study design

This is a retrospective longitudinal observational study using routinely collected data on ward and nursing staff shift patterns data, delayed/missed vital signs observations and nursing staff sickness absence data. The study data were extracted from 1 April 2012 to 31 March 2015, yielding to a three-year study period.

Observational studies represent a good strategy to address questions regarding the association of a set of characteristics and outcomes, especially when carrying out a randomised control trial would not be practical (Song and Chung 2010). For this study, it would not have been practical to introduce and implement shift patterns different from the current ones on a hospital wide basis.
A major limitation of previous shift work studies, being mostly cross-sectional, has been the inability to capture the temporal dimension of shift work, limiting the ability to establish a presumed causal pathway. This study, due to its longitudinal design, is able to explore the effect that working specific shift patterns have on outcomes along the three-year period covered by the study.

3.5 Data sources

This study drew on routinely collected data, and data were obtained as part of a larger study, *Nurse staffing levels, missed vital signs observations and mortality in hospital wards: modelling the consequences and costs of variations in nurse staffing and skill mix*. Retrospective observational study using routinely collected data. NRES Committee East Midlands – Northampton Ref: 15/EM/0099.

There are a number of advantages and potential downsides associated with the use of secondary data. One of the main advantages of using secondary data sources is that, since they have already been collected, the time spent on the study is likely to be less than the time spent on studies that use primary data collection methodologies. Furthermore, savings can be achieved markedly in terms of resources, money and staff, while the waste of data can be reduced, compared with collection of primary data. The main cost in undertaking secondary analysis is that of obtaining the data (Miller and Brewer 2003).

Other advantages include the size of the sample, its representativeness, and the reduced likelihood of common-method variance. When considering these potential biases, the benefit of using objective data on actual shift work characteristics and outcomes becomes evident. On the other hand, when dealing with secondary data, the researcher cannot control their quality and the method of collection (Sorensen et al. 1996). However, the data in this study were routinely collected and recorded automatically from electronic systems. These data are used to manage staff pay, giving more assurance regarding data quality and accuracy.

Internationally, shift work researchers have called for research based on analysis of registry data; these have several advantages, including continuous exposure information with no selection bias covering virtually all employees and no attrition. They also offer a possibility to analyse irregular, complex and changing working time patterns over long periods of time that are common in hospitals (Harma et al. 2015).
3.5.1 Shift characteristics

Data regarding nursing staff shift patterns were derived from the E-Roster, an electronic system that automatically feeds information on nurses’ shifts into payroll. The database contains individual records of shifts worked, hours worked, dates, start and end time, missed shifts due to sickness, name of the ward and band for all nursing staff employed by the hospital. The E-Roster field names along with their descriptions can be found at Table 3.1.

Table 3.1 E-Roster field names and descriptions

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Ward Name</td>
</tr>
<tr>
<td>Date</td>
<td>Shift date</td>
</tr>
<tr>
<td>Type</td>
<td>Type of shift e.g. E (early) or N (night) for worked shift; SK (Sick); UA (unauthorised absence); SD (study day) and ML (maternity leave) for absence.</td>
</tr>
<tr>
<td>Start</td>
<td>Shift start time</td>
</tr>
<tr>
<td>End</td>
<td>Shift end time</td>
</tr>
<tr>
<td>Break</td>
<td>Duration in minutes</td>
</tr>
<tr>
<td>Grade</td>
<td>Nurses’ grade</td>
</tr>
<tr>
<td>Hours</td>
<td>Shift length</td>
</tr>
<tr>
<td>name_id</td>
<td>Workforce name surrogate</td>
</tr>
</tbody>
</table>

In order to determine the total number of hours and shifts worked by each nursing staff member in the Trust, a second dataset, Overtime bookings was retrieved. It recorded all bank and agency shifts worked within the hospital and the dataset field names and description are reported in Table 3.2.

Bank shifts are shifts worked by the hospital clinical staff who sign up to work additional hours at their Trust. Agency shifts are covered by staff who are supplied to a Trust by a private agency, so they are not part of a Trust bank (Institute for Employment Studies 2010). Covering bank shifts is on a voluntary basis and employees can sign up for bank shifts in advance. Bank shifts indicate voluntary paid overtime and are paid to the employee at Agenda for Change pay structures for the assignment undertaken (NHS Health Education England 2017). From this point onwards, the term “overtime” is used to refer to bank shifts, which represent voluntary paid overtime.

Table 3.2 Overtime bookings field names and descriptions

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
</table>

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### 3.5.2 Outcomes

Sickness absence data were derived from the E-Roster, which classified any shift missed due to sickness absence with the codes “SK” for Sickness and “UA” for unauthorised absence in the field “Type” (see Table 3.1).

Data regarding delayed/missed vital signs observations were derived from a database of records made using the VitalPAC™ system, on which nursing staff record all clinical data on hand held devices at the bedside. As previously stated, the NEWS determined the frequency of the vital signs observations for each patient in the 32 wards of the study. All VitalPAC™ field names and description are reported in Table 3.3.
Table 3.3 VitalPAC™ field names and descriptions

<table>
<thead>
<tr>
<th>Field name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>time_of_reading</td>
<td>Observation date and time</td>
</tr>
<tr>
<td>NEWS_Score</td>
<td>Sum of vital signs scores</td>
</tr>
<tr>
<td>TTNO</td>
<td>Time To Next Observation. Scheduled interval to next observation as recorded by VitalPAC</td>
</tr>
<tr>
<td>ward_code</td>
<td></td>
</tr>
<tr>
<td>ews_level</td>
<td>Patient risk level 0 to 3 (low, medium, high, critical) according to protocol</td>
</tr>
<tr>
<td>prev_time_of_reading</td>
<td>Date/Time of previous vital signs observations</td>
</tr>
<tr>
<td>TTNO_prev</td>
<td>Previous TTNO i.e. requirement for this observation set.</td>
</tr>
<tr>
<td>obs_ward</td>
<td>Ward where the observation has taken place</td>
</tr>
<tr>
<td>person_id2</td>
<td>Staff identifier</td>
</tr>
<tr>
<td>patient_sg2</td>
<td>Patient identifier</td>
</tr>
<tr>
<td>epis_sg2</td>
<td>Admission identifier</td>
</tr>
</tbody>
</table>

Data of delayed/missed vital signs observations deriving from VitalPAC™ were linked to records of all nursing staff working on a given shift (E-Roster) and records of bank and agency staff working on the ward (Overtime bookings).

3.6 Study measures

3.6.1 Shift characteristics

For the purposes of describing the data, some computations were made from the variables3 extracted from the E-Roster and Overtime bookings datasets.

Shifts were classified as “day” and “night” shifts based on the end time of the shift. If a shift finished before 8 AM, it was classified as a night shift.

Each shift length was categorised as either ≤8-h (i.e. shifts lasting up to 8 hours); >8<12 h (i.e. shifts lasting more than 8 hours, but less than 12 hours); ≥12-h (i.e. shifts lasting 12

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3 For each included shift in the E-Roster and Overtime bookings, the extracted variables are: shift date; shift start and end time; shift length; shift type (e.g. sickness, night shift, study leave); name of the ward; band of nursing staff member working the shift; pseudoanonymised ID of nursing staff member working the shift.
hours or longer). This categorisation was based on shift categories used in previous studies reflecting the two major shifts used in the UK (i.e. long shifts and short shifts) (Griffiths et al. 2014; Dall'Ora et al. 2015). Categorisation of variables is generally discouraged as it leads to information loss and underestimation of the extent of variation in outcome between groups (Altman and Royston 2006). However, categorising variables may represent a favourable option (Connor 1972; Altman 1991). Main rationales for categorising variables include the ability to discern whether a non-linear relationship is taking place and enhanced results interpretability. Furthermore, while shift lengths vary, these reflect real categories (e.g. 8-hour shifts, 12-hour shifts). Shift lengths allocated on a roster come in discrete units, not as continuous variables. Experts suggest that the predictor variable is divided into three categories rather than in two (i.e. dichotomisation) (Gelman and Park 2009). Furthermore, experts recommend that, for skewed distributions, the distribution of the data is considered when choosing categories, by selecting cut-points which sensibly capture the tail of the distribution (Turner et al. 2010).

In order to examine the effect of shift characteristics on sickness absence, a calculation of shift characteristics worked in the seven days prior to a sickness/non-sickness episode was performed. From the extracted E-Roster and Overtime variables, it was possible to derive the following measures:

- Proportion of long shifts (≥12-h) over total worked shifts in the past seven days
- Proportion of night shifts over total worked shifts in the past seven days
- Proportion of days worked over the past seven days
- Proportion of overtime worked over the past seven days
- Total hours worked in the past seven days

It was not possible to ascertain whether breaks were actually taken during shifts. Therefore, breaks were included in the shift length and were not accounted for in the analysis. In order to calculate the total number of hours worked by staff members who worked with a substantive position in the hospital, only overtime shifts (i.e. Bank shifts) worked by nurses whose IDs were already present in the E-Roster were retained for analysis.

Furthermore, to replicate the approach used by previous cross-sectional studies, shift characteristics were aggregated at the nurse level. This approach allowed characterising each nursing staff member based on:

- Proportion of ≥12-hour shifts: the number of ≥12-hour shifts worked over the total number of shifts worked by the nursing staff member across the study period
Proportion of overtime worked: the number of overtime shifts worked (i.e. worked bank shifts) over the total number of shifts worked by the nursing staff member across the study period

Rotation status: whether the nursing staff member worked fixed day shifts (i.e. 0% of their worked shifts were night shifts; rotating shifts; fixed night shifts (i.e. >90% of their worked shifts were night shifts)

Grade: the majority of staff worked all their shifts as either RN or HCA, but, in a small number of cases, staff members worked shifts where their grade was classified as “HCA” and shifts where their grade was classified as “RN”. When that was the case, staff grade was determined by the grade of the majority of shifts worked by the staff member.

A further operationalisation of shift characteristics, in particular of long shifts was adopted for the analysis of delayed/missed vital signs observations. This consisted in the proportion of nursing hours per patient day (NHPPD) deriving from ≥12-hour shifts for each day in each ward. This measure was calculated separately for RNs and HCAs (RN-HPPD and HCA-HPPD).

### 3.6.2 Outcomes

#### 3.6.2.1 Sickness absence

Sickness absence was operationalised in different ways:

- **Sickness episodes:** a sickness episode was considered to be starting on the first day the employee was absent from work due to sickness/unauthorised absence and to be finishing as soon as the employee went back to work for at least one full day. It was treated as a dichotomous outcome, with possible responses: sick/not sick

- **Long term/short term absence:** long term sickness absence episodes were those involving seven or more days of consecutive absence from work, including non-working days. This is in line with previous research from the UK that has adopted this threshold. (Kivimaki et al. 2003; Ferrie et al. 2005). Previous studies reported that changes in sickness absence risk factors, or the magnitude of their effect may differ for short and long spells (Hensing et al. 1998), thus this subgroup analysis was performed.

- **Number of sickness episodes:** this measure of sickness absence was obtained by aggregating sickness episodes at the nurse level. It captured the total number of sickness episodes that each nurse staffing member experienced.
3.6.2.2 Compliance with vital signs observations

In this study, compliance with vital signs observations was assessed through an electronic system that nursing staff routinely use to record patient data (i.e. VitalPac™). This tool offered objective data of in-shift job performance, as nurses use the tool as part of their daily work routine. It should be noted that VitalPac™ classifies an observation set as missed even if all but one of the physiological parameters have been recorded.

A 12-hourly minimum frequency is used in the UK, where frequency of vital signs observations required is determined by national protocol based on the National Early Warning Score (NEWS) (Royal College of Physicians 2012), which identifies when the next observation is due. NEWS was developed based both on previous analyses and on the NICE guideline “Acutely ill patients in hospital. Recognition of and response to acute illness in adults in hospital”, which recommended routine measurement of six physiological parameters to assess illness severity: pulse rate, systolic blood pressure, respiratory rate, oxygen saturations, level of consciousness and temperature (National Institute for Health and Clinical Excellence 2007).

For each physiological parameter, a “standard” range is defined and measured; values outside of this range are allocated a score, which is weighted and colour-coded on the observation chart according to the magnitude of deviation from the standard range; the weighting reflects the severity of the physiological disturbance. The chart summarising standard ranges of the physiological parameters and the NEWS scores associated to any deviation from those are reported in Figure 3.3.
By summing the single parameters score, the NEWS aggregate is obtained; results of 5–6 trigger a medium-level clinical alert; a NEWS score of seven or more triggers a high-level clinical alert, namely an emergency clinical review. The authors recommend that an extreme score in any one physiological parameter, recorded as any RED score on the NEWS chart, should also trigger a medium-level alert.

The NEWS score sets the observation schedule and frequency for each patient, so that patients with higher NEWS scores will be scheduled to receive vital signs observations more often. The vital signs observations frequency based on the patients’ NEWS are reported in Figure 3.4. The necessity of taking vital signs observations based on the patient NEWS is a Trust policy and therefore represents a measure of a job performance, an action that employees are expected to perform. The complete policy can be found at Appendix F.
Following this classification, each vital signs observation was classified into risk categories:

- Low: where previous NEWS ≤ 2
- Medium: where previous NEWS ≥ 3 and NEWS ≤ 5
- High: where previous NEWS = 6
- Very High: where previous NEWS ≥ 7

For each study day on each ward, the numbers of observations in each of the following on-time/lateness categories were counted, based on the time to next observation stipulated by VitalPAC according to the following rules:

- OT: on time
- L0: <1/3 of time to next observation
- L1: >1/3 of time to next observations
- L2: >2/3 of time to next observations

Therefore, L1 was defined as a delayed observation and L2 as a missed observation.
3.7 Sample size

Due to the hierarchical structure of the data (i.e. shifts nested in nurses, nurses nested in wards), the adequate sample size for this study was determined based on the rule of thumbs on the accuracy of sample size in multilevel modelling reported by Maas and Hox (Maas and Hox 2005).

According to them, the rule of thumb is the “30/30 rule”, meaning that to minimise bias researchers should aim to achieve a sample of at least 30 groups with at least 30 individuals per group, for this study at least 30 shifts per each nurse. They reported that a general rule is that with increasing sample sizes at all levels, estimates and their standard errors become more accurate.

They added that if the interest is predominantly in cross-level interactions, the number of groups should be larger, leading to a 50/20 rule, that is, 50 groups with at least 20 individuals per group. The main interest in this research was not to assess cross-level interactions; therefore, the 30/30 rule was applied.

This rule implies that at least 30 nursing staff members (units) are sampled, and that for each nursing staff at least 30 shifts are included. It was possible to apply this rule also to wards; 32 wards overall participated in the study and shifts were available for all staff working on these wards.

3.8 Data management

After data were extracted, shifts worked by admin staff or clerks (i.e. not nursing staff) were excluded. Within the Overtime bookings datasets, shifts that were not worked by staff already listed in the E-Roster were removed. This was to ensure that the total number of worked hours within the hospital for each nurse in the sample were considered.

Sickness episodes not preceded by any shifts in the past seven days were excluded. This criterion was applied to ensure that sickness episodes could be shift work related and to avoid confounding from days off and annual leave. Lastly, shifts that were classified as “maternity leave” or “study leave” were excluded from the sample.

Data were provided by the Trust to the University of Southampton in its original form, except with patient and staff identification being pseudoanonymised. The data was stored in the University data repository, which is subject to additional security checks. Access to the database was limited to members of the research team. Data will be kept after the study finishes for 10 years, as per university regulation.
Data were stored in Microsoft Access in different databases (E-Roster, Agency bookings, VitalPAC™) that were linked by the means of Structured Query Language (SQL) queries. Partial cleaning of the data, adjusting or excluding missing values was done at this stage. Where convenient or required for analysis, synthetic categorisations were performed. All transfers of individual patient data used secure data transfer protocols.

In order to create datasets which could be used for data analysis, a combination of C++ language and R coding was implemented (R Development Core Team 2017). The process in whole is reported in Appendix G.

### 3.9 Data analysis

First, after having accessed the datasets, it was necessary to examine them and become familiar with the complex data. This was facilitated by the provision of a “data dictionary”, which described every variable included in the datasets; the data dictionary was provided by the information analyst at the Trust. Furthermore, some informal meetings between the study team members were held with data at hand, which enabled both the identification of any issues and the exploration of such a wealth of data. The whole data analysis script in R is attached at Appendix H. All data analyses were performed with R Studio version 1.0.143 (R Studio Team 2016) and multilevel models were fit with the lme4 package (Bates et al. 2015).

#### 3.9.1 Descriptive analysis

The first stage of data analysis involved a descriptive analysis of frequencies and summaries of shift patterns derived from the E-Roster and Overtime bookings data. Descriptive statistics included frequency tables, mean, median, interquartile ranges, and standard deviation of the variables. Furthermore, descriptive analyses were conducted for sickness absence and delayed/missed vital signs observations.

#### 3.9.2 Association of shift work characteristics and sickness absence

Generalised linear mixed models were used to model associations between nurses’ shift work characteristics and sickness absence. This is currently the most appropriate approach in repeated measurement data analysis of clustered data. Such models are useful to identify variation within and between subjects and support inference about the personal trajectory of each subject. They provide a flexible strategy to account for complex correlation structures in the analysis of repeated measurements. Since the available data are in the form of repeated measurements on different subjects, clustered
into shifts belonging to several wards, the hierarchical structure of the data was taken into account by including cluster effects at the different levels of the hierarchy.

Intraclass correlation coefficients (ICC) were computed from unconditional random intercept models to describe the between-ward and between-nurse variation for sickness absence. The ICC measures the proportion of variance in the outcome that can be attributed to variation between the different clustering units (Nakagawa and Schielzeth 2010).

As regards sickness absence, there was no strong tendency for staff in a ward to resemble each other in terms of sickness behaviours, as the ICC for ward was 0.007, but individuals tended to have a degree of consistency, as the ICC for staff ID was 0.31. Previous research argued that when the ICC for a clustering variable is lower than 0.1, then that variable should not be included as a random effect (Lee 2000). Therefore, because of the low ICC and the absence of a natural clustering of sickness episodes, multivariable models examining the association of shift characteristics and sickness absence did not include ward as a random effect. Staff id was added as a random effect.

Different models were applied to the data to assess the association between nursing staff shift characteristics and sickness absence:

- The likelihood of a planned shift been being missed based on its scheduled length was explored. In this model, shift length was categorised as ≤8-h, >8-<12, ≥12-h (for a more detailed description of shift categories, please see 3.6.1).

- A further step was modelling the association of sickness episodes and shift work characteristics of the seven days prior to the sickness/non-sickness episode, with shift characteristics being modelled in proportions. Shift characteristics included proportion of long (≥12-h) shifts worked, proportion of overtime shifts worked, and proportion of days worked. Nurse grade (RN vs HCA) was included as a control variable.

- A subgroup analysis of the likelihood of experiencing a long term and short term sickness episode based on shift characteristics worked in the seven days prior to the sickness/non-sickness episode was then performed. Shift characteristics included proportion of long (≥12-h) shifts worked, proportion of overtime shifts worked, and proportion of days worked. Nurse grade (RN vs HCA) was included as a control variable.

- Both shift and sickness data were aggregated at the nurse level and explored the association between number of sickness episodes and shift characteristics worked throughout the study period. Shift characteristics included proportion of ≥12-h shifts; proportion of overtime shifts; whether the staff member was working on
fixed day, fixed night or rotating shifts; nurse grade (RN vs HCA). Since nurses are naturally clustered into wards, a ward random effect was included in these models.

### 3.9.3 Association of shift work characteristics and delayed/missed vital signs observations

As regards the association of delayed/missed vital signs observations, generalised linear mixed models with a Poisson distribution were fit. These models sought to examine the effect of higher proportions of registered nurse hours per patient day (RN-HPPD) and healthcare assistant hours per patient day (HCA-HPPD) deriving from ≥12-hour shifts on the likelihood of delaying or missing a vital signs observation.

NHPPD is a staffing methodology and a measure of nursing workload that includes the total number of nursing hours in a unit in a 24-hour period, divided by the total number of patients in a unit in a 24-hour period (Twigg and Duffield 2009). For example, if across 24 hours in a ward there are 9 nurses and 27 patients, assuming that nurses’ hours do not overlap, in that ward there were 8 NHPPD. It could be argued that if patients receive eight hours of nursing care per day, what is happening over the other 16 hours of their day remains unclear (Kirby 2015). However, when in a ward there are 8 NHPPD, it means that, across 24-hours, a nurse is taking care of three patients at a time.

The rationale for analysing RN-HPPD and HCA-HPPD separately, as opposed to NHPPD, is that the rate of missed care may be influenced by the skill mix within the ward: a ward with a higher proportion of hours provided by registered nurses may experience more missed care when compared to a ward with higher percentages of care provided by HCAs, or vice versa (Mok et al. 2015; Chapman et al. 2017).

Delayed/missed observations in patients at high risk only were considered (i.e. patients with NEWS>6). This would ensure that the results have clinical relevance, since patients with high NEWS scores are those more likely to die and/or to experience critical deterioration (Smith et al. 2013).

These analyses were performed at the ward-day level and delayed/missed vital signs observations were treated as count outcome; these models were fitted with a Poisson distribution. Registered nurse hours per patient day (RN-HPPD) and healthcare assistant hours per patient day (HCA-HPPD) were added as control variables and ward was treated as a random effect.

Furthermore, ICCs were computed to describe the between-ward variation of delayed/missed vital signs observations. The ICC for ward was 0.37, indicating the 37% of the variation in delayed vital signs observations occurred at the ward level. When looking
Chapter 3

at missed vital signs observations, the ICC for ward was 0.37 as well. The high ICC and 
the data structure (observations nested in days, nested in wards) justified the inclusion of 
ward as a random effect in the multivariate models.

3.9.4 Criteria for model choice

In the context of hierarchical generalised linear mixed models, the choice of the model 
structure is a crucial aspect of the model selection process. The Akaike information 
criterion (AIC) and the Bayesian information criterion (BIC) were used to assess model fit. 
The first one is known as an estimator of the discrepancy between the data generating 
model and the fitted model. The Bayesian information criterion provides an approximation 
of the Bayesian posterior probability of the candidate model (Bozdogan 1987).

Furthermore, when computing the generalised linear mixed models, the Variance Inflation 
Factor (VIF) was checked in order to detect possible multicollinearity between the model 
covariates. A VIF <10 indicates low collinearity (O'brien 2007).

3.10 Ethical considerations and ethical approval

The project drew on routinely collected data from nurses' shifts records and from 
individual patient records where explicit consent had not been gained from participants. All 
patient and nursing staff data used for the project were pseudoanonymised in order to 
maintain confidentiality while allowing the necessary records to be linked.

Individual identifiers on nursing staff shifts data were not sought for this project. As per 
standard procedures for maintaining confidentiality, when using these data small numbers 
were suppressed when reporting and the same was done for the presentation of 
constellations of data that can potentially be used to reveal identities.

Because of the high level of aggregation used in the proposed analyses, no significant 
issues were anticipated. Furthermore, ward names were pseudoanonymised for the 
purpose of reporting results.

This doctoral research was part of a larger project, the HS&DR Project: 13/114/17 "Nurse 
staffing levels, missed vital signs observations and mortality in hospital wards: modelling 
the consequences and costs of variations in nurse staffing and skill mix. Retrospective 
observational study using routinely collected data". It was granted NRES approval (NRES 
Committee East Midlands – Northampton Ref: 15/EM/0099).
Chapter 3

An ethics application was submitted to the University of Southampton’s ethics committee through ERGO and was granted approval by the Research Governance Office (Submission Number 18311, attached in Appendix I).
3.11 Chapter summary

This study aims to explore the association between nursing staff shift work characteristics and job performance; it is a retrospective observational study using routinely collected data.

Data were collected in a large acute care hospital in the South of England and derived from three different sources: nursing staff shift work characteristics were extracted from the E Roster, an electronic system which automatically records actual shifts and feeds them directly into payroll; Overtime bookings, a database which archives all agency and overtime shifts in a format similar to E Roster; VitalPAC™, which tracks nursing staff delayed/missed vital signs observations.

These data were transferred securely and were joined in a single database. The analysis comprised a descriptive data analysis and a ward profiling activity, and included hierarchical generalised linear mixed models, which explored the association between shift patterns, sickness absence and delayed/missed vital signs observations.

All data were obtained in a pseudoanonymised form, which meant it was not possible to identify any subjects in the study, neither patients, nor nursing staff members. Furthermore, small numbers that could potentially lead to the identification of subjects will not be reported. Ethical approval was granted by the Research Governance Office (Submission Number 18311).
Chapter 4  Study setting and context

4.1  Introduction

The aim of this chapter is to describe the setting where this research took place. The context is first examined at the hospital level, followed by a ward profiling activity, which describes the wards’ specialties, number of beds, layout and nurse staffing levels/skill mix in each ward.

4.2  The hospital

The hospital employs 6,300 whole-time equivalent staff and provides acute services to approximately 650,000 people across a region of Southern England including a major city, smaller towns and rural areas. Indicators of health for people living in town are generally worse than the England average (Public Health England 2016).

Information on the Trust staff indicators was also gathered through a published NHS survey (NHS 2016). This survey highlighted that staff at the Trust feel more engaged than the national average. Furthermore, the Trust scored better than the national average on indicators including communication between staff and senior management; support from management; organisation and management interest in and action on health and wellbeing.

However, scores that were worse than the national average were found for the following: percentage of staff witnessing potentially harmful errors, near misses or incidents in last month (Trust percentage 34% vs national average percentage 25%); percentage of staff attending work in the last 3 months despite feeling unwell because they felt pressure from their manager, colleagues or themselves (Trust percentage 62% vs national average percentage 56%).

The Trust has a policy regarding absence management, which can be found in Appendix J. According to this policy, employees must provide certificates (both self-certificates and Statements of Fitness to Work / Fit Note) for all sickness absences longer than three days. In addition, national guidance indicates that employees should obtain a fit note from a doctor if their absence equals or is longer than 7 consecutive days (UK Government 2017).
4.3 Wards included in the study

The study took place in all acute inpatient general wards (32 wards) of the hospital. All wards included in the study were situated in the main hospital block, which had undergone major redevelopment in 2009, when the wards were modernised. The choice to restrict the study wards to acute inpatient general wards was made due to a restriction from unavailability of vital signs observations being recorded on VitalPac™ in other wards. Furthermore, these inclusion criteria were specified in the parent study.

This brought to the exclusion of: maternity services; paediatric units; intensive care units; emergency department; ambulatories; day units; theatres; discharge lounges.

4.4 Ward profiling

The 32 wards included in the study present different characteristics, which are summarised in Table 4.1. The wards cover a broad range of specialities, including general medical and surgical wards; cardiology; gastroenterology; oncology and haematology; orthopaedics; geriatrics; neurology and stroke, including neurorehabilitation; respiratory; renal; gynaecology; head and neck surgery; general acute medical and surgical units.
Table 4.1  Ward profiles

<table>
<thead>
<tr>
<th>Ward name</th>
<th>Specialty/ Directorate</th>
<th>Number of beds‡</th>
<th>Design - Layout</th>
<th>Ward acuity</th>
<th>Planned staffing levels† (RN+HCA)</th>
<th>Planned staff skill mix (RN/HCA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ward 1</td>
<td>General medical directorate, gastroenterology and liver medical specialty</td>
<td>36</td>
<td>Pod</td>
<td>High dependency patients not treated in ITU. Complex needs patients with drug and alcohol misuse. High number of enhanced observation patients</td>
<td>7+3 Late 4+3 Night 7+3 Early</td>
<td>70%/30% Late 60%/40% Night 70%/30% Early</td>
</tr>
<tr>
<td>Ward 2</td>
<td>Cardiology Directorate</td>
<td>36</td>
<td>Pod</td>
<td>High number of enhanced care observation</td>
<td>6+4 Late 4+2 Night 6+4 Early</td>
<td>60%/40% Late 65%/35% Night 60%/40% Early</td>
</tr>
<tr>
<td>Ward 3</td>
<td>Cardiology Directorate</td>
<td>Ward 3a= 11 Ward 3b= 12</td>
<td>Pod</td>
<td>Linked with Cardiac day unit next door for emergency percutaneous coronary intervention</td>
<td>6+2 Late 6+2 Night 7+2 Early</td>
<td>75%/25% Late 75%/25% Night 77%/23% Early</td>
</tr>
<tr>
<td>Ward name</td>
<td>Specialty/ Directorate</td>
<td>Number of beds‡</td>
<td>Design - Layout</td>
<td>Ward acuity</td>
<td>Planned staffing levels† (RN+HCA)</td>
<td>Planned staff skill mix (RN/HCA)</td>
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<tr>
<td>Ward 4</td>
<td>Oncology Directorate</td>
<td>Ward 4a= 18</td>
<td>Mixed</td>
<td>Ward 4a is acute oncology. Ward 4b is Haematology; immune suppressed patients all in single double door rooms. Ward 4c beds oncology 4 bed bays and some side rooms</td>
<td>8+3 Late 6+3 Night 9+3 Early</td>
<td>75%/25% Late 65%/35% Night 75%/25% Early</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ward 4b= 10</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Ward 4c= 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ward 5</td>
<td>Musculoskeletal Diseases Directorate</td>
<td>28</td>
<td>Racetrack</td>
<td>Trauma, high number of spinal patients</td>
<td>5+3 Late 4+3 Night 5+3 Early</td>
<td>65%/35% Late 60%/40% Night 65%/35% Early</td>
</tr>
<tr>
<td>Ward 6</td>
<td>General Medical Directorate</td>
<td>30</td>
<td>Racetrack</td>
<td>General medicine</td>
<td>5+3 Late 4+2 Night 5+3 Early</td>
<td>65%/35% Late 65%/35% Night 65%/35% Early</td>
</tr>
<tr>
<td>Ward 7</td>
<td>Musculoskeletal Diseases Directorate</td>
<td>34</td>
<td>Racetrack</td>
<td>General medicine</td>
<td>6+4 Late 4+2 Night 6+4 Early</td>
<td>60%/40% Late 65%/35% Night 60%/40% Early</td>
</tr>
<tr>
<td>Ward name</td>
<td>Specialty/ Directorate</td>
<td>Number of beds(^{\ddagger})</td>
<td>Design - Layout</td>
<td>Ward acuity</td>
<td>Planned staffing levels(^{\dagger}) (RN+HCA)</td>
<td>Planned staff skill mix (RN/HCA)</td>
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<tr>
<td>Ward 8</td>
<td>Musculoskeletal Diseases Directorate</td>
<td>26</td>
<td>Racetrack</td>
<td>Trauma ward, high number of head injury patients requiring enhanced observations</td>
<td>4+3 Late 4+2 Night 5+3 Early</td>
<td>60%/40% Late 65%/35% Night 65%/35% Early</td>
</tr>
<tr>
<td>Ward 9</td>
<td>Musculoskeletal Diseases Directorate</td>
<td>36</td>
<td>Pod</td>
<td>Elective orthopaedics, new ward block. Patients cannot be observed from main nurses’ station. 3 x pods of 12. Each 12 made up with 2 x 4 bed bays and 4 side rooms</td>
<td>7+3 Late 4+2 Night 7+3 Early</td>
<td>70%/30% Late 65%/35% Night 70%/30% Early</td>
</tr>
<tr>
<td>Ward 10</td>
<td>Musculoskeletal Diseases Directorate</td>
<td>36</td>
<td>Pod</td>
<td>Trauma ward elderly hips fracture, new ward block. Patients cannot be observed from main nurses’ station. 3 x pods of 12. Each 12 made up with 2 x 4 bed bays and 4 side rooms</td>
<td>7+5 Late 4+3 Night 7+5 Early</td>
<td>60%/40% Late 60%/40% Night 60%/40% Early</td>
</tr>
<tr>
<td>Ward 11</td>
<td>Surgical Specialities Directorate</td>
<td>30</td>
<td>Racetrack</td>
<td>General surgery</td>
<td>5+3 Late 4+2 Night 5+3 Early</td>
<td>65%/35% Late 65%/35% Night 65%/35% Early</td>
</tr>
<tr>
<td>Ward name</td>
<td>Specialty/ Directorate</td>
<td>Number of beds(^1)</td>
<td>Design - Layout</td>
<td>Ward acuity</td>
<td>Planned staffing levels(^1) (RN+HCA)</td>
<td>Planned staff skill mix (RN/HCA)</td>
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</tr>
<tr>
<td>Ward 12</td>
<td>Surgery - Surgical Ward</td>
<td>32</td>
<td>Racetrack</td>
<td>General surgery</td>
<td>6+3 Late 4+2 Night 6+3 Early</td>
<td>65%/35% Late 65%/35% Night 65%/35% Early</td>
</tr>
<tr>
<td>Ward 13</td>
<td>General Medical Directorate</td>
<td>36</td>
<td>Pod</td>
<td>Respiratory patients with high number of enhanced care observation</td>
<td>6+4 Late 4+2 Night 6+4 Early</td>
<td>60%/40% Late 65%/35% Night 60%/40% Early</td>
</tr>
<tr>
<td>Ward 14</td>
<td>Medicine for Older People, Rehabilitation and Stroke</td>
<td>13</td>
<td>Bay</td>
<td>Under 65 rehabilitation ward</td>
<td>2+3 Late 2+1 Night 2+3 Early</td>
<td>40%/60% Late 65%/35% Night 40%/60% Early</td>
</tr>
<tr>
<td>Ward 15</td>
<td>Medicine for Older People, Rehabilitation and Stroke</td>
<td>30</td>
<td>Racetrack</td>
<td>Acute Medicine for Older people</td>
<td>5+4 Late 4+2 Night 6+4 Early</td>
<td>55%/45% Late 65%/35% Night 40%/40% Early</td>
</tr>
<tr>
<td>Ward 16</td>
<td>Medicine for Older People,</td>
<td>25</td>
<td>Racetrack</td>
<td>Stroke rehabilitation</td>
<td>4+4 Late 3+2 Night</td>
<td>50%/50% Late 60%/40% Night</td>
</tr>
<tr>
<td>Ward name</td>
<td>Specialty/ Directorate</td>
<td>Number of beds</td>
<td>Design - Layout</td>
<td>Ward acuity</td>
<td>Planned staffing levels† (RN+HCA)</td>
<td>Planned staff skill mix (RN/HCA)</td>
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</tr>
<tr>
<td>Rehabilitation and Stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5+4 Early</td>
<td>55%/45% Early</td>
</tr>
<tr>
<td>Ward 17 Medicine for Older People, Rehabilitation and Stroke</td>
<td>34</td>
<td>Bay</td>
<td>Acute Stroke. 6 bed hyper acute beds, 6 bed bays and 4 side rooms</td>
<td>8+3 Late 7+3 Night 8+3 Early</td>
<td>75%/25% Late 70%/30% Night 75%/25% Early</td>
<td></td>
</tr>
<tr>
<td>Ward 18 Medicine for Older People, Rehabilitation and Stroke</td>
<td>23</td>
<td>Bay</td>
<td>Acute medicine for older people. 12 side rooms, wards layout challenging</td>
<td>4+3 Late 3+2 Night 4+3 Early</td>
<td>60%/40% Late 60%/40% Night 60%/40% Early</td>
<td></td>
</tr>
<tr>
<td>Ward 19 Medicine for Older People, Rehabilitation and Stroke</td>
<td>29</td>
<td>Racetrack</td>
<td>Acute Medicine for Older people</td>
<td>5+4 Late 4+2 Night 6+4 Early</td>
<td>55%/45% Late 65%/35% Night 60%/40% Early</td>
<td></td>
</tr>
<tr>
<td>Ward 20 Medicine for Older People,</td>
<td>30</td>
<td>Racetrack</td>
<td>Acute Medicine for Older people</td>
<td>5+4 Late 4+2 Night</td>
<td>55%/45% Late</td>
<td></td>
</tr>
<tr>
<td>Ward name</td>
<td>Specialty/ Directorate</td>
<td>Number of beds(^t)</td>
<td>Design - Layout</td>
<td>Ward acuity</td>
<td>Planned staffing levels(^t) (RN+HCA)</td>
<td>Planned staff skill mix (RN/HCA)</td>
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<tr>
<td>Rehabilitation and Stroke</td>
<td></td>
<td></td>
<td></td>
<td>6+4 Early</td>
<td>65%/35% Night 60%/40% Early</td>
<td></td>
</tr>
<tr>
<td>Ward 21 Medicine for Older People, Rehabilitation and Stroke</td>
<td>21</td>
<td>Racetrack</td>
<td>Acute Medicine for Older people</td>
<td>3+3 Late 3+2 Night 4+3 Early</td>
<td>60%/40% Late 60%/40% Night 60%/40% Early</td>
<td></td>
</tr>
<tr>
<td>Ward 22 Renal and Transplantation</td>
<td>10</td>
<td>Racetrack</td>
<td>Renal High Care unit. Good observation of patients</td>
<td>3+1 Late 3+1 Night 4+1 Early</td>
<td>75%/35% Late 75%/35% Night 80%/20% Early</td>
<td></td>
</tr>
<tr>
<td>Ward 23 Renal and Transplantation</td>
<td>26</td>
<td>Bay</td>
<td>4 bed bays and side rooms. Renal including transplant.</td>
<td>7+3 Late 5+2 Night 7+3 Early</td>
<td>70%/30% Late 70%/30% Night 70%/30% Early</td>
<td></td>
</tr>
<tr>
<td>Ward 24 Renal</td>
<td>14</td>
<td>Bay</td>
<td>4 bed bays and side rooms. Complex renal patients</td>
<td>4+2 Late 3+1 Night 4+2 Early</td>
<td>65%/35% Late 75%/25% Night 65%/35% Early</td>
<td></td>
</tr>
<tr>
<td>Ward name</td>
<td>Specialty/ Directorate</td>
<td>Number of beds(^t)</td>
<td>Design - Layout</td>
<td>Ward acuity</td>
<td>Planned staffing levels(^t) (RN+HCA)</td>
<td>Planned staff skill mix (RN/HCA)</td>
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</tr>
<tr>
<td>Ward 25</td>
<td>Surgical Specialities Directorate</td>
<td>22</td>
<td>Bay</td>
<td>Gynaecology beds including a gynaecology emergency assessment unit. 3 x 4 bed bays and side rooms. Good observation. There are mainly gynaecology surgery patients, late medical terminations and high dependency cancer surgery</td>
<td>5+2 Late 3+2 Night 5+2 Early</td>
<td>70%/30% Late 60%/40% Night 70%/30% Early</td>
</tr>
<tr>
<td>Ward 26</td>
<td>Surgical Specialities Directorate</td>
<td>27</td>
<td>Bay</td>
<td>12 side rooms others 4 bed bays. Patients are in post-operative with airway management</td>
<td>6+2 Late 3+2 Night 6+2 Early</td>
<td>75%/25% Late 60%/40% Night 75%/25% Early</td>
</tr>
<tr>
<td>Ward 27</td>
<td>General medicine – high acuity</td>
<td>58</td>
<td>Pod</td>
<td>4 x 9 bed wards and 1 x 22 bed ward. There are some level 2 patients with a quick turnover. Good observation of patients in individual wards, but all areas are separate from each other</td>
<td>13+6 Late 13+4 Night 13+6 Early</td>
<td>70%/30% Late 75%/25% Night 70%/30% Early</td>
</tr>
<tr>
<td>Ward name</td>
<td>Specialty/ Directorate</td>
<td>Number of beds</td>
<td>Design - Layout</td>
<td>Ward acuity</td>
<td>Planned staffing levels† (RN+HCA)</td>
<td>Planned staff skill mix (RN/HCA)</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>-------------</td>
<td>-----------------------------------</td>
<td>---------------------------------</td>
</tr>
</tbody>
</table>
| Ward 28   | Mixed specialties       | 13             | Single room     | Private patients units | 2+1 Late  
2+1 Night  
3+1 Early | 65%/35% Late  
65%/35% Night  
75%/25% Early |
| Ward 29   | General Medical Directorate  
Ward 29a= 10  
Ward 29b= 30 | Bay             | 10 bed respiratory high care unit, with 8 ITU set up and 2 observation side rooms. The remaining 30 beds are 10 side rooms and 5 x 4 bed bays. Difficult observation of patients in ward area | 9+4 Late  
7+3 Night  
9+4 Early | 70%/30% Late  
70%/30% Night  
70%/30% Early |
| Ward 30   | Surgical Specialities Directorate  | 28             | Racetrack       | Waiting room for emergency patients | 5+2 Late  
4+1 Night  
6+2 Early | 70%/30% Late  
80%/20% Night  
75%/25% Early |
| Ward 31   | Surgical Specialities Directorate  | 10             | Pod             | Patients mainly level 1a, some level 2. The ward is configured as an ITU. Observation of all patients from central point with no side rooms | 4+1 Late  
3+0 Night  
3+1 Early | 80%/20% Late  
100% Night  
75%/25% Early |
<table>
<thead>
<tr>
<th>Ward name</th>
<th>Specialty/ Directorate</th>
<th>Number of beds‡</th>
<th>Design - Layout</th>
<th>Ward acuity</th>
<th>Planned staffing levels† (RN+HCA)</th>
<th>Planned staff skill mix (RN/HCA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ward 32</td>
<td>Surgical Specialities</td>
<td>31</td>
<td>Pod</td>
<td>New ward block. Patients cannot be observed from main nurses’ station. 3 x pods of 12. Each 12 made up with 2 x 4 bed bays and 4 side rooms. Direct admissions via urology treatment room on ward</td>
<td>7+3 Late 4+2 Night 7+4 Early</td>
<td>70%/30% Late 65%/35% Night 65%/35% Early</td>
</tr>
</tbody>
</table>

‡Ward numbers followed by a letter (e.g. Ward 3a and 3b) indicate that the Ward is internally divided in 2 or more sub wards. Since staff scheduling is managed at the higher ward level in the E-Roster (i.e. no rotas are planned for Ward 3a and 3b, there is only a schedule for Ward 3), no results in this research have been reported by sub wards

† Planned staffing levels are reported with number of registered nurses followed by number of healthcare assistants by type of shift, e.g. “6+2 Early” indicates that 6 registered nurses and 2 healthcare assistants are normally scheduled on for an early shift in that ward
As ward size is concerned, variation was observed, with number of beds ranging from 10 to 58. The majority of the wards accommodated between 20 and 36 beds, with some exceptions for specialised and high acuity wards having a lower number of beds. The layout differs between wards, with some wards having more than a single layout within.

Overall, nine wards have a pod design, thirteen wards have a racetrack layout, eight wards have a bay design, one ward consists of single accommodation rooms and one ward has a mixed design. This mix occurs in the oncology department (Ward 4) and is due to the presence of haematology patients who are immunosuppressed and therefore require a single room accommodation; the remaining oncology beds are organised in bays.

Patient acuity varies considerably between wards and this is reflected in the planned staffing levels and skill mix. The Trust policy requires each ward to plan staffing levels and skill mix on a shift basis (i.e. early; late; night), according to the RCN guidance on safe staffing levels, which recommends that no more than 8 patients are assigned to each RN with a skill mix of 65% RNs and 35% HCAs (Royal College of Nursing 2010).

However, there is variation in both staffing levels and skill mix between wards. High acuity wards have higher staffing levels and skill mixes in favour of registered nurses. Some notable examples can be observed in Ward 3 where staffing levels during an early shift are 3 patients per RN with a skill mix of 80/20; in Ward 22, where during an early shift 2.5 patients are assigned to each RN with a skill mix of 70/30; and in Ward 31, where on the late shift each RN is required to care for 2.5 patients with a skill mix of 80/20. Most notably, planned skill mix for this ward on night shifts is 100% RNs.

Wards that are considered less acute exhibit lower staffing levels and skill mixes in favour of HCAs. Among these there are Ward 15 with 6.25 patients for each RN on a late shift and a skill mix of 50/40; Ward 14, where each RN is expected to care for 6.5 patients with a skill mix of 40/60 during the day; Ward 2 where during the day RNs are required to care for 6 patients each with a 60/40 skill mix; Ward 1 plans to assign 6 patients to each RN.

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Different layouts are: a “pod” layout, which involves rooms along the sides of 2 hallways; in the middle there are a central nursing station, medication and supply rooms. Each pod contains all necessary instruments for patient care and desk space for documentation and communication. A “racetrack” ward has patients’ rooms arranged around a central core where the nursing station is usually placed; the central nursing station is separated from the patients’ rooms through a corridor that surrounds it. This ward design accommodates nursing workspaces between two corridors. Long corridors with no windows, henceforth no natural light, are a typical feature of this type of ward. “Bay” wards refer to units where patients are placed in rooms, each usually containing four beds. Bays are typically parallel with the corridor and nurses cannot observe patients directly from the nursing station; this led to the deployment of the “buzzers”, namely electronic systems that patients can use to attract nurses’ attention in case of need.
during the day with a 65/35 skill mix. Some wards distance themselves from the RCN guidance on a shift basis (e.g. Ward 14 presents a 40/60 skill mix during the early and night shift).

4.5 Chapter summary

This chapter aimed to describe the hospital and the study wards. Overall, this ward profiling activity highlighted variation between wards as regards size; layout; acuity; planned staffing levels and planned skill mix. Main results are:

- Staff working at the Trust reported higher communication between staff and senior management; support from management; organisation and management interest in and action on health and wellbeing, compared to the national average.
- Worse than national average scores were found for percentage of staff attending work in the last three months despite feeling unwell because they felt pressure from their manager, colleagues or themselves.
- Number of beds in wards ranges from 10 to 58. Most of the wards has a racetrack layout (n=13), one ward only has single room accommodation.

Most wards differ from the RCN recommended staffing levels and skill mix, with high acuity wards reporting higher staffing levels and skill mixes in favour of registered nurses and low acuity wards reporting lower staffing levels and skill mixes in favour of healthcare assistants.
Chapter 5  Nursing staff shift patterns

5.1 Introduction

This chapter aims to introduce and describe the shift characteristics data by providing central tendency and dispersion measures. It describes shift characteristics worked by nursing staff between 1 April 2012 and 31 March 2015.

5.2 Shifts sample

Overall, 633,525 shifts were extracted from the E-Roster dataset. The Overtime bookings dataset contained 215,219 shifts, bringing the total extracted sample to 848,744 shifts, planned and worked between 1 April 2012 and 31 March 2015. Within the E-Roster, shifts not filled in by nursing staff (i.e. admin staff, clerks) were excluded. This led to a total of 566,206 shifts, which either were worked or not worked (i.e. sickness absence, study leave).

Within the Overtime bookings datasets, shifts that were not worked in the study wards and shifts that were not worked by staff already listed in the E-Roster were removed. This led to total a sample of 601,282 shifts, of which 566,206 (94.2%) were contracted shifts from the E-Roster and 35,076 (5.8%) were overtime\(^5\) shifts.

For the description of shifts in this section, only shifts that were worked are included, therefore shifts that were classified as sickness or study leave are not reported in this section. A description of sickness shifts can be found in section 6.2. Therefore, total number of worked shifts were 563,231, of which 528,155 (94%) were contracted shifts from the E-Roster and 35,076 (6%) were overtime shifts. 365,516 shifts (64.8%) were worked by RNs and 197,715 shifts (35.2%) were worked by HCAs.

The distribution of number of shifts within wards was heterogeneous; with an average of 17,601 shifts per ward, 2947 shifts were worked in Ward 18 and 48,693 shifts were worked in Ward 27. The total number of shifts by ward can be found in Table 5.1, along with the number of different shift types (overtime and contracted). On average, 7.5% of the shifts in each ward were overtime shifts.

\(^5\) The term “overtime” in this study refers to voluntary paid overtime.
### Table 5.1  Number of shifts per ward by shift type (Contracted / Overtime)

<table>
<thead>
<tr>
<th>Ward Number</th>
<th>Overtime shifts n (%)</th>
<th>Contracted shifts n (%)</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1208 (7.5%)</td>
<td>14,903 (95.5%)</td>
<td>16,111 (100%)</td>
</tr>
<tr>
<td>2</td>
<td>1308 (7.8%)</td>
<td>15,449 (92.2%)</td>
<td>16,757 (100%)</td>
</tr>
<tr>
<td>3</td>
<td>796 (6%)</td>
<td>12,566 (94%)</td>
<td>13,362 (100%)</td>
</tr>
<tr>
<td>4</td>
<td>1999 (6.4%)</td>
<td>29,002 (93.6%)</td>
<td>31,001 (100%)</td>
</tr>
<tr>
<td>5</td>
<td>573 (3%)</td>
<td>18,475 (97%)</td>
<td>19,048 (100%)</td>
</tr>
<tr>
<td>6</td>
<td>1132 (8.4%)</td>
<td>12,342 (91.6%)</td>
<td>13,474 (100%)</td>
</tr>
<tr>
<td>7</td>
<td>1505 (9.8%)</td>
<td>13,924 (90.2%)</td>
<td>15,429 (100%)</td>
</tr>
<tr>
<td>8</td>
<td>822 (5%)</td>
<td>15,595 (95%)</td>
<td>16,417 (100%)</td>
</tr>
<tr>
<td>9</td>
<td>814 (4.6%)</td>
<td>16,978 (95.4%)</td>
<td>17,792 (100%)</td>
</tr>
<tr>
<td>10</td>
<td>1169 (5.4%)</td>
<td>20,614 (94.6%)</td>
<td>21,783 (100%)</td>
</tr>
<tr>
<td>11</td>
<td>940 (5.5%)</td>
<td>16,300 (94.5%)</td>
<td>17,240 (100%)</td>
</tr>
<tr>
<td>12</td>
<td>1559 (7.9%)</td>
<td>18,074 (92.1%)</td>
<td>19,633 (100%)</td>
</tr>
<tr>
<td>13</td>
<td>993 (6.4%)</td>
<td>14,449 (93.6%)</td>
<td>15,442 (100%)</td>
</tr>
<tr>
<td>14</td>
<td>718 (6.6%)</td>
<td>10,188 (93.4%)</td>
<td>10,906 (100%)</td>
</tr>
<tr>
<td>15</td>
<td>1304 (5.4%)</td>
<td>22,855 (94.6%)</td>
<td>24,159 (100%)</td>
</tr>
<tr>
<td>16</td>
<td>1307 (6.6%)</td>
<td>18,613 (93.4%)</td>
<td>19,920 (100%)</td>
</tr>
<tr>
<td>17</td>
<td>867 (3.6%)</td>
<td>23,136 (96.4%)</td>
<td>24,003 (100%)</td>
</tr>
<tr>
<td>18</td>
<td>1157 (39.3%)</td>
<td>1790 (60.7%)</td>
<td>2947 (100%)</td>
</tr>
<tr>
<td>19</td>
<td>1649 (7.4%)</td>
<td>20,769 (92.6%)</td>
<td>22,418 (100%)</td>
</tr>
<tr>
<td>20</td>
<td>1346 (6.2%)</td>
<td>20,339 (93.8%)</td>
<td>21,685 (100%)</td>
</tr>
<tr>
<td>21</td>
<td>1263 (9.7%)</td>
<td>11,817 (90.3%)</td>
<td>13,080 (100%)</td>
</tr>
<tr>
<td>22</td>
<td>1270 (12.5%)</td>
<td>8929 (87.5%)</td>
<td>10,199 (100%)</td>
</tr>
<tr>
<td>23</td>
<td>1054 (6.3%)</td>
<td>15,732 (93.7%)</td>
<td>16,786 (100%)</td>
</tr>
<tr>
<td>24</td>
<td>877 (8.9%)</td>
<td>9023 (91.1%)</td>
<td>9900 (100%)</td>
</tr>
<tr>
<td>25</td>
<td>1020 (8%)</td>
<td>11,799 (92%)</td>
<td>12,819 (100%)</td>
</tr>
<tr>
<td>26</td>
<td>510 (3%)</td>
<td>16,427 (97%)</td>
<td>16,937 (100%)</td>
</tr>
<tr>
<td>27</td>
<td>1924 (4%)</td>
<td>46,769 (96%)</td>
<td>48,693 (100%)</td>
</tr>
<tr>
<td>28</td>
<td>518 (7.1%)</td>
<td>6800 (92.9%)</td>
<td>7318 (100%)</td>
</tr>
</tbody>
</table>
Chapter 5

<table>
<thead>
<tr>
<th>Ward Number</th>
<th>Overtime shifts n (%)</th>
<th>Contracted shifts n (%)</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>1082 (5.3%)</td>
<td>19,463 (94.7%)</td>
<td>20,545 (100%)</td>
</tr>
<tr>
<td>30</td>
<td>699 (5%)</td>
<td>13,358 (95%)</td>
<td>14,057 (100%)</td>
</tr>
<tr>
<td>31</td>
<td>1068 (8.6%)</td>
<td>11,342 (91.4%)</td>
<td>12,410 (100%)</td>
</tr>
<tr>
<td>32</td>
<td>625 (3%)</td>
<td>20,335 (97%)</td>
<td>20,960 (100%)</td>
</tr>
</tbody>
</table>

5.3 Nursing staff sample

There were 1944 nursing staff members in the sample. 1244 staff members were classified as a RN; 700 staff members were classified as HCA. Additionally, 88 staff members worked some shifts as HCA and some as RN. Looking at shifts worked per band\(^6\), 22 staff members were listed as Band 1; 677 were listed as Band 2; 330 were listed as Band 3; 1 was listed as Band 4; 1215 were listed as Band 5; 188 were listed as Band 6; 62 were listed as Band 7; and 6 were listed as Band 8. Some staff members appeared on the E-Roster with different bands during the three study years.

Nursing staff worked on average 276 shifts within the three-year study period, with a standard deviation of 191 shifts. The minimum number of shifts worked by a nurse in the dataset was one and the maximum was 806 shifts.

5.4 Shift characteristics descriptive findings

Descriptive findings of shift patterns are reported with shifts as units of analysis. Unless specified, descriptive results for contracted and overtime shifts are reported together.

The mean shift length was 9 hours and 54 minutes, with a median of 8.5 hours and a standard deviation of 2 hours and 18 minutes. Shift length mean, median, mode, standard deviation and interquartile range are reported in Table 5.2. Results are also presented by shift type (contracted shifts from the E-Roster and overtime shifts).

\(^6\) Nurse bands consists of Band 1: domestic support worker; Band 2: Healthcare support assistant; Band 3: Clinical support worker nursing (higher level); Band 4: Nurse associate practitioner acute; Band 5: Registered nurse, registered midwife (entry level); Band 6: Clinical nurse specialist, nurse team leader, theatre nurse specialist; Band 7: Midwife higher level, midwife team manager, advanced nurse, nurse team manager; Band 8: Midwife consultant, modern matron, nurse consultant. NHS Health Education England (2017) *Agenda for change - pay rates*. Available from: https://www.healthcareers.nhs.uk/about/careers-nhs/nhs-pay-and-benefits/agenda-change-pay-rates [Accessed 15/05/2017]
Table 5.2 Summary of shift length by shift type (Contracted / Overtime)

<table>
<thead>
<tr>
<th>Shift length measures</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>SD*</th>
<th>IQR†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall shift length</td>
<td>9 h 54 min</td>
<td>8 h 30 min</td>
<td>8 h</td>
<td>2 h 18 min</td>
<td>8 h – 12 h 30 min</td>
</tr>
<tr>
<td>Contracted shifts’ length</td>
<td>9 h 54 min</td>
<td>8 h 30 min</td>
<td>8 h</td>
<td>2 h 18 min</td>
<td>8 h – 12 h 30 min</td>
</tr>
<tr>
<td>Overtime shifts’ length</td>
<td>9 h 36 min</td>
<td>11 h</td>
<td>12 h 30 min</td>
<td>3 h</td>
<td>6 h – 12 h 30 min</td>
</tr>
</tbody>
</table>

* Standard Deviation
† Inter Quartile Range

Overtime shifts had a larger degree of variation as regards shift length, compared to contracted shifts from the E-Roster.

The most common shifts worked lasted 8 hours (n= 218,469, 38.7%), followed by 209,112 (37.1%) shifts lasting 12.5 hours and 56,097 shifts lasting 11 hours (10%). These three shift patterns covered most of the shifts available for analysis. This distribution is summarised in Figure 5.1.

Figure 5.1 Histogram of shift length distribution

In order to summarise data in a more effective way, from this point onwards, for the purposes of describing the data, shift length is categorised in three categories as follows:
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- shifts lasting 8 hours or less: “≤8”
- shifts lasting more than 8 and less than 12 hours: “>8-<12”
- shifts lasting 12 hours or more: “≥12”

As described in section 3.6.1, experts suggest that variables are divided into three categories rather than in two (i.e. dichotomisation) (Gelman and Park 2009). Furthermore, experts recommend that, for skewed distributions, the distribution of the data is considered when choosing categories, by selecting cut-points which sensibly capture the tail of the distribution (Turner et al. 2010).

270,709 shifts in the dataset lasted eight hours or less (48%), 216,877 shifts lasted 12 hours or more (38.5%) and 13.5% lasted between more than 8 and less than 12 hours (n=75,645).

Table 5.3 summarises the distribution of different shift characteristics by shift length categories (i.e. ≤8-h; >8 - <12-h; ≥12-h). As regards the type of shift, similar distributions could be observed for contracted and overtime shifts. Most of the shifts were eight hours or less for both type of shifts, with overtime shifts having a higher percentage of 12 hours or more shifts, compared to contracted shifts (respectively 41.6% for overtime shifts and 38.3% for contracted shifts).

A high degree of variation was observed within different times of day characteristics (i.e. night and day shifts). The majority of day shifts were eight hours or less in length (67.6%), with 27.4% being 12 hours or more, while night shifts were 0.2% eight hours or less in length, and 67.3% were 12 hours or more. Furthermore 32.5% of night shifts were in the between 8 and 12 hours category. Unqualified staff worked more eight hours or less shifts (51.5%) than qualified staff (46.2%).

Table 5.3 Shift characteristics by shift length categories

<table>
<thead>
<tr>
<th>Shift category n (%)</th>
<th>Type of shift (contracted vs overtime)</th>
<th>≤8-h</th>
<th>&gt;8 - &lt;12 h</th>
<th>≥12-h</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Contracted</td>
<td>255,111 (48.3)</td>
<td>70,776 (13.4)</td>
<td>202,268 (38.3)</td>
<td>528,155 (100)</td>
</tr>
<tr>
<td></td>
<td>Overtime</td>
<td>15,598 (44.5)</td>
<td>4869 (13.9)</td>
<td>14,609 (41.6)</td>
<td>35,076 (100)</td>
</tr>
<tr>
<td>Time of day</td>
<td>Day</td>
<td>270,390 (67.6)</td>
<td>22,596 (5.7)</td>
<td>106,855 (26.7)</td>
<td>399,841 (100)</td>
</tr>
</tbody>
</table>

Shift categories distribution varied between wards, as represented in Figure 5.2. No wards had an exclusive shift system, but some wards had a high proportion of 12 hours or more shifts.

High percentages of eight hours or less shifts were not observed by ward, and this was due to eight hours or less shifts covering day shifts only, while 12 hours or more shifts were both day and night shifts. Where staff were working day shifts of eight hours or less, their night shifts were between 8 and 12 hours in length. This indicates there is variation in the distribution of shift categories: some wards adopted mostly a three-shift system (two 8-h shifts – one early, one late- and one 11-h night shift), and some mostly a two-shift system (two 12-hour shifts).

<table>
<thead>
<tr>
<th>Night (shifts finishing at ≤ 8 am)</th>
<th>319 (0.2)</th>
<th>53,049 (32.5)</th>
<th>110,022 (67.3)</th>
<th>163,390 (100)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Staff grade</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualified (bands 5 to 8)</td>
<td>169,762 (46.4)</td>
<td>47,091 (12.9)</td>
<td>148,663 (40.7)</td>
<td>365,516 (100)</td>
</tr>
<tr>
<td>Unqualified (bands 1 to 4)</td>
<td>100,947 (51.1)</td>
<td>28,554 (14.4)</td>
<td>68,214 (34.5)</td>
<td>197,715 (100)</td>
</tr>
</tbody>
</table>
Figure 5.2  Shift length categories by ward
5.5 Shift length variation across study years

Mean shift length across the Trust varied during the three years, showing a 51 minutes increase in mean shift length between week 1 (i.e. first week of year 1), where mean shift length was 8 hours and 47 minutes, and week 157 (i.e. last week of year 3), with a mean shift length of 9 hours and 38 minutes. The detailed weekly mean shift length can be found at Appendix K.

Measures of central tendency and dispersion of shift length by year are reported in Table 5.4. A pattern of increase in shift length can be observed through the years. In year 3, the most frequent shift length was 12.5 hours, while in year 1 and 2 it was 8 hours.

Table 5.4 Average and dispersion of shift length by study year

<table>
<thead>
<tr>
<th>Study Year</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1 (31 March 2012 – 31 March 2013)</td>
<td>9 h 37 min</td>
<td>8 h</td>
<td>8 h</td>
<td>2 h 7 min</td>
</tr>
<tr>
<td>Year 2 (1 April 2013 – 31 March 2014)</td>
<td>9 h 44 min</td>
<td>8 h</td>
<td>8 h</td>
<td>2 h 14 min</td>
</tr>
<tr>
<td>Year 3 (1 April 2014 – 31 March 2015)</td>
<td>10 h 24 min</td>
<td>12 h 30 min</td>
<td>12 h 30 min</td>
<td>2 h 28 min</td>
</tr>
</tbody>
</table>

A regards shift categories, their distribution by year can be found in Table 5.5. This indicates that the rate of eight hours or less shifts decreased during the three years (from 56% in year 1 to 36.1% in year 3), while the rate of 12 hours or more shifts doubled (from 27.8% to 54.8%).

Table 5.5 Shift categories distribution by study year

<table>
<thead>
<tr>
<th>Study Year</th>
<th>≤8-h</th>
<th>&gt;8 - &lt;12 h</th>
<th>≥12-h</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1 (31 March 2012 – 31 March 2013)</td>
<td>102,196 (56)</td>
<td>29,402 (16.2)</td>
<td>50,844 (27.8)</td>
<td>182,442 (100)</td>
</tr>
<tr>
<td>Year 2 (1 April 2013 – 31 March 2014)</td>
<td>100,684 (52.1)</td>
<td>29,137 (15.1)</td>
<td>63,245 (32.8)</td>
<td>193,066 (100)</td>
</tr>
<tr>
<td>Year 3 (1 April 2014 – 31 March 2015)</td>
<td>67,829 (36.1)</td>
<td>17,106 (9.1)</td>
<td>102,788 (54.8)</td>
<td>187,723 (100)</td>
</tr>
</tbody>
</table>
5.6 Shift characteristics at the nurse level

Every nursing staff member was categorised as regards the proportion of 12 hours or more shifts they worked during the study years; the proportion of overtime shifts they worked during the study years and whether they were working as part of a fixed or rotating schedule.

There were overall 1944 nursing staff members. Of these, there were 1484 in Year 1, 1549 in Year 2 and 1642 in Year 3. 180 nursing staff members left between Year 1 and Year 2 and 193 left between Year 2 and Year 3.

Table 5.6 summarises the distribution of shift characteristics at the nurse level. Among the 1944 nursing staff members, 235 (12%) never worked a ≥ 12-h shift, while 25% worked more than 75% of their shifts as ≥ 12-h shifts.

The majority of nurses (65%) in this sample did not work any overtime shifts during the years 2012-2015. A very small number of nurses (13, 0.6% of the sample) worked >75% of their shifts as overtime shifts.

Working on a rotating schedule was common for nurses, as 71% of them were engaged in such a schedule during the study period. Only 6% of the nurses worked as part of a fixed night shifts rota.

Table 5.6 Shift characteristics at the nurse level

<table>
<thead>
<tr>
<th>Proportion of ≥ 12-h shifts worked</th>
<th>Number of nurses*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>235 (12)</td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>641 (33)</td>
</tr>
<tr>
<td>&gt;25 - ≤75%</td>
<td>576 (17)</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>492 (25)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proportion of overtime shifts worked</th>
<th>Number of nurses*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>1262 (65)</td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>577 (30)</td>
</tr>
</tbody>
</table>
While the proportion of staff working rotating shifts remained stable across the study years, the proportion of staff working ≥12-h shifts varied. As Table 5.7 indicates, in Year 1 43% of staff did not work any ≥12-h shifts, while in Year 3 only 9% of staff did not work any ≥12-h shifts. The proportion of those working mainly ≥12-h shifts increased from 25% in Year 1 to 35% in Year 3. As regards overtime, there was an increase across the years, with 74% of staff working no overtime shifts in Year 1 and 66% working no overtime shifts in Year 3.

Table 5.7  Shift characteristics at the nurse level by year

<table>
<thead>
<tr>
<th>Proportion of ≥12-h shifts worked</th>
<th>Year 1 number of nurses n (%)</th>
<th>Year 2 number of nurses n (%)</th>
<th>Year 3 number of nurses n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>642 (43)</td>
<td>402 (26)</td>
<td>146 (9)</td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>317 (21)</td>
<td>485 (31)</td>
<td>232 (14)</td>
</tr>
<tr>
<td>&gt;25 - ≤75%</td>
<td>156 (11)</td>
<td>273 (18)</td>
<td>693 (42)</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>369 (25)</td>
<td>389 (25)</td>
<td>571 (35)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proportion of overtime shifts worked</th>
<th>Year 1 number of nurses n (%)</th>
<th>Year 2 number of nurses n (%)</th>
<th>Year 3 number of nurses n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>1101 (74)</td>
<td>1069 (70)</td>
<td>1088 (66)</td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>302 (21)</td>
<td>373 (24)</td>
<td>410 (25)</td>
</tr>
<tr>
<td>&gt;25 - ≤50%</td>
<td>41 (2.5)</td>
<td>51 (3)</td>
<td>65 (4)</td>
</tr>
</tbody>
</table>
### Chapter 5

<table>
<thead>
<tr>
<th>&gt;50 %</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40 (2.5)</td>
<td>56 (3)</td>
<td>79 (5)</td>
</tr>
</tbody>
</table>

**Fixed/rotating schedule**

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed day</td>
<td>418 (29)</td>
<td>470 (31)</td>
<td>510 (31)</td>
</tr>
<tr>
<td>Rotating</td>
<td>932 (62)</td>
<td>939 (60)</td>
<td>969 (60)</td>
</tr>
<tr>
<td>Fixed night</td>
<td>134 (9)</td>
<td>140 (9)</td>
<td>163 (9)</td>
</tr>
</tbody>
</table>

Total number of nurses in Year 1 = 1484
Total number of nurses in Year 2 = 1549
Total number of nurses in Year 3 = 1642
5.7 Chapter summary

This chapter provided a comprehensive report of the central tendency and dispersion measures of nursing staff shift characteristics. Key findings include:

- After data cleaning, the sample comprised of 601,282 shifts, of which 566,206 (94%) were contracted shifts extracted from the E-Roster and 35,076 (6%) were overtime shifts from the Overtime bookings dataset.
- When looking at worked shifts only (n= 563,231), 365,516 shifts (64.8%) were worked by RNs and 197,715 (32.6%) were worked by HCAs.
- The nursing staff members in the sample were 1944. 1244 staff members were classified as a RN; 700 staff members were classified as HCA.
- The mean shift length in the hospital for the three study years was 9 h 54 min, the median was 8.5 hours and the mode was 8 hours.
- The frequency of shift categories varied across the three study years: 56% were eight hours or less shifts in year 1 and 36.1% in year 3, while 12 hours or more shifts were 27.8% in year 1 and doubled in year 3 at 54.8%.
- The majority of the shifts lasted 8 hours (n= 218,469, 38.7%), followed by 209,112 (37.3%) shifts lasting 12.5 hours and 56,097 lasting 11 hours (10%). These three shift patterns covered most of the shifts available for analysis.
- Most of the shifts were eight hours or less for both overtime and contracted shifts, but overtime shifts had a higher percentage of 12 hours or more shifts.

The majority of day shifts were eight hours or less in length (67.6%), with 26.7% being ≥12-h, while night shifts were 0.2% eight hours or less in length, and 67.3% were ≥12-h. Unqualified staff worked more eight hours or less shifts (51.5%) than qualified staff (46.4%).
Chapter 6  Nurses’ shift characteristics and sickness absence

6.1  Introduction

This chapter describes sickness absence distribution, sickness absence by shift characteristics and then moves on to report findings of the association of nursing staff shift characteristics and sickness absence. It starts by presenting initial exploration of the data, without taking account of the nested structure and relationship of other shift factors. The later sections 6.3, 6.4, 6.5 use multilevel models to explore the association of shift work characteristics and sickness absence.

6.2  Sickness absence descriptive findings

Sickness absence has been defined in different ways in this study, including sickness episodes and short term/long term sickness episodes. For the extensive operational definitions, please see 1.7.1.

Overall, within the three study years, 37,691 shifts were lost due to sickness and 360 shifts were missed due to unauthorised absence, making a total of 38,051 of shifts where staff were absent from work. For analysis purposes, all shifts that were recorded as “sickness absence” were aggregated into episodes, producing 8090 sickness episodes. The overall sickness shifts rate was 6.3%. Distribution of sickness absence shifts by ward can be found in Appendix M. The sickness episodes’ rate was 1.5%. Sickness episodes distribution by ward are reported in Appendix N.

In order to detect any changes in trends, sickness absence was explored by study year (Table 6.1). Sickness absence rate varied throughout the study years, decreasing from 6.7% to 6%. However, the number of sickness absence episodes increased throughout the years, from 2629 sickness absence episodes to 2813 sickness absence episodes.
### Table 6.1  Sickness absence rates by year

<table>
<thead>
<tr>
<th>Study year</th>
<th>Number of shifts lost due to sickness absence</th>
<th>Worked shifts</th>
<th>Sickness absence rate†</th>
<th>Number of sickness absence episodes</th>
<th>Sickness episodes rate ‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1*</td>
<td>13,133</td>
<td>182,442</td>
<td>6.7%</td>
<td>2629</td>
<td>1.5%</td>
</tr>
<tr>
<td>Year 2**</td>
<td>13,017</td>
<td>193,066</td>
<td>6.3%</td>
<td>2648</td>
<td>1.4%</td>
</tr>
<tr>
<td>Year 3***</td>
<td>11,901</td>
<td>187,723</td>
<td>6%</td>
<td>2813</td>
<td>1.6%</td>
</tr>
</tbody>
</table>

† \( \left( \frac{\text{Sickness absence shifts}}{\text{Sickness absence shifts} + \text{worked shifts}} \right) \times 100 \)

‡ \( \left( \frac{\text{Sickness absence episodes}}{\text{Sickness absence episodes} + \text{worked episodes}} \right) \times 100 \)

* (1 April 2012 – 31 March 2013)

** (1 April 2013 – 31 March 2014)

*** (1 April 2014 – 31 March 2015)

Sickness absence rates in the trust are higher than national nursing staff NHS sickness absence, which were 5.5%, 5.4% and 5.4% for year 1, year 2, and year 3 respectively (QualityWatch 2015). The sickness episodes’ rate was relatively stable throughout the years, and was highest on year 3.

Sickness absence shifts and episodes were then explored by staff grade – namely healthcare assistants and registered nurses. Results illustrate that both sickness rate and sickness episodes rates were higher for healthcare assistants than for registered nurses (Table 6.2).

Sickness absence rates of RNs are slightly higher than the NHS average (5.3% vs 5.14%), and healthcare assistants staff is higher than the NHS average, being at 8.1%, while the national average is 6.12%.
Table 6.2  Sickness absence by grade type (RN vs HCA)

<table>
<thead>
<tr>
<th>Grade Type</th>
<th>Number of shifts lost due to sickness absence</th>
<th>Worked shifts</th>
<th>Sickness rate†</th>
<th>Number of sickness absence episodes</th>
<th>Sickness episodes rate‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registered Nurses</td>
<td>20,584</td>
<td>365,516</td>
<td>5.3%</td>
<td>4679</td>
<td>1.3%</td>
</tr>
<tr>
<td>Healthcare Assistants</td>
<td>17,467</td>
<td>197,715</td>
<td>8.1%</td>
<td>3411</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

† [(Sickness absence shifts / (Sickness absence shifts + worked shifts)] *100
‡ [(Sickness absence episodes / (Sickness absence episodes + worked episodes)] *100

Overall, 1654 nursing staff members experienced at least one sickness episode. The longest absence length period was 496 days, and one day was the shortest absence length. Figure 6.1 shows the distribution of sickness episodes according to absence length.

Figure 6.1  Length of sickness absence episodes

The most common length of sickness absence was 2 days (n = 1221, 15.1%) and the majority of the episodes were classified as short term sickness episodes (<7 days) (n = 5555, 69.7%).

6.2.1  Sickness absence and shift characteristics

Table 6.3 illustrates the length and time of day of shifts that were missed due to sickness.
Table 6.3  Scheduled length and time of day for shifts missed due to sickness

<table>
<thead>
<tr>
<th></th>
<th>Sickness episodes n (%)</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scheduled shift length</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤8-h</td>
<td>3621 (1.4)</td>
<td>265,774 (100)</td>
</tr>
<tr>
<td>&gt;8~&lt;12 h</td>
<td>1016 (1.4)</td>
<td>73,061 (100)</td>
</tr>
<tr>
<td>≥12-h</td>
<td>3453 (1.7)</td>
<td>210,458 (100)</td>
</tr>
<tr>
<td><strong>Time of day of scheduled shift</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day</td>
<td>6776 (1.5)</td>
<td>454,096 (100)</td>
</tr>
<tr>
<td>Night</td>
<td>1314 (1.4)</td>
<td>95,197 (100)</td>
</tr>
</tbody>
</table>

The percentage of shifts, which were scheduled to be 12 hours or more in length and were missed due to sickness is 1.7% and it was higher than shifts scheduled to last eight hours or less (1.4%) and between 8 and 12 hours (1.4%). The percentage of shifts scheduled to be worked during the day and that were missed due to sickness was higher than the percentage of night shifts missed due to sickness (1.5% vs 1.4%).

Sickness episodes distribution by characteristics of shifts worked in the 7 days prior to a sickness episode were explored and are summarised in Table 6.4. Percentages of sickness episodes are calculated as percentages of the total row and worked episodes have been omitted from the table.

The percentage of sickness episodes was lower when no long shifts were worked in the past seven days (1.4%), compared to working more than three quarters of shifts as long shifts (1.7%). Working more than three quarters of shifts in the past seven days as night shifts showed the highest percentage of sickness episodes (1.6%). The higher the proportion of overtime working, the lower sickness absence prevalence was, with the lowest prevalence observed for those working more than three quarters of their past shifts as overtime shifts (0.4%).

Proportion of days worked and total number of hours worked had a similar distribution, with lowest proportion of days and hours worked reflecting a higher percentage of sickness episodes, and highest proportions of days and hours worked showed the lowest percentage of sickness episodes. Because the distribution of sickness episodes by proportion of days worked and the number of hours worked was similar, their correlation was tested. The Pearson correlation coefficient was 0.85, indicating a high correlation between these two variables. Therefore, proportion of days worked only was retained for the multilevel analysis.
Table 6.4 Sickness episodes distribution by shift characteristics worked in the past seven days

<table>
<thead>
<tr>
<th>Proportion of long shifts (≥12h) over worked shifts in past 7 days</th>
<th>Sickness episodes n (%)</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>3855 (1.4)</td>
<td>284,675 (100)</td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>204 (1.2)</td>
<td>17,115 (100)</td>
</tr>
<tr>
<td>&gt;25 - ≤50%</td>
<td>744 (1.6)</td>
<td>46,853 (100)</td>
</tr>
<tr>
<td>&gt;50 - ≤75%</td>
<td>604 (1.4)</td>
<td>42,857 (100)</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>2683 (1.7)</td>
<td>157,793 (100)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proportion of night shifts over worked shifts in past 7 days</th>
<th>Sickness episodes n (%)</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>6183 (1.5)</td>
<td>420,134 (100)</td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>160 (1.1)</td>
<td>15,462 (100)</td>
</tr>
<tr>
<td>&gt;25 - ≤50%</td>
<td>432 (1.5)</td>
<td>28,382 (100)</td>
</tr>
<tr>
<td>&gt;50 - ≤75%</td>
<td>264 (1.4)</td>
<td>19,265 (100)</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>1051 (1.6)</td>
<td>66,050 (100)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proportion of overtime shifts over shifts worked in past 7 days</th>
<th>Sickness episodes n (%)</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>7565 (1.6)</td>
<td>489,511 (100)</td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>254 (1)</td>
<td>25,068 (100)</td>
</tr>
<tr>
<td>&gt;25 - ≤50%</td>
<td>196 (1)</td>
<td>19,790 (100)</td>
</tr>
<tr>
<td>&gt;50 - ≤75%</td>
<td>30 (0.8)</td>
<td>3732 (100)</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>45 (0.4)</td>
<td>11,192 (100)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proportion of days worked over past 7 days</th>
<th>Sickness episodes n (%)</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;0 - ≤25%</td>
<td>2326 (1.9)</td>
<td>122,617 (100)</td>
</tr>
<tr>
<td>&gt;25 - ≤50%</td>
<td>2347 (1.6)</td>
<td>145,201 (100)</td>
</tr>
<tr>
<td>&gt;50 - ≤75%</td>
<td>3117 (1.2)</td>
<td>250,397 (100)</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>300 (1)</td>
<td>31,078 (100)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total number of hours worked</th>
<th>Sickness episodes n (%)</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;25 h</td>
<td>2805 (1.8)</td>
<td>159,607 (100)</td>
</tr>
<tr>
<td>&gt;25 – 37.5 h</td>
<td>2832 (1.6)</td>
<td>176,540 (100)</td>
</tr>
<tr>
<td>&gt;37.5 - &lt;48</td>
<td>1707 (1.2)</td>
<td>143,197 (100)</td>
</tr>
<tr>
<td>&gt;48 h</td>
<td>746 (1.1)</td>
<td>69,949 (100)</td>
</tr>
</tbody>
</table>

Lastly, the different distribution of proportions of shift characteristics worked in the previous seven days was explored by absence length (i.e. long term and short term
sickness episodes) and is reported in Table 6.5. The distribution is reported with percentages of the columns total.

The distribution of sickness episodes according to the proportion of long shifts worked in the past seven days was similar for short and long term absence, with a slightly higher percentage of long term sickness episodes being preceded by no long shifts worked in the past seven days. 48.8% of long term sickness episodes were preceded by no long shifts, 46.8% of short term sickness episodes were preceded by no long shifts.

As regards the proportion of overtime worked in the past seven days, a similar distribution of episodes was observed in long and short term sickness absence. 94% of long term sickness absence episodes were preceded by no overtime shifts worked in the past seven days, while 93% of short term sickness episodes were preceded by no overtime shifts.

As far as number of night shifts are concerned, a similar distribution of sickness episodes was found within long and short term sickness absence. 73.9% of long term sickness episodes were preceded by no night shifts and 77.2% of short term sickness episodes were preceded by no night shifts.

The number of short and long term episodes occurring after different numbers of shifts worked was explored. It can be observed that 33.4% of short term absence episodes were preceded by working up to 25% of the previous seven days, while 26.6% of the long term absence episodes were preceded by working up to 25% of the previous seven days.

Table 6.5  Proportion of shift characteristics worked in the past seven days and short term and long term sickness absence

<table>
<thead>
<tr>
<th>Proportion of long shifts worked over past 7 days</th>
<th>Short term sickness absence n (%)</th>
<th>Long term sickness absence n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>2596 (46.8)</td>
<td>1236 (48.8)</td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>155 (2.7)</td>
<td>56 (2.2)</td>
</tr>
<tr>
<td>&gt;25 - ≤50%</td>
<td>558 (9.9)</td>
<td>199 (7.9)</td>
</tr>
<tr>
<td>&gt;50 - ≤75%</td>
<td>433 (7.7)</td>
<td>179 (7.1)</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>1813 (32.9)</td>
<td>865 (34.1)</td>
</tr>
<tr>
<td>Total</td>
<td>5555 (100)</td>
<td>2535 (100)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proportion of night shifts worked over past 7 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short term sickness absence n (%)</td>
</tr>
<tr>
<td>----------------------------------</td>
</tr>
<tr>
<td>0%</td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
</tr>
<tr>
<td>&gt;25 - ≤50%</td>
</tr>
<tr>
<td>&gt;50 - ≤75%</td>
</tr>
<tr>
<td>&gt;75%</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
### 6.2.2 Sickness absence and shift characteristics at the nurse level

While the previous sections reported analyses at the shift level, this section reports the distribution of shift characteristics and the average number of sickness episodes at the nurse level. All shifts were aggregated at the nurse level, meaning the unit of analysis here is nursing staff members. There are overall 1944 nursing staff members. Table 6.6 reports that nurses who worked no 12 hours or more shifts experienced on average 2.9 sickness episodes each. This is lower than the averages for nurses working long shifts in any proportion higher than 0%. The lowest average number of sickness absence episodes was found for nursing staff members working >75% of their shifts as overtime (0.7), while the highest average was found for nursing staff members working between >0 - ≤25% of their shifts as overtime (5.1). The highest average of number of sickness episodes was found for nursing staff members working on fixed night patterns (4.5) and the lowest average was observed for those working on a fixed day pattern.

<table>
<thead>
<tr>
<th>Proportion of overtime shifts worked over past 7 days</th>
<th>0%</th>
<th>&gt;0 - ≤25%</th>
<th>&gt;25 - ≤50%</th>
<th>&gt;50 - ≤75%</th>
<th>&gt;75%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>4305 (77.2)</td>
<td>1037 (18.0)</td>
<td>37 (0.6)</td>
<td>31 (0.5)</td>
<td>1873 (73.9)</td>
<td></td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>130 (2.3)</td>
<td>40 (0.7)</td>
<td>34 (1.3)</td>
<td>130 (2.3)</td>
<td>34 (1.3)</td>
<td></td>
</tr>
<tr>
<td>&gt;25 - ≤50%</td>
<td>332 (5.9)</td>
<td>106 (1.9)</td>
<td>116 (4.6)</td>
<td>332 (5.9)</td>
<td>116 (4.6)</td>
<td></td>
</tr>
<tr>
<td>&gt;50 - ≤75%</td>
<td>184 (3.3)</td>
<td>50 (0.9)</td>
<td>84 (3.3)</td>
<td>184 (3.3)</td>
<td>84 (3.3)</td>
<td></td>
</tr>
<tr>
<td>&gt;75%</td>
<td>604 (11.3)</td>
<td>156 (2.8)</td>
<td>428 (16.9)</td>
<td>604 (11.3)</td>
<td>428 (16.9)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5555 (100)</td>
<td>1493 (26.6)</td>
<td>2535 (100)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proportion of days worked over past 7 days</th>
<th>0%</th>
<th>&gt;0 - ≤25%</th>
<th>&gt;25 - ≤50%</th>
<th>&gt;50 - ≤75%</th>
<th>&gt;75%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>5190 (93.0)</td>
<td>2062 (37.9)</td>
<td>2392 (94.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>167 (3.3)</td>
<td>67 (1.2)</td>
<td>72 (2.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;25 - ≤50%</td>
<td>141 (2.7)</td>
<td>53 (2.1)</td>
<td>141 (2.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;50 - ≤75%</td>
<td>19 (0.3)</td>
<td>11 (0.4)</td>
<td>19 (0.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;75%</td>
<td>38 (0.7)</td>
<td>7 (0.3)</td>
<td>38 (0.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5555 (100)</td>
<td>5555 (100)</td>
<td>2535 (100)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6.2.2 Sickness absence and shift characteristics at the nurse level</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>4305 (77.2)</td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>130 (2.3)</td>
</tr>
<tr>
<td>&gt;25 - ≤50%</td>
<td>332 (5.9)</td>
</tr>
<tr>
<td>&gt;50 - ≤75%</td>
<td>184 (3.3)</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>604 (11.3)</td>
</tr>
<tr>
<td>Total</td>
<td>5555 (100)</td>
</tr>
</tbody>
</table>

While the previous sections reported analyses at the shift level, this section reports the distribution of shift characteristics and the average number of sickness episodes at the nurse level. All shifts were aggregated at the nurse level, meaning the unit of analysis here is nursing staff members. There are overall 1944 nursing staff members. Table 6.6 reports that nurses who worked no 12 hours or more shifts experienced on average 2.9 sickness episodes each. This is lower than the averages for nurses working long shifts in any proportion higher than 0%. The lowest average number of sickness absence episodes was found for nursing staff members working >75% of their shifts as overtime (0.7), while the highest average was found for nursing staff members working between >0 - ≤25% of their shifts as overtime (5.1). The highest average of number of sickness episodes was found for nursing staff members working on fixed night patterns (4.5) and the lowest average was observed for those working on a fixed day pattern.
Table 6.6  Average number of sickness episodes per nurse by proportion of 12 hours or more shifts, overtime, rotating status

<table>
<thead>
<tr>
<th>Percentage of nursing staff members working ≥12-h shifts</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>&gt;0 - ≤25%</td>
<td>&gt;25 - ≤75%</td>
<td>&gt;75%</td>
</tr>
<tr>
<td>Average number of sickness episodes</td>
<td>2.9</td>
<td>4.8</td>
<td>3.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage of nursing staff members working overtime</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>&gt;0 - ≤25%</td>
<td>&gt;25 - ≤75%</td>
<td>&gt;75%</td>
</tr>
<tr>
<td>Average number of sickness episodes</td>
<td>3.8</td>
<td>5.1</td>
<td>2.77</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nursing staff working on rotation status</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed day</td>
<td>3.7</td>
<td>4.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Rotating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed night</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.3  Generalised linear mixed models of the association between shift characteristics and sickness absence

Having looked at descriptive findings and simple cross tabulations, this section presents the findings from the generalised linear mixed models examining the association between nurses’ scheduled shift length and sickness absence. It then moves on to measure the association between shift work characteristics worked in the past seven days and the likelihood of experiencing a sickness absence episode.

Shift characteristics worked in the past seven days were modelled with proportions categorised (i.e. 0%; >0 - ≤25%; >25 - ≤50%; >50 - ≤75%; >75%) and outputs of these models are then reported. Results of the subgroup analysis of short term and long term sickness absence are then presented.

To conclude the sickness absence findings, a section reports the outputs of generalised linear mixed models with sickness and shift data aggregated at the nurse level, using a cross-sectional design.
6.3.1 Scheduled shift length and sickness absence

This section reports the results of the generalised linear mixed model that measured the association between scheduled shift length and sickness absence. The level of clustering accounted for (i.e. random effect) was nurse ID. The likelihood of a shift being missed due to sickness absence based on the scheduled shift length varied across shift categories (see Table 6.7).

Table 6.7 Association between scheduled shift length and sickness absence

<table>
<thead>
<tr>
<th>Shift length categories</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 8-h shift (reference category)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;8-&lt;12 h</td>
<td>1.03</td>
<td>0.95-1.12</td>
</tr>
<tr>
<td>≥12-h</td>
<td>1.24*</td>
<td>1.16-1.31</td>
</tr>
</tbody>
</table>

Generalised linear mixed model; random effect: Nurse ID
* Statistically significant at p<0.05

If a shift was scheduled to be 12 hours or more in length, the odds of it being missed due to sickness absence were increased by 24%, when compared to a scheduled shift of eight hours or less (OR = 1.24; 95% CI: 1.13-1.28). Shifts scheduled to last more than eight but less than 12 hours were not significantly more likely to be missed due to sickness absence, compared to eight hours or less.

6.3.2 Shift characteristics worked in past seven days and sickness absence

The association between shift characteristics worked in the past seven days and experiencing a sickness episode was explored first with separate univariate models. These univariate analyses indicated that when the proportion of long shifts worked over the past seven days was >25%, the odds of experiencing sickness absence were increased. The highest likelihood of experiencing a sickness absence episode was found when nurses were working >75% of their shifts in the past seven days as 12 hours or more shifts (OR= 1.35; 95% CI: 1.26-1.46). The higher the number of shifts worked, the lower the likelihood of experiencing sickness absence. When more than 75% of the past seven days were worked, the odds of experiencing sickness absence were the lowest (OR= 0.61; 95% CI: 0.54-0.69). As regards night shift, a negative effect of night shifts on sickness absence was observed only when nurses were working >75% of their past shifts as night shifts (OR= 1.12; 95% CI: 1.04-1.22). When more than 75% of the shifts worked in the past seven days were overtime shifts, the likelihood of incurring in sickness absence was the lowest (OR= 0.26; 95% CI: 0.19-0.35). The full univariate model for overtime shifts can be found in Table 6.8.
Table 6.8  Association between overtime working in the past seven days and sickness absence

<table>
<thead>
<tr>
<th>Shift characteristic</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of overtime shifts over shifts worked in last 7 days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0% (reference category)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>0.71*</td>
<td>0.62-0.81</td>
</tr>
<tr>
<td>&gt;25 - ≤50%</td>
<td>0.68*</td>
<td>0.59-0.80</td>
</tr>
<tr>
<td>&gt;50 - ≤75%</td>
<td>0.59*</td>
<td>0.41-0.84</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>0.26*</td>
<td>0.19-0.35</td>
</tr>
</tbody>
</table>

* Statistically significant at p<0.05

The multivariable model combining all shift characteristics did not converge; therefore, based on the AIC and BIC results, the final model could not include proportion of overtime. Included variables were proportion of 12 hours or more shifts over shifts worked in the past seven days, proportion of worked shifts over the past seven days, proportion of night shifts over shifts worked in the past seven days, while controlling for nurse grade. Proportion of overtime was not included in the final model. All Odds Ratios, adjusted Odds Ratios and 95% Confidence intervals of these associations can be found at Table 6.9.

Table 6.9  Unadjusted and fully adjusted odds ratios of the association between shift characteristics and sickness absence

<table>
<thead>
<tr>
<th>Shift characteristics</th>
<th>OR</th>
<th>95% CI</th>
<th>aOR†</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of ≥12-h shifts over shifts worked in past 7 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0% reference category)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;0% - ≤25%</td>
<td>1.01</td>
<td>0.88-1.16</td>
<td>1.12</td>
<td>0.97-1.29</td>
</tr>
<tr>
<td>&gt;25% - ≤50%</td>
<td>1.27*</td>
<td>1.17-1.38</td>
<td>1.26*</td>
<td>1.15-1.37</td>
</tr>
<tr>
<td>&gt;50% - ≤75%</td>
<td>1.14*</td>
<td>1.04-1.26</td>
<td>1.16*</td>
<td>1.05-1.28</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>1.35*</td>
<td>1.26-1.45</td>
<td>1.27*</td>
<td>1.18-1.37</td>
</tr>
<tr>
<td>Proportion of days worked over past 7 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(25% reference category)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;25% - ≤50%</td>
<td>0.90*</td>
<td>0.85-0.96</td>
<td>0.91*</td>
<td>0.86-0.97</td>
</tr>
<tr>
<td>&gt;50% - ≤75%</td>
<td>0.74*</td>
<td>0.69-0.78</td>
<td>0.77*</td>
<td>0.73-0.82</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>0.61*</td>
<td>0.54-0.69</td>
<td>0.66*</td>
<td>0.58-0.75</td>
</tr>
</tbody>
</table>
Proportion of night shifts over shifts worked in past 7 days

(0% reference category)

<table>
<thead>
<tr>
<th>Proportion of long shifts worked in past 7 days</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;0% - ≤25%</td>
<td>0.81*</td>
<td>0.69-0.94</td>
<td>0.91</td>
<td>0.78-1.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;25% - ≤50%</td>
<td>1.09</td>
<td>0.99-1.21</td>
<td>1.11</td>
<td>1.00-1.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;50% - ≤ 75%</td>
<td>1.00</td>
<td>0.88-1.13</td>
<td>1.06</td>
<td>0.94-1.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;75%</td>
<td>1.12*</td>
<td>1.04-1.22</td>
<td>1.12*</td>
<td>1.03-1.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Nurse Grade

Healthcare Assistant (HCA) (Reference category)

Registered Nurse (RN)

| Nurse Grade                   | 0.66* | 0.58-0.74 | 0.65* | 0.58-0.73 |

Generalised linear mixed model; random effect: Nurse ID

* Statistically significant at p<0.05

† Adjusted Odds Ratio, model controlling simultaneously for proportion of long shifts worked in the past 7 days, proportion of days worked over the past 7 days, proportion of night shifts worked in the past 7 days

Some of the associations observed in the univariate models were attenuated when combining all shift characteristics together in the multivariable model. If more than 75% of shifts worked in the 7 days previous to a sickness episode were 12 hours or more in length, the odds of experiencing a sickness episode were increased by 27%, compared to working no 12 hours or more shifts (OR= 1.27; 95% CI: 1.18-1.37).

This finding shows that working long shifts in the past seven days does not have a linear effect on sickness absence. Therefore, a model with a quadratic term for proportion of long shifts was fitted. This model was able to control for proportion of days worked, proportion of night shifts and nurse grade and had nursing staff ID as random effect. It can be found in Table 6.10 and Figure 6.2.

Table 6.10 Association between proportions of long shifts worked in the past seven days as quadratic term on sickness absence

<table>
<thead>
<tr>
<th>Proportion of long shifts worked in past 7 days</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
<td>1.00</td>
<td>1.05</td>
<td>1.09</td>
<td>1.13</td>
<td>1.16</td>
<td>1.19</td>
<td>1.22</td>
<td>1.24</td>
<td>1.26</td>
<td>1.27</td>
<td>1.27</td>
</tr>
</tbody>
</table>
The analysis showed that the quadratic term was not significant (OR= 0.79, 95% CI: 0.57 - 1.01), while the linear term was (OR= 1.60, 95% CI: 1.17-1.46). Table 6.10 and Figure 6.2 show that the effect of proportion of long shifts is linear up to 90% and then flattens out without decreasing. This suggests that a linear effect of proportion of long shifts on short term sickness absence is plausible.

The higher the proportion of days worked in the past seven days, the lower the odds of calling in sick; if nurses worked >75% of the past seven days, the likelihood of experiencing a sickness episode was reduced by 34% (OR=0.66; 95% CI: 0.58-0.75), compared to working >0-≤25% of the 7 day. Working a higher proportion of night shifts, in comparison to working no night shifts, remained associated with an increased likelihood of calling in sick only for nurses working >75% of their shifts in the past seven days as night shifts (OR= 1.12; 95% CI: 1.03-1.21). Registered nurses were less likely to experience sickness, compared to HCAs (OR= 0.65; 95% CI: 0.58-0.73).

In summary, these analyses showed that working any 12 hours or more shifts in the past seven days was associated with increased odds of sickness absence and working >75% of shifts as night shifts was associated with an increased likelihood of experience sickness absence.

Since night shifts in the sample were longer in length (67.3% of night shifts lasted 12 hours or more), the models were ran with interaction terms between long shifts and night
shifts but the relationship was not significant (OR= 0.99, 95% CI: 0.98-1.00). This indicates that the effect of the proportion of long shifts on sickness absence does not vary as a function of the proportion of night shifts. Therefore, the relationship between the proportion of long shifts and sickness absence did not differ depending on the proportion of night shifts worked over the past seven days.

The full model is reported in Table 6.11.

Table 6.11 Model outputs of the association between shift characteristics and sickness absence, with interaction term of proportion of long shifts and proportion of night shifts

<table>
<thead>
<tr>
<th>Shift characteristics</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of long shifts</td>
<td>1.03*</td>
<td>1.01-1.05</td>
</tr>
<tr>
<td>Proportion of night shifts</td>
<td>1.02</td>
<td>0.99-1.05</td>
</tr>
<tr>
<td>Interaction</td>
<td>0.99</td>
<td>0.98-1.00</td>
</tr>
</tbody>
</table>

The literature suggests that working 12-hour shifts is associated with a compressed working week, namely working longer but fewer days (Bambra et al. 2008); therefore, the interaction between the proportion of long shifts and the proportion of worked days was explored, but the model did not converge. In order to explore a possible correlation between long shifts and days worked, the Pearson correlation coefficient was calculated. The Pearson correlation coefficient between long shifts and worked days was 0.20, indicating a weak correlation (Taylor 1990). This indicates that working a higher number of long days is slightly correlated with working a higher number of days, contrarily to what the literature on the compressed work week suggests.

Because the proportion of days worked in the past seven days could be confounded by sickness shifts, a sensitivity analysis was performed adding proportion of sick days in the past seven days to the model. This did not alter the results.

6.4 Generalised linear mixed models of the association between shift characteristics and short term and long term sickness absence

A subgroup analysis was performed to examine any differences between short term and long term sickness absence and their association with shift characteristics. A short term sickness episode was defined as a sickness episode lasting less than seven consecutive days. Overall, there were 5555 short term sickness episodes and 2535 long sickness episodes during the three years’ study period.
6.4.1 Scheduled shift length and short term and long term sickness absence

A further generalised linear mixed model assessed the relationship between short term sickness absence and scheduled shift length of the first day of the sickness episode, and it was replicated for scheduled shift length of the first day of the sickness episodes and long term sickness absence. Outputs of these models are summarised in Table 6.12.

Table 6.12 Association between scheduled shift length and short term and long term sickness absence

<table>
<thead>
<tr>
<th>Scheduled shift length</th>
<th>Long term sickness absence (≥7 days)</th>
<th>OR</th>
<th>95% CI</th>
<th>Short term sickness absence (&lt;7 days)</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 8-h shift (reference category)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;8-&lt;12 h</td>
<td>1.27*</td>
<td>1.11-1.46</td>
<td>0.92</td>
<td>0.83-1.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥12-h</td>
<td>1.37*</td>
<td>1.23-1.53</td>
<td>1.18*</td>
<td>1.10-1.26</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Generalised linear mixed model; random effect: Nurse ID
* Statistically significant at p<0.05

Results illustrate that if a shift was scheduled to be 12 hours or more in length, it was more likely to be missed and result in a short term sickness absence, compared to an eight hours or less shift (OR = 1.18, 1.10-1.26). This association was attenuated, compared to the overall sickness episodes’ sample (overall sickness episodes: OR=1.24; 95% CI: 1.16-1.31).

Any shift scheduled to be longer than 8 hours was more likely to be missed and result in a long term sickness absence episode, compared to an eight hours or less shift. The association between a planned shift of between eight and 12 hours and sickness absence strengthened and became significant in the long term subgroup, compared to both overall sample and the short term subgroup, where it was lower and not significant. If a shift was planned to be 12 hours or more in length, it was more likely to be missed and result in a long term sickness episode, compared to an eight hours or less shift (OR= 1.37, 1.23-1.53). This association strengthened in the long term absence subgroup, compared to the overall sickness episodes’ sample (overall sickness episodes: OR= 1.24; 95% CI: 1.16-1.31).
6.4.2 Shift characteristics worked in past seven days and short term and long term sickness absence

The association of shift characteristics worked in the past seven days and short term and long term sickness episodes was measured by multivariable models and results can be found at Table 6.13.

Table 6.13 Associations between shift characteristics worked in the past seven days and short term and long term sickness absence

<table>
<thead>
<tr>
<th>Proportion of ≥12-h shifts over shifts worked in past 7 days</th>
<th>Long term sickness absence (≥7 days)</th>
<th>Short term sickness absence (&lt;7 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% (reference category)</td>
<td>aOR† 95% CI</td>
<td>aOR† 95% CI</td>
</tr>
<tr>
<td>&gt;0 - ≤25%</td>
<td>1.14 0.87-1.51</td>
<td>1.11 0.94-1.31</td>
</tr>
<tr>
<td>&gt;25 - ≤50%</td>
<td>1.12 0.95-1.32</td>
<td>1.30* 1.18-1.44</td>
</tr>
<tr>
<td>&gt;50 - ≤75%</td>
<td>1.18 0.99-1.41</td>
<td>1.14* 1.02-1.27</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>1.22* 1.08-1.37</td>
<td>1.28* 1.18-1.39</td>
</tr>
</tbody>
</table>

| Proportion of days worked over last 7 days                 |                                          |                                      |
| (25% reference category)                                 |                                          |                                      |
| >25% - ≤50%                                              | 0.86* 0.77-0.95                       | 0.92 0.86-1.00                       |
| >50% - ≤75%                                              | 0.65* 0.58-0.73                       | 0.81* 0.75-0.87                     |
| >75%                                                     | 0.60* 0.47-0.77                       | 0.67* 0.58-0.78                     |

| Proportion of night shifts over shifts worked in last 7 days |                                          |                                      |
| (0% reference category)                                   |                                          |                                      |
| >0% - ≤25%                                               | 0.72 0.51-1.01                        | 0.97 0.81-1.15                       |
| >25% - ≤50%                                              | 1.04 0.85-1.26                       | 1.16* 1.03-1.30                     |
| >50% - ≤75%                                              | 1.18 0.93-1.49                       | 1.01 0.87-1.17                      |
| >75%                                                     | 1.31* 1.15-1.50                      | 1.02 0.92-1.13                      |

| Nurse Grade                                               |                                          |                                      |
| Healthcare Assistant (HCA) (Reference category)           |                                          |                                      |
| Registered Nurse (RN)                                     | 0.58* 0.50-0.67                       | 0.67* 0.59-0.76                     |
Generalised linear mixed model; random effect: Nurse ID

† Adjusted Odds Ratio: all generalised linear mixed models controlling for proportion of night shifts worked over past 7 days; proportion of worked shifts over past 7 days; nurse grade (HCA vs RN)

* Statistically significant at p<0.05

Results of shift characteristics worked in the past seven days and short sickness absence mirror those from the overall sample; working a higher proportion of long shifts (≥12-h) in the past seven days was associated with a higher likelihood of calling in sick, and the highest odds were observed for nurses working between >25% and ≤50% of their previous seven days as long shifts (OR= 1.30; 95% CI: 1.18-1.44). This finding shows that working long shifts in the past seven days does not have a linear effect on sickness absence. Therefore, a model with a quadratic term for proportion of long shifts was fitted. This model was able to control for proportion of days worked, proportion of night shifts and nurse grade and had nursing staff ID as random effect. It can be found in Table 6.14 and Figure 6.3.

The analysis showed that the quadratic term was not significant (OR= 0.76, 95% CI: 0.54 - 1.02), while the linear term was (OR= 1.33, 95% CI: 1.25-1.42). Table 6.14 and Figure 6.3 show that the effect of proportion of long shifts is linear up to 80% and then flattens out without decreasing. This suggests that a linear effect of proportion of long shifts on short term sickness absence is plausible.

<table>
<thead>
<tr>
<th>Proportion of long shifts worked in past 7 days</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
<td>1.00</td>
<td>1.05</td>
<td>1.09</td>
<td>1.13</td>
<td>1.17</td>
<td>1.20</td>
<td>1.22</td>
<td>1.24</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
</tr>
</tbody>
</table>
Working >0% of shifts in the past seven days as 12 hours or more shifts was associated with an increased likelihood to experience a long term sickness absence episode, but it was significant only for working >75% of long shifts (OR=1.22; 95% CI: 1.08-1.37), and this association was attenuated compared to the overall sample (see Table 6.7) and short term subgroup.

Decreased odds of experiencing a short term sickness episode were found when working a higher proportion of days in the past seven days (OR= 0.67; 95% CI: 0.58-0.78). The effect of proportion of night shifts was modified in the short term sickness absence subgroup: the only significant effect was found for nurses working between >25% and ≤50% of their previous seven days as night shifts (OR= 1.16; 95% CI: 1.03-1.30). Working any proportion of shifts over the past seven days higher than >25% was associated with a decrease in the likelihood of experiencing a long term sickness absence episode, with the lowest odds observed when the proportion was >75% (OR= 0.60; 95% CI: 0.47-0.77). This association strengthened compared to the one observed in the overall sample (see Table 6.7) and short term subgroup.

Only working >75% of shifts in the past seven days as night shifts was associated with a higher likelihood of experiencing a long term sickness absence episode (OR=1.31; 95% CI: 1.15-1.5), and this association strengthened compared to the overall sample (Table 6.7) and short term subgroup, where it was not significant. The only significant association in this subgroup was for working between >25% and ≤50% of shifts as night shifts in the past seven days.
The effect of nurse grade was attenuated for short term sickness absence, but remained significant with RNs less likely to experience a short term sickness episode by 33%, compared to HCAs (OR= 0.67, 95 CI: 0.59-0.76). Being a registered nurse was associated with a decreased likelihood of experiencing a long term sickness episode (OR = 0.58, 95 CI: 0.50-0.67).

### 6.5 Generalised linear mixed models of the association between shift characteristics and number of sickness episodes at the nurse level

The last series of analysis of shift work characteristics and sickness absence was developed with a different approach, aiming to aggregate shift characteristics at the nurse level. This approach allowed making inferences at the level of individual nursing staff members, for example by taking into account whether a nurse worked as part of a rotating schedule, or a fixed day or night schedule.

The association of shift characteristics at the nurse level was first explored through three univariate models with a Poisson distribution, which can be found in Table 6.15.

<table>
<thead>
<tr>
<th>Proportion of ≥12-h shifts</th>
<th>RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0% reference category)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;0-≤25%</td>
<td>1.58*</td>
<td>1.39-1.79</td>
</tr>
<tr>
<td>&gt;25-≤75%</td>
<td>1.27*</td>
<td>1.14-1.41</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>1.34*</td>
<td>1.02-1.77</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proportion of overtime shifts</th>
<th>RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0% reference category)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;0-25%</td>
<td>1.35*</td>
<td>1.19-1.53</td>
</tr>
<tr>
<td>&gt;25-≤75%</td>
<td>0.73*</td>
<td>0.65-0.81</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>0.18*</td>
<td>0.14-0.24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fixed vs rotating schedule</th>
<th>RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed day (reference category)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotating</td>
<td>1.19*</td>
<td>1.05-1.34</td>
</tr>
<tr>
<td>Fixed night</td>
<td>1.16*</td>
<td>1.04-1.29</td>
</tr>
</tbody>
</table>
If a nurse worked any 12 hours or more shifts during the study years, the number of sickness episodes they were experiencing was more likely to increase, compared to nurses who never worked a 12 hours or more shift.

When a nurse worked between >0% and 25% of their shifts as overtime shifts, they were more likely to experience a higher number of sickness episodes (RR = 1.35; 95% CI: 1.19-1.53), while if they were working any proportion of >25% of their shifts as overtime, they were more likely to experience a lower number of sickness episodes, with lowest RR for nurses working >75% of their shift as overtime shifts (RR= 0.18; 95% CI: 0.14-0.24).

Working as part of a rotating schedule was associated with experiencing more sickness episodes, compared to working as part of a fixed day schedule (RR= 1.19, 95% CI: 1.05-1.34). Similarly, working as part of a fixed night schedule was associated with experiencing more sickness absence episodes, compared to working as part of a fixed day schedule (RR= 1.16, 95% CI: 1.04-1.29).

These shift characteristics were combined in a single multivariable model, which took nurse grade into account. The output of this model can be found in Table 6.16.

Table 6.16 Multivariable analysis of the association between nurses' shift characteristics and number of sickness episodes

<table>
<thead>
<tr>
<th>Proportion of ≥12-h shifts</th>
<th>RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0% reference category)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;0-≤25%</td>
<td>1.45*</td>
<td>1.33-1.58</td>
</tr>
<tr>
<td>&gt;25-≤75%</td>
<td>1.15*</td>
<td>1.05-1.26</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>1.20*</td>
<td>1.07-1.34</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proportion of overtime shifts</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(0% reference category)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;0-25%</td>
<td>1.29*</td>
<td>1.23-1.35</td>
</tr>
<tr>
<td>&gt;25-≤50%</td>
<td>0.70*</td>
<td>0.62-0.80</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>0.17*</td>
<td>0.09-0.32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fixed vs Rotating schedule</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed day (reference category)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotating</td>
<td>1.10*</td>
<td>1.03-1.16</td>
</tr>
<tr>
<td>Fixed night</td>
<td>1.08</td>
<td>0.98-1.20</td>
</tr>
</tbody>
</table>

* Statistically significant at p<0.05
<table>
<thead>
<tr>
<th>Grade</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HCA (reference category)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RN</td>
<td>0.74*</td>
<td>0.71-0.78</td>
</tr>
</tbody>
</table>

* Statistically significant at p<0.001

Most of the observed associations remained significant in the multivariable model; however, working as part of a fixed night schedule was no longer significant.

Nurse grade was associated with number of sickness episodes: a registered nurse was more likely to experience a lower number of sickness episodes, compared to a healthcare assistant.
6.6 Chapter summary

This chapter provided a comprehensive report of the association between shift characteristics and sickness absence. Key findings include:

- Overall, within the three study years, 37,691 shifts were lost due to sickness and 360 shifts were missed due to unauthorised absence, corresponding to 8090 sickness episodes.
- Sickness absence rates varied across the years and according to staff grade (i.e. RN vs HCA).
- If a shift was scheduled to be 12 hours or more in length, it was more likely to be missed due to sickness, in comparison to shifts of eight hours or less. This was observed in the overall sample, in the short term sickness subgroup and in the long term sickness subgroup.
- When a higher proportion of 12 hours or more shifts was worked in the past seven days, it was more likely to be followed by sickness absence, both in the overall sample and in long term/short term sub samples.
- Nursing staff working a larger proportion of 12 hours or more shifts was associated with an increased number of sickness episodes, compared to working no 12 hours or more shifts at all.
- At the nurse level, working rotating shifts was associated with an increased number of sickness episodes.
Chapter 7  Shift work characteristics and delayed/missed vital signs observations

7.1  Introduction

This chapter presents findings regarding the analysis of nurses’ shift characteristics and delayed/missed vital signs observations.

After reporting descriptive data of delayed/missed vital signs observation, a further section reports findings of the association of the ward-day percentage of nursing hours per patient day (NHPPD) deriving from 12 hour shifts and delayed/missed vital signs observations.

This association was explored though generalised linear mixed models with a Poisson distribution, and RN and HCA hours per patient day (RN-HPPD and HCA-HPPD) were considered separately.

7.2  Delayed/missed vital signs observations descriptive findings

This section reported descriptive findings of the distribution of delayed and missed vital signs observations. Overall, 3,224,810 patient observation were extracted from the VitalPac™ dataset. The frequency of patient observations timeliness is reported in Table 7.1.

Table 7.1  Frequency of timeliness of patient vital signs observations

<table>
<thead>
<tr>
<th>Degree of timeliness/lateness n (%)</th>
<th>On time</th>
<th>Delayed (&gt;1/3 of TTNO†)</th>
<th>Missed (&gt;2/3 of TTNO)</th>
<th>Total*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,614,066 (50.1)</td>
<td>433,300 (13.4)</td>
<td>508,308 (15.8)</td>
<td>3,224,810 (100)</td>
<td></td>
</tr>
</tbody>
</table>

† TTNO = Time to next observation

* Total is greater than the sum of on time, delayed and missed observations because non-relevant observations were omitted from this table

The majority of the observations within the three study years were classified as on time (50.1%), while 13.4% observations were delayed and 15.8% were missed.
Timeliness of observations was explored by ward and its summary can be found in Table 7.2. For reporting purposes, non-relevant (NR) observations were dropped from this table; therefore, the sum of delayed, missed and on time observations does not match with the total observations recorded in each ward.

Table 7.2  Timeliness of patient vital signs observations by ward

<table>
<thead>
<tr>
<th>Ward</th>
<th>Delayed n (%)</th>
<th>Missed n (%)</th>
<th>On time n (%)</th>
<th>Total* n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20,472 (17.0)</td>
<td>31,250 (25.9)</td>
<td>50,862 (42.1)</td>
<td>120,762 (100)</td>
</tr>
<tr>
<td>2</td>
<td>23,037 (20.7)</td>
<td>27,389 (24.6)</td>
<td>36,619 (32.8)</td>
<td>111,480 (100)</td>
</tr>
<tr>
<td>3</td>
<td>11,997 (11.4)</td>
<td>14,342 (13.6)</td>
<td>59,073 (55.9)</td>
<td>105,616 (100)</td>
</tr>
<tr>
<td>4</td>
<td>21,419 (12.5)</td>
<td>19,281 (11.2)</td>
<td>99,464 (57.9)</td>
<td>171,681 (100)</td>
</tr>
<tr>
<td>5</td>
<td>10,195 (13.7)</td>
<td>14,353 (19.4)</td>
<td>37,318 (50.3)</td>
<td>74,155 (100)</td>
</tr>
<tr>
<td>6</td>
<td>16,925 (17.3)</td>
<td>17,689 (18.1)</td>
<td>45,049 (46.1)</td>
<td>97,898 (100)</td>
</tr>
<tr>
<td>7</td>
<td>17,749 (16.2)</td>
<td>15,730 (14.4)</td>
<td>61,657 (56.3)</td>
<td>109,444 (100)</td>
</tr>
<tr>
<td>8</td>
<td>12,179 (13.2)</td>
<td>10,060 (10.9)</td>
<td>54,969 (59.4)</td>
<td>92,487 (100)</td>
</tr>
<tr>
<td>9</td>
<td>9751 (8.9)</td>
<td>12,277 (11.2)</td>
<td>70,384 (64.4)</td>
<td>109,280 (100)</td>
</tr>
<tr>
<td>10</td>
<td>14,817 (13.9)</td>
<td>17,834 (16.7)</td>
<td>49,913 (46.8)</td>
<td>106,637 (100)</td>
</tr>
<tr>
<td>11</td>
<td>15,711 (12.1)</td>
<td>11,439 (8.8)</td>
<td>82,903 (63.7)</td>
<td>130,161 (100)</td>
</tr>
<tr>
<td>12</td>
<td>17,638 (12.9)</td>
<td>14,617 (10.7)</td>
<td>85,508 (62.3)</td>
<td>137,233 (100)</td>
</tr>
<tr>
<td>13</td>
<td>21,674 (16.9)</td>
<td>39,174 (30.6)</td>
<td>42,575 (33.3)</td>
<td>127,926 (100)</td>
</tr>
<tr>
<td>14</td>
<td>3528 (15.6)</td>
<td>10,391 (45.9)</td>
<td>4814 (21.3)</td>
<td>22,648 (100)</td>
</tr>
<tr>
<td>15</td>
<td>12,095 (12.6)</td>
<td>14,889 (15.5)</td>
<td>42,600 (44.3)</td>
<td>96,185 (100)</td>
</tr>
<tr>
<td>16</td>
<td>8944 (17.4)</td>
<td>18,727 (36.4)</td>
<td>14,770 (28.7)</td>
<td>51,444 (100)</td>
</tr>
<tr>
<td>17</td>
<td>22,045 (21.5)</td>
<td>20,255 (19.8)</td>
<td>37,981 (37.0)</td>
<td>102,543 (100)</td>
</tr>
<tr>
<td>18</td>
<td>2099 (16.7)</td>
<td>2060 (16.4)</td>
<td>5560 (44.3)</td>
<td>12,551 (100)</td>
</tr>
<tr>
<td>19</td>
<td>20,962 (20.6)</td>
<td>19,484 (19.2)</td>
<td>38,826 (38.2)</td>
<td>101,662 (100)</td>
</tr>
<tr>
<td>20</td>
<td>16,113 (17.6)</td>
<td>19,070 (20.9)</td>
<td>32,977 (36.1)</td>
<td>91,345 (100)</td>
</tr>
<tr>
<td>21</td>
<td>10,219 (19.3)</td>
<td>9016 (17.0)</td>
<td>18,575 (35.1)</td>
<td>52,908 (100)</td>
</tr>
<tr>
<td>22</td>
<td>5950 (12.2)</td>
<td>6415 (13.2)</td>
<td>28,463 (58.5)</td>
<td>48,636 (100)</td>
</tr>
<tr>
<td>Ward</td>
<td>Delayed n (%)</td>
<td>Missed n (%)</td>
<td>On time n (%)</td>
<td>Total* n (%)</td>
</tr>
<tr>
<td>------</td>
<td>---------------</td>
<td>--------------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>23</td>
<td>10,574 (11.4)</td>
<td>10,016 (10.8)</td>
<td>60,344 (64.9)</td>
<td>92,983 (100)</td>
</tr>
<tr>
<td>25</td>
<td>5347 (8.7)</td>
<td>5894 (9.6)</td>
<td>38,818 (62.9)</td>
<td>61,691 (100)</td>
</tr>
<tr>
<td>26</td>
<td>13,621 (14.8)</td>
<td>10,942 (11.9)</td>
<td>47,744 (51.7)</td>
<td>92,323 (100)</td>
</tr>
<tr>
<td>27</td>
<td>24,030 (8.5)</td>
<td>20,821 (7.3)</td>
<td>124,967 (44.0)</td>
<td>284,219 (100)</td>
</tr>
<tr>
<td>28</td>
<td>4514 (10.4)</td>
<td>4076 (9.4)</td>
<td>27,574 (63.3)</td>
<td>43,584 (100)</td>
</tr>
<tr>
<td>29</td>
<td>19,991 (14.4)</td>
<td>53,889 (38.8)</td>
<td>42,098 (30.3)</td>
<td>138,793 (100)</td>
</tr>
<tr>
<td>29</td>
<td>6764 (10.0)</td>
<td>6205 (9.2)</td>
<td>45,707 (67.4)</td>
<td>67,772 (100)</td>
</tr>
<tr>
<td>30</td>
<td>11,331 (8.4)</td>
<td>6557 (4.9)</td>
<td>87,568 (65.3)</td>
<td>134,157 (100)</td>
</tr>
<tr>
<td>31</td>
<td>4553 (4.2)</td>
<td>6110 (5.7)</td>
<td>81,512 (75.7)</td>
<td>107,706 (100)</td>
</tr>
<tr>
<td>32</td>
<td>17,056 (13.4)</td>
<td>18,056 (14.2)</td>
<td>56,874 (44.8)</td>
<td>127,059 (100)</td>
</tr>
</tbody>
</table>

* Total is greater than the sum of on time, delayed and missed observations because the non-relevant observations were omitted from this table.

The ward with the highest scheduled observation compliance, namely, the highest number of observations on time, was Ward 31 (75.7%), while the ward with lowest percentage of observations recoded on time is Ward 14 (21.3%).

Ward 17 had the highest percentage of delayed observations (21.5%), while the lowest percentage was found in Ward 31 (4.2%). As far as missed observations are concerned, Ward 14 had the highest percentage (45.9%), while Ward 30 had the lowest percentage (4.9%).

Delayed/missed observations were also explored by scheduled interval, as reported in Figure 7.1. The numbers on the x-axis indicate the previous time to next observation in hours; 0.25 hours equals to 15 minutes, 0.5 equals to 30 minutes, 0.75 hours equals to 45 minutes.
Figure 7.1 shows that the more frequent the observations, the more the observations were missed (i.e. L2, red columns): when observations were due every 15 minutes, they were missed 60% of the times; when observations were scheduled every 30 minutes, they were missed 70% of the times.

On the other hand, when observations were less frequently scheduled, they were recorded on time: when observations were scheduled every 12 hours, they were on time more than 80% of the times. Frequency of observations is strongly related with patient acuity: the more critical the patient, the highest the frequency of vital signs observations (see Figure 3.4). This figures indicates that more acute patients were less likely to have their observations recorded in VitalPac™.

### 7.2.1 Delayed/missed vital signs observations in ward-days

Vital signs observations were aggregated at the ward-day level. Overall, the sample included 1,908,442 observations nested in 24,069 ward-days.

Since the multilevel analysis focused on delayed and missed observations in high and very high acuity patients (≥ 6 NEWS), the distributions of these observations are reported only. The total number of observations in high acuity patients was 184,628. The total
number of delayed observations in high acuity patients was 99,043, while the missed observations were 81,568.

7.2.2 Delayed/missed vital signs observations and nursing staff 12 hours or more shifts

This section summarises the descriptive findings regarding delayed/missed vital signs observations and nursing staff (RNs and HCAs) proportion of nursing hours per patient day (NHPPD) deriving from 12 hours or more shifts. For analysis purposes, the proportion of NHPPD deriving from 12 hours or more shifts is reported in four categories (i.e. 0-25%; >25-50%; >50-75%; >75%).

Table 7.3 summarises the distribution of delayed and missed observations by the proportion of RN-HPPD deriving from 12 hours or more shifts. When reading this table, it should be borne in mind that delayed observations and missed observations are not mutually exclusive categories.

Table 7.3 Distribution of proportion of delayed/missed vital signs observations by RN-HPPD deriving from 12 hours or more shifts

<table>
<thead>
<tr>
<th>Proportion of RN-HPPD from ≥12-hour shifts</th>
<th>Delayed observations n (%)</th>
<th>Missed observations n (%)</th>
<th>All Observations n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25%</td>
<td>23,150 (49.4)</td>
<td>18,725 (39.9)</td>
<td>46,822 (100)</td>
</tr>
<tr>
<td>&gt;25-50%</td>
<td>3180 (41.3)</td>
<td>2560 (33.2)</td>
<td>7690 (100)</td>
</tr>
<tr>
<td>&gt;50-75%</td>
<td>21,534 (49.7)</td>
<td>17,109 (39.4)</td>
<td>43,329 (100)</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>51,179 (59)</td>
<td>43,174 (49.7)</td>
<td>86,727 (100)</td>
</tr>
</tbody>
</table>

For registered nurses, most of the delayed and missed observations happened when >75% of the RN-HPPD were part of a 12 hours or more shift. The lowest amount of delayed and missed observations was found when >25-50% of the RN-HPPD were part of a 12 hours or more shift.

Table 7.4 reports the distribution of delayed and missed observations by the proportion of HCA-HPPD deriving from 12 hours or more shifts. The proportion of HCA-HPPD from 12 hours or more shifts are reported in four categories (0-25%; >25-50%; >50-75%; >75%).
Chapter 7

Table 7.4 Delayed/missed observations distribution by proportion of HCA-HPPD deriving from 12 hours or more shifts

<table>
<thead>
<tr>
<th>Proportion of HCA-HPPD from ≥12-hour shifts</th>
<th>Delayed observations n (%)</th>
<th>Missed observations n (%)</th>
<th>All Observations n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25%</td>
<td>23,859 (48.6)</td>
<td>19,263 (39.2)</td>
<td>49,076 (100)</td>
</tr>
<tr>
<td>&gt;25-50%</td>
<td>4027 (42.7)</td>
<td>3240 (34.3)</td>
<td>9434 (100)</td>
</tr>
<tr>
<td>&gt;50-75%</td>
<td>26,964 (52.9)</td>
<td>21,850 (42.9)</td>
<td>50,912 (100)</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>44,156 (58.7)</td>
<td>37,189 (49.5)</td>
<td>75,099 (100)</td>
</tr>
</tbody>
</table>

Similarly to the registered nurses’ scenario, the highest percentage of delayed and missed observations was observed when >75% of HCA-HPPD were worked as part of a 12 hours or more shift, while the lowest amount of missed and delayed observations was found when >25-50% of the HCA-HPPD were worked as part of a 12 hours or more shift.

7.3 Generalised linear mixed univariate models of the association between nursing hours per patient day\(^7\) from 12 hours or more shifts and delayed/missed vital signs observations

The final step of the analysis included examining the association between nursing hours per patient day deriving from 12 hours or more shifts and delayed/missed vital signs observations. The analysis focused on patients whose previous NEWS was ≥6, indicating that the patient was either at high or very high risk of deterioration (see Figure 3.4).

This analysis was performed at the ward-day level. RN-HPPD and HCA-HPPD deriving from 12 hours or more shifts as proportion of total RN-HPPD and HCA-HPPD were added, while controlling for total RN-HPPD and HCA-HPPD.

Before fitting the multivariable models, the univariate relationship between the proportion of RN-HPPD and HCA-HPPD deriving from 12 hours or more shifts and delayed/missed vital signs observations was explored. Since number of delayed and missed vital signs observations was a count outcome, all four models were fit with a Poisson distribution. All models included ward as a random effect.

---

\(^7\) Nursing hours per patient day (NHPPD) covers both RN-HPPD and HCA-HPPD
Table 7.5 reports the output of the two models investigating the association between the proportion of RN-HPPD and HCA-HPPD deriving from 12 hours or more shifts, delayed vital signs observations and missed vital signs observations.

<table>
<thead>
<tr>
<th>Delayed vital signs observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift characteristics</td>
</tr>
<tr>
<td>----------------------------------</td>
</tr>
<tr>
<td>Proportion of RN-HPPD deriving from ≥12-hour shifts</td>
</tr>
<tr>
<td>Proportion of HCA-HPPD deriving from ≥12-hour shifts</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Missed vital signs observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift characteristics</td>
</tr>
<tr>
<td>----------------------------------</td>
</tr>
<tr>
<td>RN-HPPD deriving from ≥12-hour shifts</td>
</tr>
<tr>
<td>HCA-HPPD deriving from ≥12-hour shifts</td>
</tr>
</tbody>
</table>

Neither proportion of RN-HPPD nor HCA-HPPD deriving from 12 hours or more shifts were associated with delayed vital signs observations. No association between neither RN-HPPD, nor HCA-HPPD deriving from 12 hours or more and missed vital signs observations was observed. These associations were then explored through multivariable generalised linear mixed models in section 7.4.

### 7.4 Generalised linear mixed multivariable models of the association between nursing hours per patient day from 12 hours or more shifts and delayed/missed vital signs observations

This section reports results of the multivariable generalised linear mixed models, which assessed the association between proportions of RN-HPPD, HCA-HPPD deriving from 12 hours or more shifts, delayed vital signs observations and missed vital signs observations. Results can be found in Table 7.6. All models controlled for RN-HPPD and HCA-HPPD and ward was included as random effects.
Table 7.6  Multivariable association between the proportions of RN-HPPD, HCA-HPPD deriving from 12 hours or more shifts and delayed/missed vital signs observations

<table>
<thead>
<tr>
<th>Shift characteristics</th>
<th>RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>RN-HPPD</td>
<td>0.99</td>
<td>0.98-1.00</td>
</tr>
<tr>
<td>Proportion of RN-HPPD deriving from ≥12-hour shifts</td>
<td>0.96</td>
<td>0.91-1.01</td>
</tr>
<tr>
<td>HCA-HPPD</td>
<td>1.00</td>
<td>0.99-1.01</td>
</tr>
<tr>
<td>Proportion of HCA-HPPD deriving from ≥12-hour shifts</td>
<td>1.05*</td>
<td>1.00-1.10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Shift characteristics</th>
<th>RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>RN-HPPD</td>
<td>0.98*</td>
<td>0.97-0.99</td>
</tr>
<tr>
<td>Proportion of RN-HPPD deriving from ≥12-hour shifts</td>
<td>0.96</td>
<td>0.91-1.01</td>
</tr>
<tr>
<td>HCA-HPPD</td>
<td>1.00</td>
<td>0.99-1.01</td>
</tr>
<tr>
<td>Proportion of HCA-HPPD deriving from ≥12-hour shifts</td>
<td>1.04</td>
<td>0.99-1.09</td>
</tr>
</tbody>
</table>

* Statistically significant at p< 0.05

Random effect: ward

The proportion of HCA-HPPD deriving from 12 hours or more shifts was found to be significantly associated with number of delayed vital signs observations. The higher the proportion of HCA-HPPD deriving from 12 hours or more shifts, the higher the number of delayed vital signs observations (RR = 1.05; 95% CI: 1.00-1.10). 1.05 is the estimated rate ratio for a 1% increase in the proportion of HCA-HPPD deriving from ≥12-hour shifts, given the other variables are held constant in the model. If HCA-HPPD deriving from ≥12-hour shifts were increased by 1%, the rate ratio for sickness absence would be expected to increase by 5%, while holding all other variables in the model constant.

Proportions of both RN-HPPD and HCA-HPPD deriving from 12 hours or more shifts were not significantly associated with missed vital signs observations.
7.5 Chapter summary

As regards delayed and missed vital signs observations, key findings are:

- Overall, 3,224,810 patient observation were extracted from the VitalPac™ dataset. The majority of the observations within the three study years were classified as on time (50.1%), while 13.4% observations were delayed and 15.8% were missed.
- The more frequent the observations were scheduled, the more they were missed.
- For both healthcare assistants and registered nurses, most of the delayed and missed observations happened when >75% of the ward nursing hours per patient day were part of a 12 hours or more shift.
- The association between RN-HPPD from 12 hours or more shifts and number of delayed and missed vital signs observations was not significant.
- A higher proportion of HCA-HPPD deriving from 12 hours or more shifts was associated with a higher number of delayed vital signs observations (RR=1.05; 95% CI: 1.00-1.10), but this association was not observed for missed vital signs observations.
Chapter 8 Discussion

In this discussion chapter, after summarising findings, results are reviewed to assess how they relate to previous studies and what they add to the current literature. A reflection on the methodological strengths and limitations that this study encountered is followed by its implications for future research and practice.

8.1 Summary of findings

The overarching aim of this thesis has been to measure the association between shift work characteristics, sickness absence and delayed/missed vital signs observations in a sample of registered nurses (RN) and healthcare assistants (HCA) on acute hospital wards. Specific aims were to:

- explore and describe the ward nurses’ shift work characteristics in the hospital, in terms of shift length, total hours worked, night shifts, overtime shifts
- measure the association between ward nurses’ shift work characteristics and sickness absence
- determine the association between ward nurses’ shift work characteristics and delayed/missed vital signs observations

This study found that 48% of the shifts lasted eight hours or less, with 38.5% lasting 12 hours or more. 13.5% lasted between 8 and 12 hours. The prevalence of shifts of 12 hours or more doubled across the three years, from 27.8% in year 1 to 54.8% in year 3. Most common shift length was eight hours or less for both overtime and contracted shifts, but overtime shifts had a higher percentage of 12 hours or more shifts. The majority of day shifts lasted eight hours or less, while the majority of night shifts were 12 hours or more in length. The majority of unqualified staff worked eight hours or less shifts, and the most common shift length for qualified staff was eight hours or less.

Overall, within the three study years, 37,691 shifts were lost due to sickness and 360 shifts were missed due to unauthorised absence, corresponding to 8090 sickness absence episodes.

Working night shifts was associated with a higher likelihood of experiencing sickness absence only when it was very frequent (i.e. more than 75% of shifts worked) in the past seven days. This finding was independent of shift length. Working a higher proportion of overtime shifts in the past seven days was associated with a reduced likelihood of experiencing sickness absence. This study found that if a shift was scheduled to be of 12 or more hours, it was more likely to be missed due to sickness absence, in comparison to
a shift of 8 hours or less. This association was observed for both short term and long term sickness episodes. While working occasional long shifts did not show any effect on sickness absence, working a higher proportion (i.e. more than 75% of shifts worked) of long shifts in the past seven days was associated with a higher likelihood of reporting sickness absence.

There was some evidence that job performance, measured through completeness and timeliness of vital signs observations, was compromised. A higher number of healthcare assistant hours per patient day (HCA-HPPD) deriving from shifts of 12 or more hours was associated with a higher number of delayed and missed vital signs observations.

8.2 Discussion of key findings

8.2.1 Night shifts

The analysis performed at the nurse level showed that when staff were working on a rotating schedule, they were more likely to experience a higher number of sickness episodes, compared to nursing staff working on fixed day schedules. Previous studies indicated that night work is associated with increased sickness absence when such shifts are done as part of a rotating shift schedule (Niedhammer et al. 2013; Catano and Bissonnette 2014; Natti et al. 2014). Previous research found rotating schedules to be associated with higher fatigue levels (Han et al. 2014), and fatigue may be a mediating factor between rotating night work and sickness absence. A similar association was found for nurses working on permanent night shifts, although only when the analysis was univariate. It should be noted that the number of staff members working on permanent night shifts was low (n = 123; 6% of the sample).

However, while previous studies assessed shift rotation by its presence or absence in a schedule, this study expanded knowledge about the proportion of night shifts that is likely to result in employee sickness. Staff who had worked a high proportion of night shifts (more than 75% of shifts worked) in the past week were more likely to experience sickness compared to those who worked none. This finding suggests that nursing staff members working such high proportions of night shifts (i.e. >75% of shifts worked) were more likely to be those operating around a fixed night schedule, rather than a rotating one.

Despite permanent night shifts not being significantly associated with sickness absence and rotating shifts being associated with sickness absence, the benefits of working a permanent night schedule are unclear. In a literature review, Folkard concluded that in standard work environments, permanent night work is unlikely to result in sufficient circadian adjustment in most individuals to benefit health and safety, since only 3% of
employees showed a complete adaptation to night work (Folkard 2008). Permanent night schedules may affect sickness absence due to their association with job dissatisfaction (Burch et al. 2009) and burnout (Cheng and Cheng 2017), so that staff working fixed nights only may resort to taking sick leave due to being dissatisfied with the job or because they feel exhausted. Further, it is possible that permanent night workers engage in non-sleep activities during most of the day; there is evidence that nurses with childcare responsibilities often re-enter established domestic routines within hours after night shifts end (Lowson and Arber 2014), thus not benefitting from adequate recovery.

This doctoral research found an association between working more than three quarters of shifts in the past week as night shifts and long term sickness absence. A long term sickness absence episode usually represents a health impairment process (Bakker et al. 2003). Night work, regardless of being performed as part of a fixed or rotating schedule, has been associated with higher chronic fatigue and insomnia (Øyane et al. 2013). Several health impairments have been associated with night work; among these there peptic ulcer disease, coronary heart disease, negative pregnancy outcomes (Knutsson 2003) and work-related injuries (Smith et al. 1994). Nurses and healthcare assistants in this sample may have chosen to avoid work or found themselves unable to attend work because they were experiencing these adverse outcomes.

8.2.2 Overtime

A linear effect between proportion of overtime shifts and occurrence of sickness absence was found: any proportion of overtime shifts above 0% was associated with a decreased likelihood of experiencing sickness absence, with the lowest odds found for RNs and HCAs working more than 75% of their shifts as overtime shifts.

In the study Trust, RNs and HCAs can choose to register and work additional paid shifts (i.e. a bank shift) from a list of available shifts in the hospital. There is evidence that staff opting to work overtime on a voluntary basis tend to be less fatigued and more satisfied, compared to staff who work mandatory overtime (Beckers et al. 2008). Absenteeism was found to be lower in trusts where higher proportions of staff reported working extra shifts (Powell et al. 2014). In contrast, mandatory unpaid overtime may have a negative effect on employees’ psychological wellbeing related to lack of control (Lobo et al. 2013). Control over overtime and financial rewards for extra work are likely to be predictors for employees’ wellbeing and satisfaction.

While the existing evidence supports the finding that working more overtime is associated with a lower degree of absenteeism, it can explain it only partially. Overtime, regardless of whether it is voluntary or mandatory, has been reported to be a risk factor for fatigue and
sleepiness (Bae 2013) and fatigue is likely to be a mediator in the causal pathway between shift work and sickness absence (Zboril-Benson 2002; Sagherian et al. 2017). These results would therefore be in contrast with the finding that the highest proportion of overtime shifts is associated with the lowest odds of experiencing sickness absence.

However, in this study overtime shifts were recorded on the Overtime bookings dataset only if they were actually worked. If an employee chose to cancel a booked overtime shift because they were feeling unwell or too fatigued to work, this was not recorded as a sickness episode. Sickness absence episodes are recorded on the contracted shifts rostering system only (i.e. E-Roster) and only when contracted shifts are missed.

When aggregating the shifts at the nurse level, it emerged that staff working small proportions of overtime (i.e. less than 25% of shifts worked) experience a higher rate of sickness episodes, compared to nursing staff working no overtime at all. However, those working above 25% of their shifts as overtime experienced a lower rate of sickness episodes. Therefore, employees working a higher proportion of overtime shifts were more likely to be those workers feeling fit enough to engage in extra work. In addition, employees working such high proportions of overtime may be those who mainly work on the bank and have more control over their hours – a positive feature for achieving work-life balance – compared to those who engage in small proportions of bank work, on top of their main job.

This introduces a further validity threat, which may be at play when looking at this relationship, by which sickness absence may influence the proportion of overtime shifts an individual works: this is simultaneity. Simultaneity is a type of bias where reversed causality is observed, namely an independent variable is potentially caused by the dependent variable (Antonakis et al. 2010). Staff members who are feeling more fit and healthy may choose to work higher proportions of overtime shifts, so that the outcome (i.e. no sickness absence) is influencing the predictor (i.e. overtime shifts), and this leads the effect of overtime shifts to be overestimated to such an extent that it appears to operate in the opposite expected direction. The more plausible explanation is that registered nurses and healthcare assistants who are not sick are more likely to work overtime. Therefore, a hypothesised negative effect from a higher proportion of overtime shifts could have resulted in coefficients indicating the opposite effect.

Therefore, results should be interpreted with caution as regards the “protective” effect of overtime shifts on sickness absence, bearing in mind that it is likely a reversed association. Employees who work a higher proportion of overtime are plausibly those who feel fit enough to engage in high volumes of extra work.
8.2.3 12 hours or more shifts

Previous studies have observed associations between low job satisfaction and other adverse employee outcomes in cross-sectional studies, although none has studied sickness absence. This longitudinal study with objective measures of work patterns provides stronger evidence that the association may be causal.

When a shift of 12 hours or more (i.e. long shift) was scheduled, it was more likely to be missed due to sickness absence, compared to a shift of eight hours or less. This was observed in the overall sample and in both the short term and long term sickness absence subgroups.

One study using a similar approach showed a link between the anticipated workload and sickness absence: nurse absenteeism was higher when fewer nurses were scheduled to a shift with high workload (Green et al. 2013). Research on shift work and sickness absence has tended to focus on the typical patterns of employees by aggregating shift data at the employee level.

The finding that an upcoming long shift is more likely to be missed due to sickness than a shift of 8 hours or less could indicate that if an employee is feeling tired and fatigued, either at a physical or psychological level or both, a shorter shift may appear more feasible than a longer one. This untested hypothesis should be further explored and it is supported by findings that working long shifts are associated with higher fatigue levels (Barker and Nussbaum 2011), which could explain the choice of an employee to remain absent from work when a long shift is scheduled. Furthermore, higher fatigue levels have been associated with absenteeism in nursing (Zboril-Benson 2002; Sagherian et al. 2017).

Being scheduled to work any shift longer than 8 hours was associated with long term sickness absence, which is argued to be an indicator of “involuntary absence”, likely reflecting a health impairment or a situation of accumulated stress (Bakker et al. 2003). Missing a shift longer than 8 hours for nurses in the long term subgroup may have been a coping mechanism for a health impairment condition, which working longer shifts may have exacerbated.

While occasional 12 hours or more shift work (less than 25% of shifts worked) in the past seven days was not significantly associated with more sickness absence, when nurses worked a higher proportion of long shifts, sickness rates were increased. When RNs and HCAs were working more than three quarters of shifts as long shifts in the past seven days, they were more likely to experience a sickness absence episode than staff working no long shifts in the past seven days. This association was observed for both short term
and long term sickness absence subgroup and remained significant when adjusting for other shift characteristics\(^8\).

One of the main reported drivers for nurses preferring long shifts is their ability to offer a compressed work week, which gives access to a higher number of days off by compressing total work hours in a shorter number of work days (Smith et al. 1998; Bambra et al. 2008). Previous research was unable to discern whether working long shifts was associated with working fewer shifts (i.e. the compressed working week). This is exemplified by a study that found that when nurses were working 8-hour shifts, they were more likely to report missed shifts than those working 12-hour shifts (Stone et al. 2006). However, this result may be confounded: if nurses worked 12-hour shifts as part of a compressed week, they could have worked fewer shifts overall, implying that there are fewer shifts to be missed.

This study was able to overcome this limitation and found that even when adjusting for days worked, the negative effect of higher proportions of 12 hours or more shifts remained significant, indicating that having a higher number of days off is unlikely to be an effective strategy for recovering from long shifts. These findings mirror evidence that the choice of the compressed work week for shift workers may be in conflict with recommended criteria of a safe shift system, and health may be compromised (Kecklund et al. 2008).

Long shifts and shift work induced fatigue have been identified as a risk factor for negative employee outcomes (Dawson et al. 2011). Fatigue is a well-established predictor of sickness absence (Janssen et al. 2003), suggesting that it may play a mediating role between long shifts and sickness absence (Barker and Nussbaum 2011). There is not a single accepted definition of fatigue (Akerstedt and Wright 2009), but common symptoms that characterise fatigue are tiredness and feeling exhausted and worn-out (Shen et al. 2006).

Fatigue can be acute or chronic; one could hypothesise that acute fatigue could prompt short sickness absence episodes, where the employee may take a sickness day as a recovery strategy to reduce tiredness. It may be expected that chronic fatigue would be reflected in long term sickness episodes, where conditions such as stress and burnout may be present (Schaufeli et al. 2009), and likely to lead to slower recovery periods before returning to work.

\(^8\) These were: proportion of night shifts worked in the past 7 days; proportion of shifts worked over the past 7 days; nurse grade (RN vs HCA)
Fatigue can be due to a variety of causes, including adverse work organisation characteristics (Rogers 2008). Research has shown that long shifts of more than nine hours are associated with higher levels of fatigue among registered nurses (Josten et al. 2003). According to the effort-recovery model (Meijman and Mulder 1998), a high level of fatigue may have negative consequences on health if there is insufficient time for recovery after work periods. The authors argue that when employees do not have the chance to fully recover after work periods, they will use an excessive effort to maintain performance when they return to work, which, in turn, will contribute to increase fatigue levels.

This cumulative fatigue may then lead to employee's health impairments, resulting in sickness absence. The finding that working long shifts is associated with higher sickness absence regardless of the fact that long days are associated with more days off, suggests that working such long shifts may increase fatigue to the extent that the additional days off may be insufficient a benefit to counteract fatigue. Further, absenteeism has been explained by an overload of job demands that exhaust employees’ cognitive and physical resources and, therefore, cause health and wellbeing problems (van Woerkom et al. 2016). Hence, it may be that a higher proportion of long shifts may lead to a job demand overload and having additional days off is not a sufficient recovery option to avoid sickness absence.

When sickness absence is reflecting a health impairment process it tends to last longer (Bakker et al. 2003). It was found that working a higher proportion of long shifts, specifically more than three quarters of previous shifts, was also associated with long term sickness absence, suggesting that these longer shifts are likely to affect nurses also in terms of health impairment.

Links between nurses’ working long shifts and adverse nurse outcomes have been reported (Bae and Fabry 2014; Harris et al. 2015). Previous work indicated that working long shifts was associated with a higher likelihood of reporting burnout and job dissatisfaction (Stimpfel et al. 2012; Dall'Ora et al. 2015; Ball et al. 2017b). This doctoral research has increased knowledge by exploring sickness absence as a nurse outcome of job performance that can be affected by working long shifts.

A further outcome of job performance affected by working long shifts is nurse-reported missed care (Griffiths et al. 2014). The current study is the first to use an objective measure of missed care in terms of missed/delayed vital signs observations. An association was found between higher proportions of HCA-HPPD deriving from long shifts and delayed vital signs observations.

The level of compliance with vital signs observations was moderately low in the Trust, and a high degree of variation was found among different wards, with compliance ranging from
75.7% to 21.3%. Current evidence suggests that compliance with vital sign monitoring protocols is often poor, with incomplete observation sets (Hands et al. 2013). Time constraints, high workload and low staffing levels have been reported as factors associated with healthcare staff ability to comply with scheduled vital signs observations (Smith et al. 2017).

The finding that 12 hours or more shifts affect compliance with vital signs monitoring when there is a higher proportion of HCA-HPPD deriving from 12 hours or more shifts, but not for RN-HPPD, raises some questions. It is necessary to ascertain the extent to which both these different staff groups perform vital signs observations. In the study Trust, all frontline staff, including healthcare assistants, are required to demonstrate ability to accurately record vital signs on VitalPAC™, as this is one of the requirements of the Generic Competency Framework adopted by the hospital (see Appendix O). The data did not yield information regarding the staff grade performing the vital signs observations and there was no way of determining which staff group was responsible for the vital signs of any individual patient.

The monitoring of vital signs is increasingly being delegated to HCAs. Research undertaken in two NHS Trusts interviewed registered nurses and healthcare assistants and found that vital signs observations were a central feature of healthcare assistants' roles (Bach et al. 2012). Furthermore, there are reports of registered nurses considering the assessment of vital signs a basic, skill-based task; therefore, those RNs believe it should be delegated to more junior and less experienced staff members (Hogan 2006). The extent to which such delegation has occurred in the present Trust is unclear, although anecdotal accounts and unpublished research suggest it may be widespread. Thus, it may be that compliance with the vital signs observation protocol is a good indicator of job performance for HCAs but not for RNs because of different responsibilities.

To conclude, a link between the length of the shift healthcare assistants are working and the likelihood of delaying vital signs observations is plausible. However, given the small size of the effect and the possibility that these results are confounded by other factors that could not be included in the analysis (i.e. time of the day when vital signs observations were scheduled; grade of the staff who were expected to perform and record vital signs observations), the association between 12-h shifts and compliance with vital signs observations should be interpreted with caution.

8.3 Methodological strengths and limitations

The interpretation of the study’s findings is accompanied by a reflection of the strengths and limitations. These are the study design; the outcome measures of job performance;
and additional variables that are likely to influence the relationship between shift work characteristics and job performance. These aspects and how they relate to this thesis’ findings are discussed in this section.

8.3.1 Study design and methodology

This is the first research to objectively measure the effect of shift work characteristics on nursing staff job performance, namely sickness absence and delayed/missed vital signs observations. The retrospective longitudinal design and the use of objective data collected over a three-year period allowed a deeper understanding of the effect of nurses’ shift patterns than had been reported from previous studies, which were mostly cross-sectional, using self-reported data. The possibility of nesting shifts into staff allowed to explore the effects of sickness absence at a more granular level. Nevertheless, this research encountered some methodological challenges.

Firstly, because of limited computational capacity, it was not possible to analyse more than seven days backwards in the sickness absence analysis. Consequently, the effect of cumulative shift work characteristics could not be explored over a longer period of time. However, to complement the longitudinal retrospective analysis of shift work characteristics and sickness absence, data were also analysed at the nurse level with a cross-sectional approach similar to that used by previous studies. Therefore, these two different approaches provided a better picture of the effects of multiple shift characteristics worked in the past seven days, but, to some extent, also of the typical shift characteristics worked by an individual.

Secondly, the retrospective longitudinal analysis for the association of shift work characteristics and delayed/missed vital signs observations was not possible at the individual level and the association could only be measured at the ward-day level. This was due to the high complexity of this analysis, which required linkage of four different datasets (i.e. E-Roster, Agency Bookings, Patients admissions and VitalPac™). This led to the inability to explore in detail the effect of multiple shift work characteristics worked by an individual in the past, while considering the impact of the proportion of nursing hours per patient day (NHPPD) deriving from 12 hours or more shifts worked in wards every day by both registered nurses and healthcare assistants.

Furthermore, although the aim of this study was to examine and measure associations, warranting therefore a quantitative design, adopting a mixed methods approach including exploration of staff views and experiences may have provided additional understanding (Borglin 2015). However, as stated in the ethics approval, staff IDs were
pseudoanonymised, making it impossible to contact individuals, so that interviews or focus groups were not feasible.

Lastly, while the availability of objective data represented a unique opportunity to undertake a more detailed analysis of nursing staff shift characteristics than had hitherto been possible, it should be noted that this was a single centre study and so there must also be a cautious approach to generalisation. Each hospital in England is different, but as a previous study has noted, there tends to be more variation in shift patterns within hospitals than there is between hospitals (Griffiths et al. 2014).

### 8.3.2 Measures of job performance: sickness absence

Sickness absence was adopted as a measure of job performance, and it was primarily conceptualised as an employee behaviour (Michie and West 2004), rather than as an indicator of staff health. It indicates that an employee is experiencing a problem (Arnold et al. 2016), and sickness absence is either deemed as a reasonable solution to that problem (i.e. “voluntary” absence episodes) or the only possible reaction to the problem (i.e. “involuntary” absence episodes). In this study, sickness absence data were derived by an electronic system that records sickness absence and then feeds these data directly into payroll, suggesting it is an objective measure. This overcame one of the major limitations in previous research, which relied mainly on self-reported data.

Sickness absence is a complex and multi-faceted phenomenon which could be influenced by several different factors (Dekkers-Sanchez et al. 2008); it has been argued that sickness absence can be a measure of ill health and that it reflects employees’ reaction in response to their health status (Marmot et al. 1995). Furthermore, previous research has shown that sickness absence predicts employee risk of death as well as poor self-rated health and disabilities (Kivimaki et al. 2003). Sickness absence may reflect ill health, but it may also be an indicator of how the employees react to increased workloads or to job-related stress.

One limitation of this research is the lack of available information about the cause of absence; the E-Roster only recorded whether an employee was absent due to sickness or to unauthorised absence, therefore it is not possible to establish with certainty what led the employees to be absent. In order to provide a proxy for absence cause, a subgroup analysis of short term and long term sickness absence was performed. Schaufeli and colleagues’ seminal work suggests that absence length can be a valid disambiguating factor between “voluntary” and “involuntary” sickness absence (Schaufeli et al. 2009).
According to their research, involuntary sickness absence episodes represent a reaction to distress caused by high job demands or ill health, and reflect an actual inability to attend work. They argued that this involuntary sickness absence process is characterised by longer absence episodes (Schaufeli et al. 2009). Short term sickness absence episodes (i.e. episodes where the employee is absent for ≥7 consecutive days) are self-certified and do not require any medical certification (UK Government 2017). These shorter episodes may reflect staff dissatisfaction with the job (Bakker et al. 2003) or may be viewed as a recovery strategy when staff feel the need to benefit from additional rest before returning to work. Therefore, categorising and analysing separately short term and long term sickness absence episodes provides an accurate proxy for absence cause, albeit not an objectively documented one.

8.3.3 Measures of job performance: delayed and missed vital signs observations

In this study, delayed and missed vital signs observations were also explored as a measure of job performance, which has been defined as the observable behaviours or actions that an employee is expected to perform. Missed vital signs observations are associated with failure to recognise patient deterioration associated with cardiac arrest, unanticipated intensive care unit admission and death (Smith et al. 2013). However, missed vital signs observations represent just a few of the safety-related outcomes that could be explored. There is ample evidence that nurses miss several care tasks during their shifts (Ausserhofer et al. 2014; Ball et al. 2014), and patient monitoring is not the only one that should be studied. Vital signs observations, therefore, could be adopted as a partial measure of nurses’ job performance.

Furthermore, VitalPac™ classifies a vital signs observations set as missed even if all but one of the physiological parameters have been recorded. Therefore, if respiration rate, oxygen saturations, temperature, systolic blood pressure, heart rate were recorded, but level of consciousness was not recorded as part of a vital signs observations set, that vital signs observations set is classified as missed. However, not recording one physiological parameter, while not suggesting that a patient has been unobserved, still indicates an omission in care. In addition, vital sign observations sets should be complete in all instances, otherwise patients’ physiological instability could be missed (Clifton et al. 2015). The potential harm resulting from incomplete vital signs observations sets suggests that an incomplete missed vital signs observation set in VitalPac™ should be considered an omission of care which could jeopardise patient safety.

The work conducted for this study was unable to ascertain whether time of day played a role in the compliance with vital signs observations. Previous studies indicated that fewer
vital signs are recorded at night compared with daytime (Gordon and Beckett 2011; De Meester et al. 2013; Hands et al. 2013). Similarly, the UK National Patient Safety Agency reported that fewer vital signs observations are performed during the night (NHS National Patient Safety Agency 2007). A recent qualitative study found that nursing staff often deemed unnecessary those night time observations where patients had chronic conditions and always scored high NEWS. Furthermore, nursing staff reported sometimes choosing not to perform observations at night because they did not want to wake up patients who had difficulty sleeping and patients in the same bay or ‘confused’ patients who may become agitated, waking others (Hope et al. 2017).

8.3.4 Additional variables

The relationships being examined between shift work characteristics and outcomes are occurring in acute hospital wards, which represent a complex work environment. This complexity indicates that several potential confounders could be controlled for when measuring the association between shift work, sickness absence and delayed/missed vital signs observations.

8.3.4.1 Shift factors

This study could not control for ability to take breaks or the frequency, length and timing of breaks. The ability to take rest breaks during shifts impacts positively outcomes of job performance (Tucker 2003). Ability to take breaks has been studied not merely as a dichotomous variable (i.e. yes/no), but also by exploring the frequency and the length of breaks. A recent literature review concluded that if the total length of break remains unvaried, strain is more reduced when healthcare staff can benefit from short and frequent rest breaks than from longer but fewer breaks (Wendsche et al. 2017). The work culture in some healthcare settings leads nurses to be unable to take their breaks in order to avoid interruptions in the care for patients (Fallis et al. 2011). There are several anecdotal reports of nurses not using breaks during a shift because wards are understaffed and patient safety may be compromised if they leave the ward for some time (Ball et al. 2015; Merrifield 2017b). It should be noted that the ability of taking breaks during the shift is a confounder only if it is systematically related to other shift characteristics.

8.3.4.2 Individual variables

The degree of work time control that nurses can benefit from when planning their shifts could not be included in this study. Work time control represents the employees’ ability to control the duration, position, and distribution of work time (Harma 2006) and there is evidence that it may be associated with better job performance (Nijp et al. 2012). Although
degree of work time control was not formally assessed in this research, the E-Roster offers the ability to self-schedule. Every month, nursing staff members can write down their requests and ward managers then approve them, provided these requests do not conflict with the Trust roster management policy (Appendix P). Furthermore, the inclusion of overtime shifts in the analysis represents a further aspect of self-scheduling that this research was able to consider. Therefore, it is likely that the effect of work time control has been explored at least partially, despite not being explicitly acknowledged.

No information regarding age of the nursing staff was available. There are conflicting arguments about the effect of age on shift workers; according to a systematic review, a number of studies found young age to be associated with higher shift work tolerance (Saksvik et al. 2011). However, some studies indicated that older age may be positive for shift work tolerance and other studies found no association between age and shift work tolerance (Costa and Di Milia 2008; Blok and de Looze 2011; Saksvik et al. 2011). Older workers may represent a selection of workers who are able to cope with shift work (Knutsson 2004) and their shift schedules may be less demanding than those of young shift workers. Young shift workers may be less fatigued and, having had less exposure to shift work than older shift workers, may have experienced less cognitive impairment (Marquie et al. 2015). This study, despite not being able to control for age, could nest all shifts and sickness episodes into nursing staff, so that the individual differences were at least partially controlled for.

Furthermore, it was not possible to ascertain whether staff members were holding a second job. National UK statistics indicate that 4.1% of the population has two jobs (Dickey et al. 2011). This figure is likely to be higher in nursing, where a recent RCN survey highlighted that nurses feel their pay is too low (Royal College of Nursing 2017), and, therefore, may be highly motivated in seeking an additional income source. Working a second job has consequences on fatigue levels (Marucci-Wellman et al. 2014); this is mainly due to staff attending to their second jobs on days off from their primary jobs, suggesting that these staff members lack rest opportunities and fail to achieve adequate inter-shift recovery. It should be acknowledged that nursing staff working 12 or more hours shift schedules are those more likely to hold a substantial second job. If, by working a compressed work week, nurses were on shift for three days a week, they would benefit from four days off. During these four days off, they would be able to hold a secondary employment.

Therefore, if nurses working on 12 or more hour schedules had a second job, the association between long shifts and sickness absence could be confounded by secondary employment. However, a correlation analysis of the proportion of long shifts and proportion of days worked indicated a slightly positive correlation between the two. This
suggests that nurses working long shift patterns also tend to work more days, implying that they do not benefit from a larger number of days off. If nurses working on 12 hours or more schedules do not have more days off, it is unlikely that they are holding a second job and, therefore, that results are confounded. Nonetheless, the absence or presence of a second job should be explored in future studies, especially if it is associated with the compressed working week.

8.4 Conceptual framework

For this doctoral research, a conceptual framework was designed by combining results from the literature review (see 2.4); the algorithm for the assessment of variables describing working time patterns developed by Harma and colleagues (Harma et al. 2015); and a framework originated in the organisational psychology field, attempting to explain the links between organisational context, people management, psychological consequences for employees, employee behaviour and organizational performance (Michie and West 2004). The study’s conceptual framework can be found in Figure 3.2.

This conceptual framework attempted to identify the relationships that characterise shift work factors and the study outcomes of job performance. However, Ferguson and Dawson argue that research into shift work has failed to embrace the complexity of the association, by considering shift work characteristics as independent variables and outcomes as dependent variables, without taking into account any mediating variables (Ferguson and Dawson 2012). As noted in the discussion of key findings (section 8.2.3), fatigue deriving by long shifts could be a plausible mediator between working several long shifts; the relationship between long shifts and fatigue has been confirmed (Josten et al. 2003; Barker and Nussbaum 2011), as it has been the relationship between fatigue and absenteeism (Duijts et al. 2006; Akerstedt et al. 2007) and between fatigue and decreased job performance (Barker and Nussbaum 2011).

In light of the study results and of the new research ideas generated by this doctoral research, the original conceptual framework was revised. Michie and West’s framework provides a broad picture in which the research sits, that of work organisation (Michie and West 2004). This is presented first, with the dimensions that would be investigated highlighted by circles, as reported in Figure 8.1. Then, the specific framework is presented and can be found in Figure 8.2. It comprises of three main domains: context and people management, consequences for employees and employee behaviours.

Context and people management include shift characteristics and workload. It then suggests that protective factors may moderate the relationship between shift characteristics, workload and fatigue. Individual factors may also have a moderating
Chapter 8

This research has found that working high proportions of long shifts and night shifts is associated with sickness absence. In this framework, fatigue is conceptualised as a consequence for employees, mediating the effect of long shifts and night shifts on employee behaviours. The outcomes are employee behaviours of sickness absence and missed care tasks. This research explored delayed/missed vital signs as indicators of missed care, but further missed care tasks could be included in future research or other measures of job performance, for example unplanned omission or delays in providing patient medication, which has been reported to be a nursing red flag indicator by NICE (National Institute for Health and Clinical Excellence 2014).

The dotted arrows indicate relationships that are plausible but still untested. The straight lines indicate relationships that have been established by either this study, by previous studies or both. The two-directional arrows indicate factors that are likely to influence each other, rather than simply involving a causal-effect pathway. A two-way relationship is likely to be in place between staffing levels and shift length. On one hand, when wards are understaffed, adopting longer shifts is a typical solution in the current NHS context (NHS Evidence 2010). On the other hand, when staff work 12-hour shifts, staffing levels will be adjusted. Shift work would be moderated by individual factors.

Similarly, a demanding shift pattern may be resulting in fatigue if an employee has a second job or high non-work commitments, but the presence of these may also play a role as to how much employees choose to work and which types of schedules. The impact of workload on fatigue is very likely moderated by individual factors. Individual factors including having a second job or high non-work commitments influence rest opportunities. This implies that having additional days off is not a protective factor of demanding shifts per se; the impact of days off on fatigue depends on what employees do on those days off.
Figure 8.1 Dimensions of the Michie and West (2004) model considered in the proposed framework
Figure 8.2 Proposed framework for future studies
8.5 Implications for practice

Ward managers are required to organise, approve and review all nursing staff members’ schedules. Whilst the hospital where this study was conducted encourages self-rostering, managers have to comply with the rostering policy (Appendix P) and assess how many long shifts, how many days off, how many night shifts employees are working, while taking into account staffing levels and skill mix. The main goal for ward managers is to ensure that the nursing workforce is configured so that safe quality of patient care can be delivered. As this research has found, how aspects of shift work are organised has implications for nurses’ behaviour and job performance and, ultimately on organisational and patient outcomes (Michie and West 2004).

This research has implications for healthcare systems. These implications are far from the description of an “ideal” shift system in nursing, but may offer further knowledge to health service managers and ward managers aiming to maintain and improve their employees’ job performance. It may also apply to nursing staff who are able to make decisions regarding their working patterns, for instance, staff who can control how much they work, their shift length and their night shifts schedule.

Long shifts in England have been introduced as a strategy to reduce staffing costs by decreasing the overlaps between shifts (NHS Evidence 2010), with some NHS Trusts currently implementing mandatory 12.5 hour shifts for nursing staff hospital-wide (Merrifield 2017a). The study Trust itself saw 12.5-hour shifts doubling in three years and this coincided with the final years of the Nicholson challenge. This was a set of mandates that Sir Nicholson\(^9\) enforced in an effort to achieve efficiency savings; the challenge expected the NHS to find £20 billion in efficiency savings by 2015 (Appleby et al. 2014). To cope with this challenge, trusts adopted several strategies, and moving to 12.5 h shifts may have been one of these strategies. The doubling of 12-hour shifts in the Trust over just three years suggests that these long shifts may have appeared as a practical solution to decrease expenses.

However, if long shifts are associated with higher rates of sickness, any efficiency benefits may be undermined, potentially leading to a decrease in the system efficiency. Sickness absence is costly to the economy, with the median annual absence cost per employee being £522, with public sector employees annual absence cost averaging at £833 (Chartered Institute of Personnel and Development 2016). Public Health England put the

\(^9\) CEO of NHS England from 2006-2012
cost to the NHS of staff absence at £2.4bn a year, accounting for around £1 in every £40 of the total budget. This figure is before the cost of agency staff to fill in gaps, or the cost of treatment, is taken into account (QualityWatch 2015).

When a registered nurse or healthcare assistant experience sickness absence, managers may have to resort to the use of agency staff to fill the vacant shift; this represents a costly option that the NHS is increasingly trying to avoid (NHS Improvement 2016). Resorting to agency staff has implications not only for costs, but potentially also for patient safety. Agency staff may be unfamiliar with the ward environment and with the patients; wards with higher rates of temporary staff are more likely to experience a higher number of adverse events, including patient falls with injury and poor quality of care (NHS National Patient Safety Agency 2007; Bae et al. 2010).

The effectiveness and safety of 12-hour shifts are an increasingly debated topic in the UK and worldwide, and the discussion has often revolved around whether these long shifts are good or bad (Ball et al. 2015), better or worse than 8-hour shifts (Ferguson and Dawson 2012). This study’s findings and the existing evidence cannot support a definitive answer to these questions; however, the association of a higher proportion of 12 hours or more shifts and sickness absence indicates that these long shifts may not represent a favourable shift pattern in the current context.

If staff were able to take breaks during their shifts, if the workload during the shift were not exceedingly high and if there were enough staff on the wards to complete care activities, the effect of 12-hour shifts may be different. However, the NHS is struggling with an increasing nursing shortage (Marangozov et al. 2016), high rates of vacancies filled with temporary and agency staff (NHS Improvement 2016; NHS Digital 2017) and anecdotal reports of lack of breaks during the shifts due to understaffing (Merrifield 2017b). In this current context, these findings suggest that, while occasional 12-hour shift work may not have adverse consequences, working higher proportions may lead to higher sickness absence.

### 8.6 Recommendations for future research

While the large amount of objective data analysed with longitudinal techniques enabled a deeper knowledge of the effect of shift characteristics on outcomes, the absence of a qualitative insight prevented a more complete understanding of these effects. Future studies should aim to include a qualitative strand by adopting a mixed-methods approach, which would enable to better understand the perspective of nursing staff members and
ward managers. This approach would go beyond demonstrating associations, moving to understand why these associations exist.

For instance, questions could be asked as to why nursing staff members prefer certain shift patterns and what are the perceived pros and cons of these patterns; how employees feel after working several long shifts or night shifts in a row and what motivates them to do so; why employees choose to work many overtime shifts and what their coping mechanisms are; how important the amount of consecutive days off is; what is the impact of having breaks during the shift. These are just a few of the questions about the organisation of shift work that could be formulated to nursing staff and ward managers.

This study took place in a single hospital; the inclusion of at least a further research site is warranted to corroborate these findings. This single site study is a starting point for future research; it demonstrated that the use of routinely collected data from NHS staff and patient datasets is feasible and the extracted data are reliable. NHS trusts adding to the sample should have the same electronic systems in place (i.e. E-Roster, Agency Bookings, VitalPAC™) in order to enable data linkage between different research sites. This should be feasible, since several NHS trusts adopted and routinely use E-Roster and VitalPAC™.

None of the studies reviewed was able to take into account all shift, individual and organisational variables, and it would be unreasonable to expect a single study to encompass such complexity. The choice of variables included in this research was based upon available data (i.e. this study relied on a secondary dataset) and an extensive literature review of shift work studies spanning across the past 30 years. While most of the associations between shift characteristics are compatible with previous research, they are not likely to be the only ones.

Future studies should include variables that could not be investigated in this research; shift variables would be ability to take breaks during the shifts and how long and how frequent breaks are. Individual variables should be explored: age; degree of work time control when shifts are planned; non-work commitments, including childcare responsibilities, care of frail relatives, and having a second job.

Besides including these variables, future research should aim to explore mediating and moderating factors between shift work characteristics and outcomes. The underlying mechanism that leads long shifts to potentially cause harm remains unexplored. By exploring interactions between the study variables and reviewing the available evidence, fatigue has emerged as a plausible mechanism sitting between long shifts and negative outcomes and should be therefore measured in future studies.
Not only should future studies aim to shed more light on the causal pathway of shift work characteristics; cost-effectiveness analyses of shift patterns are also warranted. No studies have investigated whether routinely implementing 12.5-hour shifts in hospitals leads to achieving higher effectiveness and lower costs than maintaining an 8-hour schedule or whether it generates increased costs.

Furthermore, future research should aim to develop indicators and thresholds that can capture cost-effectiveness of workforce interventions. The cost per QALY gained threshold adopted by NICE has been designed to determine whether a treatment represents an efficient use of the limited NHS resources (McCabe et al. 2008); however, basing decisions around shift patterns according to how many lives would be saved and what would be the cost of saving these lives represents an impartial view. Sickness absence may be adopted as a cost outcome of different shift patterns.

Through the current evidence, economic models of shift patterns would rely on estimates of benefit derived from observational data, making therefore their application to decisions limited. In this regard, experimental research on the effect of shift work, while not easily applicable to this field, is not theoretically impossible. This would ensure that the move to 12-hour shifts based on alleged savings on staffing costs is not producing the opposite effects.
8.7 Conclusions

This thesis has been informed by research in the field dating back to more than 30 years and it has contributed to knowledge about the impact of nurses’ shift characteristics on sickness absence and compliance with vital signs observations. It adds to the body of evidence concluding that long shifts are associated with aspects of job performance.

This study found that working shifts of 12 hours or more is associated with nursing staff sickness absence. An association between working long shifts and delayed vital signs observations was found for health care assistants. While the sample consisted of a single hospital Trust and findings should not be generalised, the associations were observed in a number of different wards and across three years.

For the first time in nursing, the associations between shift characteristics and job performance were examined using objective data and with techniques that took into account the temporality aspect of shift work on sickness absence. These findings suggest causality is plausible, especially when considering previous studies, none of which was able to establish that long shifts are associated with better job performance outcomes.

This research has some limitations, and every limitation calls for further research. Routinely collected data are becoming increasingly implemented in NHS Trusts and future studies should aim to draw on these objective data, so that common-method variance can be avoided when measuring associations. Further work is warranted to shed light on the causal pathway that brings long shifts to be associated with sickness absence, by exploring fatigue as a mediating factor; by adding more shift and individual variables to the picture (e.g. ability to take breaks during the shifts, non-work commitments, and age); and by exploring further outcomes of job performance within the missed care domain (e.g. failure to administer medicines on time). A mixed methods approach could assist in the search of “why” some shift characteristics appear to hinder job performance and how staff feel when working certain shift patterns. Furthermore, in order to support generalisability of the findings, it would be essential to replicate this study in at least one different Trust.

Despite limitations, these findings have implications for health service managers, ward managers and nurses alike. Since long shifts are associated with higher rates of sickness, any efficiency benefits of these long shifts may be undermined, leading to a decrease in the system efficiency. The NHS is struggling to reduce sickness absence, especially in the current climate of increasing nursing shortage, with high numbers of unfilled nursing vacancies.

In this current context, these findings suggest that, while occasional 12-hour shift work may not have adverse consequences, working higher proportions may lead to higher
sickness absence and contribute, therefore, to a phenomenon that NHS managers are striving to reduce. A trend of shifting from predominantly 8-hour work to 12-hour work was observed in the study Trust. This move should be at least questioned in light of the study findings.

It is hoped that this doctoral research can prompt a reflection and dialogue regarding how nurses’ shift work is planned in the NHS. Given its impact on nurses’ performance, the implementation of shift patterns should not be implemented based merely on perceived savings. Nursing staff wellbeing and performance are key to the success of our healthcare system, and this research has shed light on how shift patterns can potentially hinder nurses’ performance. More needs to be done to ensure that nurses can benefit from safe and effective shift patterns.
Appendix A

Published manuscript: Nurses’ shift length and overtime working in 12 European Countries. The association with perceived quality of care and patient safety

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Background: Despite concerns as to whether nurses can perform reliably and effectively when working longer shifts, a pattern of two 12- to 13-hour shifts per day is becoming common in many hospitals to reduce shift to shift handovers, staffing overlap, and hence costs.

Objectives: To describe shift patterns of European nurses and investigate whether shift length and working beyond contracted hours (overtime) is associated with more-reported care quality, safety, and care left undone.

Methods: Cross-sectional survey of 31,627 registered nurses in general medical/surgical units within 488 hospitals across 12 European countries.

Results: A total of 50% of nurses worked shifts of ≥8 hours, but 13% worked ≥12 hours. Typical shift length varied between countries and within some countries. Nurses working ≥12 hours were more likely to report poor or failing patient safety [odds ratios (OR) = 1.41; 95% confidence interval (CI) = 1.13–1.76], poor care quality of care (OR = 1.30; 95% CI = 1.10–1.53), and more care activities left undone (RR = 1.13; 95% CI = 1.09–1.16). Working overtime was also associated with reports of poor or failing patient safety (OR = 1.67; 95% CI = 1.51–1.86), poor care quality of care (OR = 1.32; 95% CI = 1.23–1.42), and more care left undone (RR = 1.29; 95% CI = 1.27–1.31).

Conclusions: European registered nurses working shifts of ≥12 hours and those working overtime report lower quality and safety and more care left undone. Policies to adopt a 12-hour nursing shift pattern should proceed with caution. Use of overtime working to mitigate staffing shortages or increase flexibility may also incur additional risk to quality.

Key Words: shift work, quality, safety, nurses, workforce, efficiency, Europe

(Med Care 2014;52: 975–981)

BACKGROUND

Traditionally, shift work was organized by dividing the day into three 8-hour shifts. This pattern was the norm in nursing for many years. In common with other industries, there is now a trend for some health care employers to adopt longer shifts, typically 2 shifts per day each lasting 12–13 hours. Employees work fewer shifts each week. Changes are driven by perceived efficiencies for the employer, and improved work life balance for employees because they work fewer days per week. However, persistent concerns...
have been raised about negative impacts on the quality of care associated with working longer hours.

From an employer’s perspective, a move from 3 to 2 shifts per day reduces periods of shift overlap and the number of handovers, thus reducing costs by reducing total workforce requirements. Because handovers and overlappings between shifts are regarded as unproductive, the aim is to improve efficiency with no detrimental effect on quality. Indeed a reduced number of handovers might have beneficial effects as handovers are associated with discontinuity and errors.25 From an employee perspective, there are reports that many nurses prefer the compressed working week that results from working fewer hours.16

Nonetheless, the introduction of 12-hour shifts has raised concerns. Long working hours are correlated with fatigue and decreased levels of alertness, potentially resulting in more adverse events.11,12 However, the point at which longer shifts adversely affect performance is likely to be industry, context, and task specific,9 and studies in healthcare have given mixed results.13 A recent study based on a survey of 22,275 registered nurses (RNs) in 4 US states found that nurses who worked shifts of ≥12 hours were significantly more likely to report poor quality of care and poor patient safety when compared with nurses working 8- to 9-hour shifts.14 Patients in hospitals where a higher proportion of nurses worked longer shifts also reported lower satisfaction.10 However, the odds of adverse reports of quality and safety were greater for nurses working 10–11 hours than for those working ≥12, which is inconsistent with a sample effect from longer hours worked on the shift. Analysis of a subsample of 3710 pediatric nurses found that reports of poor quality and safety were substantially elevated only among nurses working ≥13 hours.15

Several issues remain to be clarified. Hospitals in many countries worldwide are implementing 12-hour shifts,17 18 but the extent to which employers are adopting this shift pattern is unclear. Surveys of US RNs indicated that 65% worked shifts of 12–13 hours.14 A survey in 11 European countries indicated variation in shift patterns between countries but did not report specifically on shift length.19 Studies from outside the United States have generally focused on nurse job satisfaction and have not quantified associations with care quality (e.g., Richardson and colleagues).20 21 It is unclear whether findings relating to quality of care from the United States will be replicated in a European context, where typical weekly working hours are shorter and annual leave allowances more generous with the EU working time directive setting limits to both the total working week and continuous hours worked for many countries.

In the past, research in this area has lacked a clear theoretical framework. Recently, a simple model has been proposed, whereby increased fatigue during the shift mediates the effect of shift length on performance leading to errors, omissions, and lower efficiency.20 However, previous research has tended to confuse overtime working (working beyond contracted hours) with long shifts. Overtime working has also been associated with adverse quality because of cumulative fatigue, lack of rest, and adverse working environments.20 22 To more fully understand the issue of shift length and make research more useful to guide hospitals in developing their staffing policy it is therefore important to also consider both overtime working and total hours worked.

In this study, we describe the shift patterns worked by nurses on medical and surgical wards in European hospitals and explore associations between hours worked, working beyond contracted hours on a shift, and reports of quality and safety of care while controlling for total hours of work.

METHODS

We undertook a cross-sectional survey of RNs in medical and surgical wards of acute hospitals as part of the RN4CAST study.22 Data were collected in 12 European countries: Belgium, England, Germany, Finland, Greece, Ireland, The Netherlands, Norway, Poland, Spain, Sweden, and Switzerland. Depending on national legislation, the study was approved by either central (e.g., national, regional) or local (e.g., hospitals) ethical committees.

Sample

The survey was mailed or directly distributed to RNs in acute general hospitals between June 2009 and June 2010. The target sample was 30 hospitals in each country. In Ireland, Norway and Sweden all eligible hospitals were included. In Belgium, England, Germany, The Netherlands, Switzerland, and Spain, hospital selection was random with stratification for geographical location, type, and size. In Finland, Poland, and Greece, hospitals were sampled purposively to be geographically representative. A minimum of 2 (mean, 5.1) adult medical/surgical wards were randomly selected from each hospital. In Sweden, nurses were approached by the professional association which organizes over 70% of nurses and so all wards were potentially sampled. Specialized nursing units (e.g., intensive care, high dependency, long-term care) were excluded because staffing and shift patterns in these can differ substantially. In each ward, all RNs delivering direct care to patients were asked to complete and return a written questionnaire. In total, 54,140 questionnaires were distributed. Responses were obtained from 33,659 (62%) RNs in 488 hospitals (Table 1). Fuller details have been published elsewhere.22

Measurements

The survey was based on the validated International Hospital Outcomes Study questionnaire.23 The English survey was translated into Dutch, German, Greek, French, Italian, Finnish, Norwegian, Polish, Swedish, and Spanish using the translation-back translation method. Content validity and translation quality indices for all items used in this study were classified as “good” or better (content validity index ≥0.6).24

Nurses were asked to report the number of hours worked, the period of the day, and whether they had worked beyond their contracted hours on the last shift they worked. Shifts were dichotomized into day (including afternoon/evening shifts) and night shifts. Shift length was grouped into 5 categories: ≤8, 8.1–10, 10.1–11.9, 12–13, ≥13 hours. Where nurses had identified a shift length that was ≥18 hours, we treated data as missing. Absolute numbers of these
were very low (<1%). In most cases it appeared that these nurses had given the number of hours worked weekly. Nurses also reported on the number of patients on the ward and the numbers of nursing staff working on that shift. From this we calculated patient to nurse ratios.

Nurses were asked to evaluate the quality of nursing care on their ward as fair or poor as opposed to good or excellent. This measure has been validated by associations with hospital-level mortality, patient satisfaction, and care processes.21 For analysis, “poor” and “fair” responses were grouped to reflect negative evaluations of quality. Patient safety was rated as poor, failing, acceptable, very good, or excellent with “poor” and “failing” ratings combined to reflect negative evaluations.

Nurses were asked to identify whether any necessary activities from a list of 13 core nursing duties were left undone on their last shift worked because of lack of time. Items were derived from the HERCNA instrument, which has validated associations between care left undone, patient experience, and outcomes.24 A rate of care left undone was derived by summing the number of activities ticked per person, resulting in a score indicating the number of areas of care left undone (range from 0 to 13) (see Fig. 1 for details of specific questions used).

Analysis

Intraclass correlation coefficients (ICC 1) were computed from unconditional random intercept models to describe within-country, within-hospital, and within-unit variation for shift length. The ICC 1 measures the degree of similarity between individuals within a cluster.25 It also indicates the proportion of variance in the outcome that can be attributed to variation between groups (wards, hospitals, countries) as opposed to between individuals.30

The association of shift length and overtime with the outcome measures was estimated through a binomial generalized linear mixed model. The association of shift length and overtime with care left undone was estimated by a generalized linear model with a Poisson distribution. Because of the small sample size of the >13 hours category (n=260, 0.08%), we grouped the >13 hours category with the 12–13 hours into a ≥12 hours category for analysis. The multilevel structure allowed nurses to be nested into units, hospitals, and countries. We controlled for potential confounding variables, including variables chosen because they have been shown elsewhere to have independent relationships with the quality of care in hospitals,12,30 or the ability to cope with shift work.33 Control variables were shift type (day/night), ward type, nurse staffing levels (quantified by the ratio of patients per nurse), nurses’ age, full-time versus part-time working, hospital size (<250, 250–500, >500 beds), high-technology hospitals (those that performed major organ transplant surgery and/or open heart surgery), and teaching status (hospitals that provide training to undergraduate medical students). The variance inflation factor (VIF) was assessed for all model predictors to identify multicollinearity, with VIF < 5 indicating no multicollinearity.31 Analysis was conducted using RStudio version 0.96.330 and lme4 package.35

RESULTS

Data from 31,627 respondents working on adult medical/surgical wards was available for analysis. The mean age of respondents was 38. Ninety-two percent were female. Sixty-five percent of nurses worked full time (n=20,513). Sixty-seven percent worked in high-technology hospitals and 68% in teaching hospitals. Fifty-seven percent worked in medical units or mixed medical/surgical units, with the remaining 43% in surgical units. The majority (76%) of nurses reported on day shifts (Table 2).

Shift Length

The most common shift length was ≤8 hours (50%, n=15,936). Thirty-two percent worked from 8.1 to 10 hours

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**TABLE 1.** Hospital/Nurse Sample by Country

<table>
<thead>
<tr>
<th>Countries</th>
<th>Hospitals</th>
<th>Nurses</th>
<th>Nurses Per Hospital (Mean)</th>
</tr>
</thead>
<tbody>
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<td>2186</td>
<td>48</td>
</tr>
<tr>
<td>England</td>
<td>46</td>
<td>2918</td>
<td>63</td>
</tr>
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<tr>
<td>Switzerland</td>
<td>35</td>
<td>3562</td>
<td>77</td>
</tr>
<tr>
<td>Total</td>
<td>448</td>
<td>33,659</td>
<td></td>
</tr>
</tbody>
</table>

---

**FIGURE 1.** Survey items about shift work and quality.

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### Table 2. Characteristics of Last Shift Worked and Hours Worked

<table>
<thead>
<tr>
<th>Hours Worked</th>
<th>All</th>
<th>Day</th>
<th>Night</th>
<th>Overtime*</th>
<th>Part Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 or less</td>
<td>15,936 (50)</td>
<td>15,411 (49)</td>
<td>519 (2)</td>
<td>2,669 (8)</td>
<td>5,858 (16)</td>
</tr>
<tr>
<td>8.1–10</td>
<td>9,665 (32)</td>
<td>5,960 (19)</td>
<td>4,605 (13)</td>
<td>4,175 (13)</td>
<td>4,169 (13)</td>
</tr>
<tr>
<td>10.1–11.9</td>
<td>11,59 (3)</td>
<td>3,85 (1)</td>
<td>820 (3)</td>
<td>461 (1)</td>
<td>229 (1)</td>
</tr>
<tr>
<td>12–13</td>
<td>4,315 (15)</td>
<td>2,070 (8)</td>
<td>1,653 (5)</td>
<td>1,165 (4)</td>
<td>476 (1)</td>
</tr>
<tr>
<td>&gt; 13</td>
<td>26 (1)</td>
<td>22 (1)</td>
<td>51 (0)</td>
<td>156 (0)</td>
<td>6 (0)</td>
</tr>
<tr>
<td>Total</td>
<td>31,022 (100)</td>
<td>21,027 (70)</td>
<td>7,900 (22)</td>
<td>3,606 (27)</td>
<td>10,757 (35)</td>
</tr>
</tbody>
</table>

*Overtime* values in minutes reporting that they worked beyond contractual hours on that last shift.

Countries varied in their typical shift length (Table 3). For Belgium, Germany, Greece, The Netherlands, Norway, Sweden <5% of nurses reported working shifts of ≥ 12 hours. In all these countries the majority of day shifts were ≤ 8 hours. Shifts of ≥ 12 hours were more common in Finland, Spain, and Switzerland. For Ireland and Poland, shifts of ≥ 12 hours were the norm (≥ 73% of all shifts). England presented a more mixed picture, with 32% of day shifts and 37% of night shifts lasting ≥ 12 hours. Most variation in shift length was between units, with individuals within units tending to work similar shifts (ICC = 0.63). Individuals in the same hospital and country also tended to work similar shifts (ICC = 0.58, 0.59) with substantial variation between hospitals and countries.

### Table 3. Day and Night Shift Length by Country

<table>
<thead>
<tr>
<th>Countries</th>
<th>5.8h</th>
<th>8.1–10h</th>
<th>10.1–11.9h</th>
<th>12–13h</th>
<th>&gt; 13h</th>
<th>Overtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>36</td>
<td>11</td>
<td>22</td>
<td>12</td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td>Day (n = 230)</td>
<td>15</td>
<td>10</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>4</td>
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<tr>
<td>Night (n = 50)</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>35</td>
<td>3</td>
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<tr>
<td>England</td>
<td>4</td>
<td>11</td>
<td>22</td>
<td>29</td>
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<td>3</td>
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<td>Day (n = 209)</td>
<td>10</td>
<td>23</td>
<td>30</td>
<td>36</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Night (n = 670)</td>
<td>20</td>
<td>21</td>
<td>30</td>
<td>39</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Germany</td>
<td>7</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Day (n = 1210)</td>
<td>71</td>
<td>22</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Night (n = 287)</td>
<td>74</td>
<td>21</td>
<td>37</td>
<td>35</td>
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<td>1</td>
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<tr>
<td>France</td>
<td>5</td>
<td>11</td>
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<td>12</td>
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<td>4</td>
</tr>
<tr>
<td>Day (n = 357)</td>
<td>30</td>
<td>20</td>
<td>30</td>
<td>30</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Night (n = 82)</td>
<td>82</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Greece</td>
<td>3</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Day (n = 247)</td>
<td>80</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Night (n = 87)</td>
<td>80</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ireland</td>
<td>5</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
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<td>The Netherlands</td>
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<td>4</td>
</tr>
<tr>
<td>Day (n = 358)</td>
<td>50</td>
<td>10</td>
<td>30</td>
<td>30</td>
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<td>1</td>
</tr>
<tr>
<td>Night (n = 87)</td>
<td>50</td>
<td>10</td>
<td>30</td>
<td>40</td>
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<td>1</td>
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<tr>
<td>Norway</td>
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<td>12</td>
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<td>4</td>
</tr>
<tr>
<td>Day (n = 354)</td>
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<td>30</td>
<td>30</td>
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<td>1</td>
</tr>
<tr>
<td>Night (n = 87)</td>
<td>50</td>
<td>10</td>
<td>30</td>
<td>40</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Poland</td>
<td>6</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Day (n = 156)</td>
<td>50</td>
<td>10</td>
<td>30</td>
<td>30</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Night (n = 87)</td>
<td>50</td>
<td>10</td>
<td>30</td>
<td>40</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Spain</td>
<td>1</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>2</td>
<td>4</td>
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<tr>
<td>Day (n = 247)</td>
<td>50</td>
<td>10</td>
<td>30</td>
<td>30</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Night (n = 87)</td>
<td>50</td>
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<td>30</td>
<td>40</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sweden</td>
<td>8</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Day (n = 156)</td>
<td>50</td>
<td>10</td>
<td>30</td>
<td>30</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Night (n = 87)</td>
<td>50</td>
<td>10</td>
<td>30</td>
<td>40</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Switzerland</td>
<td>7</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Day (n = 156)</td>
<td>50</td>
<td>10</td>
<td>30</td>
<td>30</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Night (n = 87)</td>
<td>50</td>
<td>10</td>
<td>30</td>
<td>40</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

*Overtime* values in minutes reporting that they worked beyond contractual hours on that last shift.

Metal values for length of day/night shifts in each country are indicated in bold type.
Overall, 8606 nurses (27%) reported that they had worked overtime (beyond their contracted hours) on their last shift (Table 3). Most reports of overtime work were made by nurses who reported working 8.1–10 hours (40%, 4175/8606). A majority of nurses who reported working shifts of >12 hours worked overtime on that shift (60%, 156/260). There was wide variation between hospitals, with a range from 0% to 40% of nurses working overtime. There was also variation between countries ranging from 50% (England) to 12% (Poland) (Table 3).

**Associations With Quality, Safety, and Care Left Undone**

Twenty-five percent (n = 7815) of nurses reported poor/ fair quality of care and 7% (2736) reported “poor” or “failing” patient safety. Distributions of quality and safety statements by country are reported elsewhere. Nurses reported on average 3 activities left undone on their last shift. Only 3934 nurses (12%) did not report leaving any care undone.

 Longer shifts and working overtime were significantly associated with quality of care, patient safety reports, and care left undone (p < 0.05). Compared with nurses working ≤8 hours, nurses working ≥12 hours on their last shift were more likely to rate the quality of nursing care in their unit as “poor” or “failing” (OR = 1.36, 95% CI, 1.10–1.65) and more likely to report “failing” or “poor” patient safety in their units (OR = 1.41, 95% CI, 1.12–1.76). Although not statistically significant, odds of adverse quality and safety were raised for all shift lengths >8 hours although only marginally for shifts of 8.1–10 hours. Nurses working ≥12 hours reported higher rates of care left undone than did nurses working ≤8 hours (RR = 1.13, 95% CI, 1.09–1.16). All shifts >8 hours were associated with statistically significant increases in the rate of care left undone (p < 0.05) (Table 4).

Nurses working overtime on their last shift were more likely to report poor/fair quality of nursing care (OR = 1.32; 95% CI, 1.23–1.42), poor/failing patient safety (OR = 1.67; 95% CI, 1.51–1.86), and higher rates of care left undone (RR = 1.29; 95% CI, 1.27–1.31) (Table 4).

There were significant associations between reports of quality, safety, or care left undone for several control variables including night shifts (fewer negative evaluations), patient to nurse ratio (more negative evaluations with more patients per nurse), and part-time work (fewer negative evaluations) (Table 4).

We tested for interaction between shift length and overtime (model not shown—available from authors); however, the relationship was not significant. To assess the impact of our decision to collapse the 12–13 hours and >13-hour categories, we analyzed the data with the 12–13 hours and >13-hour categories separately. To ensure conclusions were not biased by post hoc classification of safety ratings, we analyzed the data with “acceptable” safety ratings.

### Table 4. Results of Multilevel Regression Models: Associations Between the Model Predictors, and Quality of Care, Patient Safety, and Care Left undone

<table>
<thead>
<tr>
<th>Poor Quality of Nursing Care Rating</th>
<th>Poor Patient Safety Rating</th>
<th>Care Left undone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odds Ratio (95% CI)</td>
<td>Odds Ratio (95% CI)</td>
<td>Rate Ratio (95% CI)</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>≤8: shift (reference category)</td>
<td>1.03 (0.95–1.12)</td>
<td>1.08 (0.95–1.22)</td>
</tr>
<tr>
<td>8.1–10</td>
<td>1.07 (0.96–1.21)</td>
<td>1.12 (0.97–1.29)</td>
</tr>
<tr>
<td>10.1–11.9</td>
<td>1.29 (1.10–1.51)</td>
<td>1.47 (1.33–1.63)</td>
</tr>
<tr>
<td>≥12</td>
<td>1.39* (1.10–1.75)</td>
<td>1.75 (1.53–1.99)</td>
</tr>
<tr>
<td>Not overtime (reference category)</td>
<td>1.32* (1.22–1.42)</td>
<td>1.67* (1.51–1.86)</td>
</tr>
<tr>
<td>Day shift (reference category)</td>
<td>0.99 (0.82–1.09)</td>
<td>0.87 (0.76–0.99)</td>
</tr>
<tr>
<td>Medical unit (reference category)</td>
<td>0.87 (0.62–0.99)</td>
<td>0.92 (0.83–1.03)</td>
</tr>
<tr>
<td>Surgical unit</td>
<td>0.82 (0.65–1.00)</td>
<td>0.92 (0.83–1.03)</td>
</tr>
<tr>
<td>&lt;6.1 patients/nurse (reference category)</td>
<td>1.34 (1.17–1.54)</td>
<td>1.43 (1.28–1.61)</td>
</tr>
<tr>
<td>6.1–7 patients/nurse</td>
<td>1.44 (1.19–1.74)</td>
<td>1.58 (1.34–1.86)</td>
</tr>
<tr>
<td>7.0–9.2 patients/nurse</td>
<td>1.69 (1.46–1.95)</td>
<td>1.85 (1.58–2.18)</td>
</tr>
<tr>
<td>9.3–11.5 patients/nurse</td>
<td>1.88 (1.62–2.20)</td>
<td>2.15 (1.83–2.54)</td>
</tr>
<tr>
<td>&gt;11.5 patients/nurse</td>
<td>2.01 (1.70–2.38)</td>
<td>2.31 (2.01–2.69)</td>
</tr>
<tr>
<td>Full time (reference category)</td>
<td>0.97 (0.90–1.04)</td>
<td>0.96 (0.89–1.03)</td>
</tr>
<tr>
<td>Part time</td>
<td>0.97 (0.90–1.04)</td>
<td>0.96 (0.89–1.03)</td>
</tr>
<tr>
<td>Age &lt;25 yrs (reference category)</td>
<td>1.39 (1.22–1.57)</td>
<td>1.50 (1.32–1.69)</td>
</tr>
<tr>
<td>Age 25–34 yrs</td>
<td>1.37 (1.16–1.60)</td>
<td>1.48 (1.28–1.73)</td>
</tr>
<tr>
<td>Age 35–44 yrs</td>
<td>1.60 (1.42–1.81)</td>
<td>1.75 (1.54–2.00)</td>
</tr>
<tr>
<td>Age 45–54 yrs</td>
<td>1.83 (1.62–2.08)</td>
<td>1.99 (1.78–2.25)</td>
</tr>
<tr>
<td>Age &gt;54 yrs</td>
<td>2.01 (1.70–2.38)</td>
<td>2.21 (1.90–2.58)</td>
</tr>
<tr>
<td>Small hospital (&lt;250 beds) (reference category)</td>
<td>1.15 (0.92–1.43)</td>
<td>1.10 (0.88–1.40)</td>
</tr>
<tr>
<td>Medium hospital (250–999 beds)</td>
<td>1.17 (0.92–1.47)</td>
<td>1.21 (0.98–1.50)</td>
</tr>
<tr>
<td>Large hospital (&gt;500 beds)</td>
<td>1.02 (0.84–1.25)</td>
<td>0.97 (0.82–1.16)</td>
</tr>
<tr>
<td>High-technology hospital (reference category)</td>
<td>0.87 (0.70–1.01)</td>
<td>0.99 (0.88–1.14)</td>
</tr>
<tr>
<td>Teaching hospital (reference category)</td>
<td>0.87 (0.70–1.01)</td>
<td>0.99 (0.88–1.14)</td>
</tr>
<tr>
<td>Non-teaching hospital</td>
<td>0.87 (0.70–1.01)</td>
<td>0.99 (0.88–1.14)</td>
</tr>
</tbody>
</table>

*Statistically significant (p < 0.05).
CI: confidence interval.
grouped with "poor" and "failing." These changes did not alter results significantly.

**DISCUSSION**

To our knowledge, this is the first study in Europe to document associations between shift patterns of hospital nurses and problems in the quality and safety of care. Shifts of ≥12 hours and working overtime (beyond contracted hours) on a shift were independently associated with nurses' reports of lower quality of care, poorer patient safety, and increasing rates of care left undone. All shifts ≥12 hours were associated with increasing rates of care left undone. Our results show substantial variation in typical shift patterns between European countries. Although overall only 15% of nurses reported working ≥12 hours on their last shift, long shifts were common in England, Ireland, and Poland. The reason for the variation is unclear. Of countries where 12-hour shifts were common, only England was reported as experiencing nursing shortages at the time of the study, although the pattern may have been established in Poland and Ireland during historical periods of shortage. Twenty-seven percent of all nurses reported working overtime on their last shift.

In the USA, shifts of ≥12 hours are prevalent and have been associated with poorer quality ratings. However, it was not clear in these studies whether the adverse associations between shift length and quality were the result of the number of hours worked on the shift or working overtime. Associations between overtime and delirium in medical care quality have also been reported previously. Our study shows working overtime on a shift to be a negative factor independent of the total hours worked on the shift. This finding indicates that shifts of ≥12 hours are associated with reports of reduced quality, independently of working overtime and the length of the normal working week (full time vs. part time).

The finding has a large impact on health care organizations, especially in the current economic climate, where employers in many countries are aiming to use the existing workforce more efficiently, either to reduce expenditure or because of nursing shortages. Previous research indicates that low nurse staffing levels are associated with worse patient outcomes. This finding is supported by our analysis. Moving from 3 shorter shifts per day to 2 longer ones to maintain current patient to nurse ratios with fewer total staff has been advocated in England and elsewhere, with claimed savings of up to 14% on salary costs for nurses working shifts. However, such a strategy may not have the desired effect if nurses perform less effectively and safely.

Overtime working is common in nursing. This is reflected by the prevalence seen in the current study and in reports from US and elsewhere. In our survey, reported overtime varied between hospitals from 0% to 98% consistent with surveys from the US which also show substantial variation between hospitals. Variation of such magnitude suggests that it is unlikely to be a simple product of variation in workforce supply but may also result from variation in staffing policies. The results of this study suggest that the apparent flexibility for employers, using overtime to meet dynamic staffing requirements, may be counterproductive because of the negative associations with quality and safety. Although increased fatigue, loss of alertness, and impaired decision making are plausible mechanisms to explain reduced ratings of quality and safety with longer shifts, this does not fully explain an adverse effect from overtime independent of shift length. Overtime has previously been associated with increased nurse turnover and it may be that use of overtime is associated with less favorable working environments for nurses, which are known to be linked to subjective and objective measures of reduced quality and safety of care. Overtime can be an individual voluntary strategy of "working late" (unpaid) to complete work or an organizational strategy of asking or requiring workers (unpaid or with additional pay or time off in lieu) to extend working hours to meet demand. Although the distinction between these modes of overtime has been questioned, they may be relevant in determining engagement and motivation for those working overtime. For example, overtime that is mandatory may have a negative effect on psychological well-being related to lack of control.

The degree to which nurses are subsisting health services through unpaid overtime and the impact of long hours and overtime on burnout have implications for both the costs and the effectiveness of extended shifts, which require further exploration. The paradox whereby longer shifts appear to be preferred by nurses because of the compressed working week, and yet deliver poorer evaluations of safety and quality of care also merits further investigation.

Our study has some limitations. Our analysis of cross-sectional survey data showed associations between shift patterns and quality and safety, but it is not possible to infer causality. Because we did not test for interaction effects between country and shift work, we can only estimate the average effect across all countries and cannot explore differences between countries related to (for example) cultural differences. The outcome measures used in this study were nurses' self-report. The clinical impact of any differences noted is unclear. Although nurses' self-reports of quality and safety have validated associations with objective measures such as rates of mortality and failure to rescue, further research should include objective measures and consider patients' experiences. Although our sampling strategy was designed to obtain a representative sample of hospitals and nurses in each country, we cannot fully judge the extent to which this was successful because of lack of data for comparison for most countries. Furthermore, the primary purpose of the RNACAST study was not to assess shift work in particular and so the survey did not ask about the nature of overtime and more specific aspects of shift work, including the number of hours overtime, the nurses usual shift pattern, the possibility of taking breaks during shifts and opportunities to rest between shifts, factors that may be relevant in modeling the effects of shift work on performance. Although we were able to use full time versus part time status as a proxy for total hours worked, we did not directly measure hours worked.

**CONCLUSIONS**

European nurses working ≥12 hours and those working overtime on a shift were more likely to describe the quality
Appendix B Published manuscript: Association of 12 h shifts and nurses’ job satisfaction, burnout and intention to leave: findings from a cross-sectional study of 12 European countries

BMJ Open

Association of 12 h shifts and nurses’ job satisfaction, burnout and intention to leave: findings from a cross-sectional study of 12 European countries

Chira Dall’Or,1 Peter Griffiths,1 Jane Ball,1 Michael Simon,2,16 Linda H Aikin7

ABSTRACT

Objectives: 12 h shifts are becoming increasingly common for hospital nurses but there is concern that long shifts adversely affect nurses’ wellbeing, job satisfaction and intention to leave their job. The aim of this study is to examine the association between working long shifts and burnout, job dissatisfaction, dissatisfaction with work schedule flexibility and intention to leave current job among hospital nurses.

Methods: Cross-sectional survey of 51,627 registered nurses in 217 general medical/surgical units within 480 hospitals across 12 European countries.

Results: Nurses working shifts of ≥12 h were more likely than nurses working shorter hours (<8 h) to experience burnout, in terms of emotional exhaustion (adjusted OR=1.26, 95% CI 1.00 to 1.56), depersonalisation (OR=1.21, 95% CI 1.01 to 1.47) and low personal accomplishment (OR=1.39, 95% CI 1.28 to 1.52). Nurses working shifts of ≥12 h were more likely to experience job dissatisfaction (OR=1.49, 95% CI 1.20 to 1.83), dissatisfaction with work schedule flexibility (OR=1.15, 95% CI 1.00 to 1.35) and report intention to leave their job due to dissatisfaction (OR=1.29, 95% CI 1.12 to 1.48).

Conclusions: Longer working hours for hospital nurses are associated with adverse outcomes for nurses. Some of these adverse outcomes, such as high burnout, may pose safety risks for patients as well as nurses.

BACKGROUND

Job satisfaction and burnout in the nursing workforce are global concerns.1,2 Both due to their potential impact on quality and safety of patient care and because low job satisfaction is a contributing factor associated with nurses leaving their job and the profession.3 Numerous studies previously reported different rates of nurses’ job satisfaction, burnout and intention to leave.4,5 Shift patterns have been identified as an important factor in determining well-being and satisfaction among nurses.6,7 Providing inpatient nursing care inevitably involves shift work. Shifts of 12 h or longer have become increasingly common for nurses in hospitals in some countries in Europe.8 This change is mainly driven by managers’ perceptions of improved efficiency from reducing the number of nurse shifts a day, thereby resulting in fewer handovers between shifts, less interruptions to clinical care provision and increased productivity due to a reduction in the overlap between two shifts.9 From the nurse perspective, longer shifts offer a potential to benefit from a compressed working week, with fewer work days and more days off-work, lower commuting costs and increased flexibility10,11. However, previous studies on shift length in Europe did not provide evidence of nurses working a compressed work week, so it is not clear if working 12 h shifts is associated with fewer days at work.12 These scheduling practices have not been systematically evaluated and the movement to longer shifts for nurses has not been based on research evidence of improved outcomes for nurses and an absence of harm to patients.13,14

Strengths and limitations of this study

This study showed that European registered nurses working shifts of 12 h or longer were more likely to report job dissatisfaction, dissatisfaction with schedule flexibility, intention to leave their current job and to experience burnout.

This study was performed across 12 European countries over a large sample (51,627 registered nurses).

The design of this study is cross-sectional which limits the ability to infer causal relationship between nurses’ shift length and nurse outcomes causally.

We were not able to control for other aspects of shift work, including weekly hours, number of hours over-time, the possibility of taking breaks during shifts and sleep patterns.
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In the limited research literature on the outcomes of nurse work hours, results have been mixed.16-23 Estabrook et al found insufficient evidence of effects of shift length on nurse job satisfaction and burnout, while a more recent systematic review reported evidence of adverse nurse outcomes associated with shifts of 12 or more hours, including burnout, job dissatisfaction, intention to leave and fatigue from a number of studies, mostly from the US.19 A recent study among European nurses investigated the association between shift length and nurses' psychological wellbeing. The findings show that nurses preferred 12 h shifts because more time off helped them balance work and personal responsibilities, although the nature of these was not examined (eg, having a second job, having caring responsibilities at home and other potential confounders on the impact of 12 h shifts on nurse outcomes). Paradoxically, the study also found that nurses who worked 12 h shifts were more likely to experience high levels of burnout than nurses working shorter shifts.20,21 Similarly, Smpiel reported that American nurses working extended shifts, particularly longer than 15 h, were more satisfied with their work schedules but were more likely to experience burnout and job dissatisfaction than nurses who worked shifts of 8 or 9 h. However, the US study did not disentangle scheduled shift length from extended shifts due to overtime worked, a common limitation in previous research on nurses' shift lengths.

Differences between work hour regulations between countries may limit the generalisability of US research. The US has regulations governing nurses' work hours that differ from the European Working Time Directive, in terms of limiting weekly hours, including overtime, and providing extra protection for between-shift rest hours and night work.28

The present study aims to examine the extent to which European hospital nurses' extended shifts (12 h or more) are associated with burnout, job dissatisfaction, satisfaction with work schedule flexibility and intention to leave current job.

METHODS

We performed a cross-sectional survey of European registered nurses as part of the RNCAS study.22 Data were collected in 12 European countries: Belgium, England, Finland, Germany, Greece, Ireland, Netherlands, Norway, Poland, Spain, Switzerland and Sweden. The study protocol was approved by either central ethical committees (eg, nation or university) or local ethical committees (eg, hospitals).

Sample

At least 50 hospitals were enlisted in each country and in each hospital a minimum of two medical/surgical nursing units were included. Specialised nursing units (eg, intensive care, long-term care) were excluded because of their potential difference in staffing and shift patterns. In each sampled unit, all registered nurses delivering direct care to patients, working either full time or part time, were asked to participate. No minimum working hours or percentage of direct care hours were set as inclusion criteria. The survey was mailed or directly distributed between June 2009 and June 2010. Overall, 488 hospitals participated in the RNCAS study22 and 39 659 registered nurses were surveyed, with an average response rate of 62% across the 12 European countries. More details on the sample selection are available on the RNCAS protocol.22

Measurements

The survey included a total of 118 questions organised in five sections: 'About your job', investigating work environment, burnout and job satisfaction, 'quality and safety', 'About your most recent shift at work in this hospital', which had the purpose to measure shift length and nurse staffing levels. The 'About you' section aimed to investigate demographic details such as age, gender and education. The English survey was translated into the 10 primary languages (Dutch, German, Greek, French, Italian, Finnish, Norwegian, Polish, Swedish and Spanish) and underwent pilot testing and validation.23 The survey did not enquire if nurses were holding their principal position at the hospitals they were surveyed.

Shift length was recorded by asking the actual number of hours worked on the most recent shift. In order to perform descriptive and multilevel regression analysis, shift length was grouped into five categories: ≤6, 6.1–10, 10.1–11.9, 12–15, ≥15. We described separately day and night shifts, however we could not examine whether the nurses were working fixed or rotating shifts. A survey question inquired whether nurses had worked overtime on their last shift, and a further question asked whether they worked full time at the hospital. Where nurses had identified a shift length that was 18 h or longer (1% of responses), we treated data as missing.

Burnout was assessed using the Maslach Burnout Inventory (MBI).24 The MBI is internationally the most widely used instruments for measuring work-related burnout. The MBI assesses three dimensions of burnout through three distinct subscales: emotional exhaustion, depersonalisation and personal accomplishment. Burnout is indicated by high scores on emotional exhaustion (≥27) and depersonalisation (≥21) and low scores on personal accomplishment (≤51).25 For our analysis, we contrasted nurses with high-burnout scores of emotional exhaustion ≥27, depersonalisation ≥21 and personal accomplishment ≤51 and those with lower burnout scores. We did not combine the three subscales into one, single total score, because Maslach suggested that the scores of each subscales are to be considered separately, due to little knowledge about the relationship between the three aspects of burnout.24

Job satisfaction was measured with a single survey question: 'How satisfied are you with your job?' Responses were reported on a 4-point scale, ranging
from 'very dissatisfied' to 'very satisfied'. Nurses who reported being 'very satisfied' and 'moderately satisfied' were compared with nurses who reported being 'a little dissatisfied' and 'very dissatisfied'. We also assessed satisfaction with work schedule flexibility, because flexibility is one of the most important benefits of 12 h shifts.\textsuperscript{11,12} We asked: 'How satisfied are you with ... work schedule flexibility?' with responses ranging from 'very dissatisfied' to 'very satisfied' on a 4-point scale. 'Very dissatisfied' and 'a little dissatisfied' were combined and 'moderately satisfied' and 'very satisfied' were combined to form a dichotomous variable.

Nurses' intention to leave was established by the question: 'If possible, would you leave your current hospital within the next year as a result of job dissatisfaction?' Possible answers were 'yes' and 'no'.

**Data analysis**

First we undertook a descriptive analysis of registered nurses' burnout, job satisfaction, satisfaction with work schedule flexibility and intention to leave. We also examined the characteristics of nurses and hospitals by shift length category.

We examined the bivariate association between nurses' shift length and nurse outcomes (burnout, job dissatisfaction, dissatisfaction with work schedule flexibility, intention to leave), using generalised linear mixed models.

We then controlled for potential confounding variables, including variables that have been shown previously to have independent relationships with burnout and job satisfaction in hospital.\textsuperscript{13,14} We included shift type (day/night), overtime (yes/no), nurse staffing levels (quantified by the ratio of patients per nurse on the last shift they worked, reported in the nurse survey), hospital size (<250, 250 to 500 beds, >500 beds), technology status (those that performed major organ transplant surgery, open heart surgery or both), teaching status (hospitals that provide training to undergraduate medical students), full time/part time status, nurses' age and gender as control variables in our generalised linear mixed models. This multivariate analysis allowed us to net nurses into units, hospitals and countries. Owing to the small sample size of the >12 h category (n=290, 0.96%), we grouped the >12 h category and the 12–13 h into a ≥12 h category for analysis.

To estimate the explained variance we computed inter-class correlations (ICCs) from the generalised linear mixed models. The ICC indicates the proportion of variance in the outcome that can be attributed to variation between groups (units, hospitals, countries) as opposed to between individuals.

The possible presence of multicollinearity was assessed for all model predictors through the variance inflation factor (VIF), resulting in VIF below 5, indicating no multicollinearity.\textsuperscript{20} All the analysis were conducted using Rstudio V9.99.339\textsuperscript{19} and lmfit package.\textsuperscript{25}

**Results**

**Hospital and nurses characteristics**

The sample size was reduced (n=31,627) due to the presence of out-of-range values and missing data regarding shift length. The mean age of respondents was 38 years old. Ninety-two per cent were female (n=29,195). Sixty-three per cent of the participants worked in high technology hospitals (n=19,806) and 67% in teaching hospitals (n=21,432). Most of the participants (n=17,995, 57%) reported working in medical units, while the remaining 43% practised in surgical units: 10,787 nurses reported working part time (34%). Distribution of demographic and hospital characteristics across shift lengths is reported in table 1.

**Shift length and nurse outcomes**

The majority of nurses reported working a day shift (n=24,627, 78%) on their last shift. The most common shift length was ≤8 h (n=15,980, 50%). A total of 9963 nurses had worked from 8.1 to 10 h (31%), while 1159 nurses (4%) had worked from 10.1 to less than 12 h. A total of 6314 nurses (14%) reported working from 12 to 13 h, while only 260 nurses (<1%) worked more than 13 h. A total of 8606 nurses (27%) overall reported working overtime on their last shift. Distribution of shift length categories on the individual level can be found in table 1. For the majority of the countries reports of 12 h shifts were less than 15%. In some countries—most notably England, Ireland and Poland—12 h shifts are far more common (percentages of nurses reporting working 12 h shifts in England 30%; Ireland 20%; Poland 99%); extensive descriptive data for shift length on the country level is reported elsewhere.\textsuperscript{9}

Overall 8666 nurses (27%) experienced high emotional exhaustion, 3157 nurses (10%) experienced high depersonalisation and 5300 nurses (17%) experienced low personal accomplishment. A total of 8268 nurses (25%) reported being very or a little dissatisfied with their job (25%). A total of 8616 nurses (25%) reported being very or a little dissatisfied with work schedule flexibility and 10,440 (33%) reported intention to leave their current job. The proportion of variance in the outcome attributable to variation between groups as opposed to between individuals varied according to outcome. For job satisfaction the ICC was 0.25; for intention to leave 0.14; for satisfaction with work schedule flexibility 0.19; for emotional exhaustion 0.25; for depersonalisation 0.16; for personal accomplishment 0.09. Table 2 reports rates of burnout, job dissatisfaction, dissatisfaction with work schedule flexibility and intention to leave by shift length category. Reports of these outcomes by country can be found elsewhere.\textsuperscript{9}

Increases in shift length were associated with significant increases in adverse nurse outcomes, even after we adjusted for potential confounding factors. The output of the fully adjusted models show that nurses working 12 h or longer on their last shift were more likely to experience high burnout, when compared to nurses
### Table 1: Characteristics of nurses and hospitals, by shift length

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>≤8</th>
<th>8.1–10</th>
<th>10.1–11.9</th>
<th>≥12</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registered nurses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of registered nurses; n (%)</td>
<td>15 930 (50)</td>
<td>9963 (32)</td>
<td>1159 (4)</td>
<td>4575 (14)</td>
<td>31 627 (100)</td>
</tr>
<tr>
<td>Worked day shift on their last shift; n (%)</td>
<td>15 411 (49)</td>
<td>5960 (16)</td>
<td>397 (1)</td>
<td>2398 (8)</td>
<td>24 627 (78)</td>
</tr>
<tr>
<td>Worked night shift on their last shift; n (%)</td>
<td>519 (2)</td>
<td>4003 (13)</td>
<td>802 (3)</td>
<td>1676 (6)</td>
<td>7030 (22)</td>
</tr>
<tr>
<td>Worked overtime on their last shift; n (%)</td>
<td>2669 (8)</td>
<td>4175 (13)</td>
<td>461 (1)</td>
<td>1301 (4)</td>
<td>8606 (27)</td>
</tr>
<tr>
<td>Works part-time in the hospital; n (%)</td>
<td>5888 (19)</td>
<td>4109 (13)</td>
<td>320 (1)</td>
<td>470 (1)</td>
<td>10 767 (34)</td>
</tr>
<tr>
<td>Age, mean</td>
<td>38.1</td>
<td>38.4</td>
<td>39.5</td>
<td>37.5</td>
<td>38.2</td>
</tr>
<tr>
<td>Age min-max</td>
<td>18–70</td>
<td>20–70</td>
<td>20–65</td>
<td>20–68</td>
<td>18–70</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female; n (%)</td>
<td>14 631 (46)</td>
<td>9170 (30)</td>
<td>1018 (4)</td>
<td>4336 (14)</td>
<td>29 165 (92)</td>
</tr>
<tr>
<td>Male; n (%)</td>
<td>1299 (4)</td>
<td>793 (3)</td>
<td>141 (1)</td>
<td>229 (1)</td>
<td>2472 (8)</td>
</tr>
<tr>
<td>Unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical; n (%)</td>
<td>9227 (29)</td>
<td>5732 (18)</td>
<td>648 (3)</td>
<td>2352 (7)</td>
<td>17 959 (57)</td>
</tr>
<tr>
<td>Surgical; n (%)</td>
<td>6703 (21)</td>
<td>4231 (13)</td>
<td>511 (2)</td>
<td>2223 (7)</td>
<td>13 668 (43)</td>
</tr>
<tr>
<td>Starting levels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;0.1 patients/nurse (reference category); n (%)</td>
<td>2944 (25)</td>
<td>2231 (10)</td>
<td>222 (1)</td>
<td>1047 (3)</td>
<td>12 444 (59)</td>
</tr>
<tr>
<td>0.1–0.7 patients/nurse; n (%)</td>
<td>2145 (7)</td>
<td>1070 (5)</td>
<td>158 (0)</td>
<td>594 (2)</td>
<td>8497 (12)</td>
</tr>
<tr>
<td>0.7–1.5 patients/nurse; n (%)</td>
<td>2179 (7)</td>
<td>1288 (4)</td>
<td>176 (0)</td>
<td>778 (2)</td>
<td>4401 (14)</td>
</tr>
<tr>
<td>1.5–1.9 patients/nurse; n (%)</td>
<td>1887 (6)</td>
<td>1417 (5)</td>
<td>229 (1)</td>
<td>1042 (3)</td>
<td>4575 (14)</td>
</tr>
<tr>
<td>&gt;1.9 patients/nurse; n (%)</td>
<td>1776 (6)</td>
<td>2917 (9)</td>
<td>394 (1)</td>
<td>1114 (3.5)</td>
<td>6570 (20)</td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High technology (performing major organ transplant surgery, open heart surgery, or both); n (%)</td>
<td>10 236 (32)</td>
<td>6437 (20)</td>
<td>566 (2)</td>
<td>2567 (8)</td>
<td>19 806 (63)</td>
</tr>
<tr>
<td>Not high technology hospital; n (%)</td>
<td>5694 (18)</td>
<td>3526 (11)</td>
<td>593 (2)</td>
<td>2008 (6)</td>
<td>11 413 (27)</td>
</tr>
<tr>
<td>Teaching status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching; n(%)</td>
<td>10 913 (34)</td>
<td>6950 (22)</td>
<td>667 (2)</td>
<td>2696 (9)</td>
<td>21 432 (67)</td>
</tr>
<tr>
<td>Not teaching; n(%)</td>
<td>5017 (16)</td>
<td>3007 (10)</td>
<td>492 (1)</td>
<td>1679 (5)</td>
<td>10 195 (23)</td>
</tr>
<tr>
<td>Size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small (&lt;250 beds); n(%)</td>
<td>3894 (12)</td>
<td>2390 (7)</td>
<td>207 (1)</td>
<td>545 (2)</td>
<td>7099 (22)</td>
</tr>
<tr>
<td>Medium (≥250, ≤500); n(%)</td>
<td>5564 (17)</td>
<td>3684 (12)</td>
<td>457 (1)</td>
<td>1007 (3)</td>
<td>10 712 (34)</td>
</tr>
<tr>
<td>Large (&gt;500); n(%)</td>
<td>6472 (20)</td>
<td>3888 (12)</td>
<td>495 (1)</td>
<td>2023 (9)</td>
<td>13 878 (44)</td>
</tr>
</tbody>
</table>

Percentages may not sum to 100 because of rounding (N=31 827).

Working 8 h or less. When working 12 h or more, the odds of reporting high emotional exhaustion were increased by 26%, in comparison with working 8 h or less (adjusted OR (aOR)=1.21; 95% CI 1.09 to 1.36). Nurses working 12 h or more were more likely to experience high depersonalisation (aOR=1.21; 95% CI 1.01 to 1.47) and low personal accomplishment (aOR=1.39; 95% CI 1.20 to 1.62).

### Table 2: Nurse outcomes, by shift length category

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>≤8</th>
<th>8.1–10</th>
<th>10.1–11.9</th>
<th>≥12</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blunout</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional exhaustion (&gt;27); n (%)</td>
<td>3951 (25)</td>
<td>2593 (26)</td>
<td>406 (3)</td>
<td>1714 (57)</td>
<td>8666 (27)</td>
</tr>
<tr>
<td>Depersonalisation (&gt;13); n (%)</td>
<td>1471 (9)</td>
<td>927 (9)</td>
<td>144 (12)</td>
<td>583 (13)</td>
<td>3127 (10)</td>
</tr>
<tr>
<td>Low personal accomplishment (&gt;31); n (%)</td>
<td>2373 (15)</td>
<td>1382 (14)</td>
<td>238 (21)</td>
<td>1307 (29)</td>
<td>5300 (17)</td>
</tr>
<tr>
<td>Job satisfaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A little dissatisfied/very dissatisfied with job; n (%)</td>
<td>3648 (23)</td>
<td>2650 (27)</td>
<td>416 (36)</td>
<td>1553 (34)</td>
<td>8268 (26)</td>
</tr>
<tr>
<td>A little dissatisfied/very dissatisfied with work schedule flexibility; n (%)</td>
<td>3938 (23)</td>
<td>2599 (26)</td>
<td>270 (23)</td>
<td>1269 (26)</td>
<td>8016 (23)</td>
</tr>
<tr>
<td>Intend to leave job within the next year; n (%)</td>
<td>4677 (29)</td>
<td>3241 (34)</td>
<td>491 (42)</td>
<td>1251 (42)</td>
<td>10 440 (32)</td>
</tr>
<tr>
<td>All</td>
<td>15 930 (100)</td>
<td>9963 (100)</td>
<td>1159 (100)</td>
<td>4575 (100)</td>
<td>31 627 (100)</td>
</tr>
</tbody>
</table>

Percentages may not sum to 100 because of rounding. N=31 827.
Appendix B

Table 3 Outputs of multilevel models: associations between the model predictors, and burnout, job dissatisfaction, dissatisfaction with work schedule flexibility and intention to leave

<table>
<thead>
<tr>
<th>Shift length category</th>
<th>Unadjusted</th>
<th>Fully adjusted*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>Burnout</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional exhaustion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1–10</td>
<td>1.14†</td>
<td>1.07 to 1.21</td>
</tr>
<tr>
<td>≥12</td>
<td>1.26†</td>
<td>1.11 to 1.44</td>
</tr>
<tr>
<td>Depersonalisation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1–10</td>
<td>1.13†</td>
<td>1.03 to 1.25</td>
</tr>
<tr>
<td>≥12</td>
<td>1.49†</td>
<td>1.23 to 1.73</td>
</tr>
<tr>
<td>Personal accomplishment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1–10</td>
<td>1.12†</td>
<td>1.04 to 1.21</td>
</tr>
<tr>
<td>≥12</td>
<td>1.44†</td>
<td>1.21 to 1.71</td>
</tr>
<tr>
<td><strong>Job dissatisfaction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1–10</td>
<td>1.30†</td>
<td>1.22 to 1.39</td>
</tr>
<tr>
<td>≥12</td>
<td>1.40†</td>
<td>1.39 to 1.52</td>
</tr>
<tr>
<td><strong>Dissatisfaction with work schedule flexibility</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1–10</td>
<td>1.13†</td>
<td>1.06 to 1.21</td>
</tr>
<tr>
<td>≥12</td>
<td>1.07</td>
<td>0.99 to 1.26</td>
</tr>
<tr>
<td>Intention to leave job within next year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1–10</td>
<td>1.19†</td>
<td>1.12 to 1.27</td>
</tr>
<tr>
<td>≥12</td>
<td>1.51†</td>
<td>1.33 to 1.71</td>
</tr>
</tbody>
</table>

The reference group is the shift category of 8.1–9 h. ORs and 95% CIs are derived from generalised linear mixed models that accounted for nesting within countries, hospitals and units.

*Fully adjusted models account for nurse age, gender, full-time/part-time status, shift type (day/night), overtime (yes/no), type of unit, nurse staffing, hospital size and hospital teaching and technology status.

If both sides of the 95% CI of the OR are greater than 1, or both sides are less than 1, the result is considered significant.

The odds of nurses reporting job dissatisfaction were greater for all nurses working shifts of 8.1 h or longer than for nurses working shifts of 8 h or less. For nurses working 12 h or more the odds of reporting being dissatisfied with their job were increased by 40%, in comparison with nurses working 8 h or less (aOR=1.40; 95% CI 1.20 to 1.62). Nurses who worked 12 h or longer during their last shift were more likely to report being dissatisfied with work schedule flexibility, when compared to nurses working 8 h or less (aOR=1.15; 95% CI 1.00 to 1.35). Compared to nurses who worked 8 h or less, nurses who worked 12 h or more had a greater likelihood to report intention to leave their current job due to dissatisfaction (aOR=1.28; 95% CI 1.12 to 1.48; see table 3).

Since the literature has suggested an interaction between shift length and working overtime, we modelled the interaction between shift length and working overtime (model not shown—available from authors) but the relationship was not significant. Both shift length and overtime had independent effects on the variables of interest. In order to assess the impact of our decision to collapse the 12–15 h and >15 h categories, we analysed the data with the 12–15 h and >15 h categories separately and this did not alter the findings.

**DISCUSSION**

We found that shifts of 12 h or more for hospital nurses are associated with more reports of burnout, job dissatisfaction, dissatisfaction with work schedule flexibility and intention to leave. Additionally, all shifts longer than 8 h appeared to be detrimental to nurses’ job satisfaction. Our study indicates that working overtime on a shift is associated with poor nurse outcomes independent of the total hours worked on that shift.

We found an association between shifts of 12 h or more and all three subscales of burnout; this finding is in line with previous studies. Nurses may prefer working only three shifts of 12 h per week; however it appears to be at the expense of their psychological well-being. Employers should be aware of the multiple consequences of burnout, including higher risks of medical error, decreased quality of care, reduced well-being, and economic loss through increased absenteeism and higher turnover rates.

Current literature tends to report that 12 h shifts represent a way to retain nurses in hospital clinical practice because it is believed to be the preferred shift length and that nurses are more satisfied with their jobs; our results suggest the opposite, that is that nurses'
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job satisfaction declines with longer shift lengths. One possible explanation of the apparent paradox of nurses between nurses preferring 12 h shifts but actually experiencing lower job satisfaction is that longer shifts may have a cumulative negative effect on well-being that may be unmeasured of or do not attribute to shift work. Nurses may be choosing to sacrifice work satisfaction for benefits in other areas of life. However, this type of choice is likely to compromise nurses’ recovery sleep, physical and psychological well-being: the stress of these long work days and the recovery time needed may counterbalance any perceived benefits.

Although several studies have indicated that 12 h shifts might be regarded as a strategy to increase flexibility, our results show that nurses who worked 12 h or longer on their last shift were more likely to report lower satisfaction with work schedule flexibility. However, our survey aimed to investigate a specific aspect of flexibility, therefore overall flexibility might have been captured.

Therefore, our findings pose substantial questions for managers, most notably because job satisfaction is a consistent and robust predictor of remaining in a job. Our findings show that the odds of intending to leave their jobs due to job dissatisfaction were increased by 31% for nurses working 12 h or more in comparison with nurses working 8 h or less; this finding is consistent with previous research. Therefore, increasing shift lengths, potentially seen as a retention strategy because of expressed preferences, may have unintended consequences: managers need to balance nurses’ choice of working 12 h shifts with consideration that the results may include a burnt out and dissatisfied workforce. Once 12 h shifts have been adopted it may be difficult to return to traditional shift systems because of the perceived benefits among nurses for work-life balance.

Our findings regarding working overtime are consistent with other studies, indicating that when nurses work more hours than scheduled, they are more likely to be dissatisfied with their job and to report burnout. However, our study did not capture the mode of overtime (mandatory or voluntary; paid or unpaid) or the total weekly working hours, and these factors may be relevant in determining engagement and motivation for those working overtime. For example, mandatory and/or unpaid overtime may have a negative effect on psychological well-being related to lack of control and effort reward.

Our study has some limitations. First, its cross-sectional design limited our ability to infer causal relationship between nurses’ shift length and nurse outcomes. Furthermore, although we aimed to include most relevant confounding factors in our models, it is possible that some unmeasured factors have not been included. Lastly, the RN4CAST study was not designed primarily to investigate shift work and therefore the survey did not include some relevant aspects of shift work, including the number of hours worked, mode of overtime, the possibility of taking breaks during shifts and opportunity to rest between shifts, sleep patterns and total hours worked per week. A further limitation was our impossibility to identify whether the workers were on fixed or rotating patterns. Previous studies reported that permanent night workers have higher odds of dissatisfaction, compared to permanent day or rotating workers. Furthermore, we were not able to include any information about nurses’ work-life balance or about the proportion of time spent with children or commitments. These are factors that should be included in future research on outcomes of nurses’ shift length.

CONCLUSION

This study is one of the first to explore the relationship between nurses’ shift length and nurse outcomes in Europe. Twelve-hour shifts are relatively common in some countries in Europe; nonetheless, these longer shifts are associated with more reports of burnout (high levels of emotional exhaustion and depersonalisation, low levels of personal accomplishment), dissatisfaction with work schedule flexibility, and intention to leave. All shifts longer than 8 h are associated with higher job dissatisfaction.

Our results provide the basis for managers and nurses alike to question routine implementation of shifts longer than 8 h, and the use of overtime that is associated with poor nurse outcomes under any shift length, suggesting that overtime may not be a useful strategy to cope with nursing shortages. In the context of authority measures leading to cuts in spending on public services in Europe, it is particularly important for policymakers and managers to have good evidence on which to base decisions on hospital nurse work hours to ensure that the wellbeing of workers and the quality of care is maintained.

Twitter Follow Chinna Dori Ora at @ChinnaOra, Jane Ral at @JaneRal, Michael Sorensen at @MichaelSorensen and Linda Al-Ali at @LindaAlAli_Pers.

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Contributors CDO drafted the article, collaborating in its conception and design, performed statistical analyses and interpreted the data and gave final approval of the version to be published. The paper is accountable for all aspects of the work in ensuring that questions related to the accuracy of
Appendix C Conceptual framework of the links between organizational context, people management, psychological consequences for employees, employee behaviour and organizational performance, by Michie and West (2004)
Appendix D Published manuscript: Characteristics of shift work and their impact on employee performance and wellbeing: a literature review

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ABSTRACT

Objective: To identify the characteristics of shift work that have an effect on employee’s performance (including job performance, productivity, safety, quality of care delivered, errors, adverse events and client satisfaction) and wellbeing (including burnout, job satisfaction, absenteeism, intention to leave the job) in all sectors, including healthcare.

Design: A scoping review of the literature was undertaken.

Data sources: We searched electronic databases (CINAHL, MEDLINE, PsychINFO, SCOPUS) to identify primary quantitative studies.

Methods: The search was conducted between January and March 2015. Studies were drawn from all occupational sectors (i.e. health and non-health), meeting the inclusion criteria: involved participants aged ≥ 18 who have been working shifts or serve as control group for others working shifts, exploring the association of characteristics of shift work with at least one of the selected outcomes. Reference lists from retrieved studies were checked to identify any further studies.

Results: 35 studies were included in the review; 25 studies were performed in the health sector. A variety of shift work characteristics are associated with compromised employee’s performance and wellbeing. Findings from large multicentre studies highlight that shifts of 12 h or longer are associated with jeopardised outcomes. Working more than 40 h per week is associated with adverse events, while no conclusive evidence was found regarding working a compressed working week. Working overtime was associated with decreased job performance outcomes. Working rotating shifts was associated with worse job performance outcomes, whilst fixed night shifts appeared to enable resynchronisation. However, job satisfaction of employees working fixed nights was reduced. Time breaks had a positive impact on employee fatigue and alertness whilst quick returns between shifts appeared to increase pathologic fatigue. The effect of shift work characteristics on outcomes in the studies reviewed is consistent across occupational sectors.

Conclusions: This review highlighted the complexity that encompasses shift work, but many studies do not account for this complexity. While some consistent associations emerge (e.g. 12 h shifts and jeopardised outcomes), it is not always possible to conclude that results are not confounded by unmeasured factors.

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0020-7489/© 2016 Elsevier Ltd. All rights reserved.
What is already known about the topic?

- Research has identified that individual characteristics of shift work such as shift length, total number of weekly hours, night work, rest opportunities may impact on employees' job performance and wellbeing.
- Shift work is a complex interaction of organisational characteristics, yet to date synthesis of all these shift characteristics in relation to job performance and wellbeing has been produced, and no examination by employment sector.

What this paper adds

- A scoping review of the effect of shift characteristics on job performance and employee wellbeing.
- Associations of shift characteristics and outcomes in the healthcare sector were similar to those found in other occupational sectors (e.g. the detrimental effect of shifts of 12 h or longer on making errors was found both in the healthcare and in the nuclear sector).
- The majority of the studies assessed a single shift characteristic only and fail to consider the complexity of shift work.

1. Introduction

Employers worldwide are constantly challenged to organise the healthcare workforce effectively, so that employees can deliver high quality services that respond to the needs and expectations of their clients (Cursen et al., 2010) within limited budgets. In this search for effectiveness (and cost-effectiveness), the centrality of employee wellbeing and organisational factors has been recognised in healthcare (Michie and West, 2004), where there is evidence of employees' impaired psychological wellbeing playing mediating roles between work environment and poor job outcomes, including the delivery of poor quality care (Van Bogaert et al., 2013).

A component of the work organisation that may affect the balance between efficiency and employee wellbeing is shift work; healthcare work is characterised by 24-h operations, so that drawing upon shift work is common for several nursing services. The challenge to provide 24-h services is not unique to healthcare, since other occupational sectors such as police, transport and power provision industries have to adopt shift work on a regular basis.

Shift work refers to a wide variety of working time arrangements, including all working hours that are outside the normal daytime ones (Knutsson, 2004). Shift systems can be organised in different ways, depending on how several components are set, including shift length, rest breaks and consecutive shifts (Folkard et al., 2007), which may consequently lead to a different impact on employee's performance and wellbeing.

The variability in the organisation of shift work in nursing specifically has been described in large European studies, including the RN4CAST (Griffiths et al., 2014) and NEXT (Estryn-Behar et al., 2012) studies. Due to this variability in shift work, previous research aimed to describe favourable shift patterns using an aggregate of acceptable shift characteristics and averted strong conclusions about the implementation of "ideal" shift systems.

Previous reviews have considered the effect of single shift characteristics on adverse outcomes, including the effect of 12 h shifts on patient safety (Rae and Fabry, 2014; Clendon and Gibbons, 2015; Harris et al., 2015) and job satisfaction (Easterbrooks et al., 2009), the association of extended hours and fatigue (Harrington, 2001) and safety (Wagstaff and Sigstad Lie, 2011). These reviews have largely contributed to expand the evidence on individual components of shift work, however, up to date no synthesis of all these shift characteristics has been produced. Therefore, the aim of this review is to identify evidence for the characteristics of shift work that have an effect on employee's performance and wellbeing, drawing on literature from all sectors.

2. Design

We referred to the framework outlined by Arkesley and O'Malley to conduct a scoping review, aiming to summarise existing empirical evidence and to identify gaps in research on shift work (Arkesley and O'Malley, 2005). Scoping studies do not systematically assess the quality of included studies; however a narrative comment is provided in the discussion section.

3. Methods

The main literature search was performed between January and March 2015. A number of industries beyond the healthcare sector have opted to implement shift work, therefore, in order to achieve a comprehensive understanding of the topic, our review encompassed occupational contexts beyond healthcare.

The outcome measures of interest in this review are indicators of employee's performance (including job performance, productivity, safety, quality of care delivered, errors, adverse events and client satisfaction) and of employee's wellbeing (including burnout, job satisfaction, absenteeism, intention to leave the job).

We included studies published in the English language that met all of the following criteria: participants aged >18, are or have been working shifts or serve as control group for others working shifts; the study is a primary study, has quantitative design and explores the association of characteristics of shift work and at least one of the selected outcomes (including job performance, productivity, safety, quality of care delivered, errors, adverse events and client satisfaction; burnout, job satisfaction, absenteeism, intention to leave the job). Reviews, editorials, notes, letters, and case reports were not included. No limits were put on the date of included research, in order to ensure that the review of research was as comprehensive as possible.

3.1. Data sources

We searched MEDLINE (Ovid), CINAHL (EBSCO), PsycINFO (EBSCO), SCOPUS, Cochrane Library using the following terms (title, abstract, key words): "shift work", "shift work"
"work schedule", "shift pattern" "shift length", "shift or schedule", "safety", "error", "satisfaction", "burnout", "quality", "performance", "efficiency", "stress". We also searched related index terms (Table 1).

The following data were extracted from included studies: Occupational Context; Country; Sample Size; Study Design; Shift Characteristic studied; Outcome Measures; Relevant Results.

4. Results

13,975 records were retrieved from the database searches. The titles and abstracts were screened and 13,693 studies were rapidly excluded, while 282 papers were identified as potentially relevant, (i.e. directly addressing the effect of shift work on one or more relevant outcomes) and the full text was accessed. References of the 282 papers were checked to identify any additional articles: this resulted in the addition of further three papers. After reading the full text, 250 papers were excluded, due to lack of explicit methodology, and 35 papers were included in the final review. Fig 1 reports the flow chart of the study selection.

The 35 studies explored a variety of shift-work characteristics including shift length, weekly hours and compressed working week, overtime working, night work and fixed/rotating shifts, rest and break opportunity as organisational characteristics of shift work that have an impact on employee performance and wellbeing.

The included studies were published between 1988 and 2014. The majority of the studies (n = 24) were published in the last decade, with 11 published more than one decade ago. Most of the studies were conducted in the United States (US)/Canada region (n = 21), 3 in Central Europe, 3 in the United Kingdom, 3 in Northern Europe, 3 in Asia and 2 in Australia. The majority of the studies related to the healthcare sector (n = 25), predominantly in nursing (n = 21); other industries were chemical/electrical (n = 3), police (n = 2), mining (n = 1), transport (n = 1), automotive (n = 1), manufacturing (n = 1) and one study covered multiple occupational contexts.

The majority of the studies had a cross-sectional design (n = 23), 5 were experimental, 2 descriptive observational, 2 case-controlled, 2 longitudinal and 1 was retrospective. The sample size ranged from 12 to 31,627.

Results are reported by shift work characteristics and their association with the selected outcomes, namely: job performance, productivity, safety, quality of care delivered, errors, adverse events and client satisfaction; burnout, job satisfaction, absenteeism, intention to leave the job. We extracted meaningful parameters indicating the size of effect; where these were not available, only statistical significance is reported (with exact p value if given). All studies are summarised in Tables 2–4. Table 2 presents studies regarding the association of work hours factors and outcomes within the health sector, while Table 3 covers those from other occupational sectors. Table 4 summarises results of studies regarding the association of fixed/rotating shifts, night shifts and rest opportunities and the selected outcomes.

4.1. Shift length

Overall, we found 17 studies regarding the association of shift length and outcomes of interest. Of these, 15 studied job performance and 11 examined employee wellbeing (total number does not sum up to 17 because some of these studies were exploring both job performance and employee wellbeing).

4.1.1. Shift length and job performance

Most studies exploring the effect of shift length on job performance focussed on the comparison between 8 and 12 h shifts: none of the studies found an improvement in job performance after the introduction of 12 h shifts or when employees work 12 h shifts, compared to those working 8 h shifts.

A single before and after study found no statistically significant impact on job performance, following the introduction of 12 h shifts among 41 underground miners in Canada (mean differences not reported) (Duchon et al., 1994). A study from the USA (United States of America) aimed to identify changes in cognitive performance due to different shift lengths working either 12 or 24 h shifts. This cross-sectional study was carried out within 34 air medical providers and the results indicated no difference (mean differences not reported) in cognitive performance; however, air medical providers working 24 h shifts were able to sleep on average 6.8 h during the shift, whereas those working 12 h slept on average 1 h on shift (Guyette et al., 2013). A cross-sectional study carried out with 745 nurses from different nursing organisations found a link between shift length and fatigue, and between fatigue and job performance. Nurses’ shifts of 9–12 h were associated with higher levels of physical fatigue (p < 0.001), and higher levels of acute fatigue (p < 0.001), and fatigue levels were negatively correlated with performance (Barker and Nunnbaum, 2011).

Two studies aimed specifically to evaluate the association between shift length and alertness, vigilance and fatigue. One reported no significant change, whilst the other found a reduction in alertness when employees worked 12 h shifts. A cross-sectional study of 162 chemical workers, reported that when employees worked 12 h shifts, their fatigue and mean alertness levels did not differ significantly from employees working 8 h shifts (Tucker et al., 1996). Scott and colleagues performed a cross-sectional study on 502 critical care nurses, recruited randomly from the American Association of Critical Care Nurses, in order to explore whether long hours affect nurses’ vigilance. Nurses who worked more than 12.5 h were more likely to struggle to stay awake at work (OR (odds ratio) = 1.5, p = 0.007), and were twice as likely to report resting to make an error (OR = 1.94, p = 0.03) compared to those who worked fewer hours (Scott et al., 2006).

The evidence regarding the association of shift length and safety and errors/ adverse events is consistent, as regards the detrimental effect that long shifts have.

104 employees working either 8 or 12 h shifts at different nuclear power plants were included in a retrospective observational study, and were tested for
### Table 1

#### Search strategy:

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<td>shift pattern-exp.</td>
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several safety outcome measures: no difference was found in safety system failures, but a significant increase in operator error was reported ($R^2 = 0.20$, $p < 0.05$) (Baker et al., 1984). Similarly, a study in an electrical plant reported an increase in the mean number of errors on a standardised test following the introduction of 12 h shifts. Authors reported a 30% increase in errors made after a 12 h day shift, compared to an eight hour day shift and a 50% increase after a 12 h night shift, compared to an eight hour night shift ($p < 0.02$). A possible explanation provided for the increased error rate was an increase in fatigue experienced by the employee at the end of the working day (Mitchell and Williamson, 2000). A study performed in the healthcare sector, comprising 1052 patient records and 1159 staff, reported a similar association: a mean ward-level working hours of more than 5 h and 45 min was associated with nearly 3 times higher infection risk, compared to a mean ward-level working of 3 h and 45 min (OR = 2.74, 95% CI (confidence interval): 1.07–7.04) (Virtanen et al., 2009). Lastly, when 393 nurses from a single hospital, sampled for a cross-sectional study, worked 12.5 h or more, they were more likely to report making a medication error, when compared to their peers working 8 h shifts (OR = 3.29, $p = 0.001$) (Rogers et al., 2004).

As far as quality of care is concerned, contrasting results were derived from four nursing studies. A small single descriptive exploratory study sought to evaluate the nurses’ perceptions in a hospital unit after the introduction of 12 h shifts. Twelve nurses agreed to participate in the study, six of which expressed no perceived change in the quality of caring care they provided, while six nurses agreed or strongly agreed it had improved (O’Neyer et al., 2007). However, the questionnaire to evaluate the shift pattern was distributed at a single point in time, just 3 months after the new shift pattern had been implemented, and the small sample size prevents any generalisability. A further cross-sectional study of 865 nurses from 13 hospitals found no difference in nurse reported quality of care for nurses working 8 and 12 h shifts (OR = 1.35, 95% CI = 0.79–2.29) (Stone et al., 2006). By contrast, a study performed in 12 European countries on a large sample of hospital nurses
(n = 31,627) concluded that 12 h shifts are detrimental for quality of care, patient safety and missed care, as reported by nurses. A full report of ORs and 95% CIs for these associations is available in Table 2; however, the odds of nurses working 12 or more hours and reporting adverse patient outcomes were increased in a range of 30–41%, in comparison with nurses working 8 h or less (Griffiths et al., 2014). Three large studies from the US (sample size ranging from 3710 to 22,275 nurses), performed in different hospitals and settings, explored the association of long shifts and quality of care, patient safety and patient dissatisfaction. They concluded that all these outcomes were negatively affected when nurses worked shifts of 13 h or longer (ORs and 95% CIs are available in Table 2) (Stimpfel et al., 2012, 2013; Stimpfel and Aiken, 2013).

4.1.2. Shift length, job satisfaction and psychological wellbeing

The evidence regarding the impact of length of shifts on employee outcomes, including job satisfaction, burnout, and psychological wellbeing, satisfaction with schedule and employee morale is mixed.

Working 12 or 8 h shifts did not appear to influence 162 chemical plant employees’ psychological wellbeing, in terms of job satisfaction and attitudes towards shift work (Tucker et al., 1996). Studies of small samples of workers (sample size ranging from 12 to 41) testing the impact of the introduction of 12 h shifts on employees’ satisfaction with schedule concluded that staff largely prefer longer shifts and wanted to retain them (Dechon et al., 1994; Dwyer et al., 2007; Mitchell and Williamson, 2000). However a similar study with 162 nurses reported the opposite result; namely, after the introduction of 12 h shifts, nurses were more dissatisfied with their job (p < 0.0001) (Todd et al., 1993). A further cross sectional study of 805 nurses from 13 hospitals, comparing job satisfaction and burnout among nurses working 8 or 12 h shifts, reported that those working 12 h shifts were more likely to be satisfied with their job (OR = 1.05, p = 0.025) and to experience less burnout, with a reduction of 5.9 points on the emotional exhaustion scale (p < 0.001) (Stone et al., 2006). However, a large-scale study from Europe (n = 25,524 nurses) indicated that working 12 h shifts was associated with higher burnout scores (OR = 1.34; 95% CI = 1.00–1.78), in comparison with working 8 h or less (Estyn-Behar et al., 2012).

Two large cross-sectional studies (sample size respectively 22,275 nurses and 3710 nurses) from the US indicated that when nurses are working 13 h shifts or longer, the odds for them reporting job dissatisfaction and burnout were higher than for those working 8 h, with ORs ranging from 2.02 to 2.73 (full reports of ORs and 95% CIs are available in Table 2) (Stimpfel et al., 2012, 2013).

Three studies explored absenteeism and intention to leave with conflicting results. Stone and colleagues reported that, after having introduced 12 h shifts, 805 nurses were less likely to report missing shifts (OR = 0.42, 95% CI = 0.29–0.60) (Stone et al., 2006). In contrast, two
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<tr>
<th>Author, year</th>
<th>Design</th>
<th>Number, year</th>
<th>Shift factor</th>
<th>Outcome (measurement)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reuter and Trujillan</td>
<td>Cross-sectional</td>
<td>764 nurses, USA</td>
<td>Shift length (8 vs. 12 h shifts)</td>
<td>(a) Higher levels of physical fatigue for more working 12 h shifts (p &lt; 0.05)</td>
<td>(b) Higher levels of physical fatigue for more working 12 h shifts (p &lt; 0.05)</td>
</tr>
<tr>
<td>(2011)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(c) Higher levels of fatigue for more working 12 h shifts (p &lt; 0.05)</td>
</tr>
<tr>
<td>Day et al. (2003)</td>
<td>Descriptive-exploratory study, (n = 63) group:</td>
<td>53 nurses</td>
<td>Shift length (introduction of 12 h shifts)</td>
<td>(a) Nurse’s belief on difference in fatigue</td>
<td>(b) Nurses’ belief on change in fatigue (p &lt; 0.001)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>(c) Nurses’ belief on change in fatigue (p &lt; 0.001)</td>
</tr>
<tr>
<td>Farhan et al. (2011)</td>
<td>Cross-sectional</td>
<td>20,154 nurses, Europe</td>
<td>Shift length (8 vs. 12 h shifts)</td>
<td>(a) Skilled and experienced nurses (p &lt; 0.001)</td>
<td>(b) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>(2011)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(c) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>Cafferty et al. (2004)</td>
<td>Cross-sectional</td>
<td>30,632 nurses, Europe</td>
<td>Shift length (8 vs. 12 h shifts)</td>
<td>(a) Skilled and experienced nurses (p &lt; 0.001)</td>
<td>(b) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>(2004)</td>
<td></td>
<td></td>
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<td>(c) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>Gaydos et al. (2013)</td>
<td>Cross-sectional</td>
<td>34 air medical personnel, USA</td>
<td>Shift length (12 vs. 24 h shifts)</td>
<td>(a) Cognitive performance (Frenzel Auditory Scanning Test (FASAT))</td>
<td>(b) Cognitive performance (Frenzel Auditory Scanning Test (FASAT))</td>
</tr>
<tr>
<td>(2013)</td>
<td></td>
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<td></td>
<td></td>
<td>(c) Cognitive performance (Frenzel Auditory Scanning Test (FASAT))</td>
</tr>
<tr>
<td>Regen et al. (2004)</td>
<td>Cross-sectional</td>
<td>399 nurses, USA</td>
<td>Shift length (12 vs. 24 h shifts)</td>
<td>(a) Skilled and experienced nurses (p &lt; 0.001)</td>
<td>(b) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>(2004)</td>
<td></td>
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<td></td>
<td>(c) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>Scott et al. (2000)</td>
<td>Descriptive-exploratory study; cross-sectional</td>
<td>502 nurses, USA</td>
<td>Shift length (8 vs. 12 h shifts)</td>
<td>(a) Skilled and experienced nurses (p &lt; 0.001)</td>
<td>(b) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>(2000)</td>
<td></td>
<td></td>
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<td></td>
<td>(c) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>Sorensen et al. (2013)</td>
<td>Cross-sectional</td>
<td>22,575 nurses, USA</td>
<td>Shift length (8, 12, 16 h shifts)</td>
<td>(a) Skilled and experienced nurses (p &lt; 0.001)</td>
<td>(b) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>(2013)</td>
<td></td>
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<td></td>
<td>(c) Skilled and experienced nurses (p &lt; 0.001)</td>
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<td>(a) Skilled and experienced nurses (p &lt; 0.001)</td>
<td>(b) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>(2013)</td>
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<td>(c) Skilled and experienced nurses (p &lt; 0.001)</td>
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<td>Sorensen et al. (2012)</td>
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<td>22,575 nurses, USA</td>
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<td>(a) Skilled and experienced nurses (p &lt; 0.001)</td>
<td>(b) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>(2012)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(c) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>Roe et al. (2008)</td>
<td>Cross-sectional</td>
<td>885 nurses, USA</td>
<td>Shift length (8 vs. 12 h shifts)</td>
<td>(a) Skilled and experienced nurses (p &lt; 0.001)</td>
<td>(b) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>(2008)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(c) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>Wald et al. (2008)</td>
<td>Before and after study (introduction of 12 h shifts)</td>
<td>319 nurses, UK</td>
<td>Shift length (introduction of 12 h shifts)</td>
<td>(a) Skilled and experienced nurses (p &lt; 0.001)</td>
<td>(b) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
<tr>
<td>(2008)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(c) Skilled and experienced nurses (p &lt; 0.001)</td>
</tr>
</tbody>
</table>
multistate large cross sectional studies (sample size respectively 22,275 nurses and 3718 nurses) by Stimpfel
and colleagues, indicated that nurses were more likely to
report intention to leave when they worked $\geq 12$ h shifts (Stimpfel et al., 2012, 2013).

In summary, there is insufficient evidence to conclu-
sively say that 12 h shifts are safe and lead to more
productivity. Large multi-site healthcare studies report
that working 12 h shifts is associated with decreased
quality of care, patient safety and increased rates of errors.
Results are conflicting as regards employees’ job satis-
faction and wellbeing, with some small-scale studies report-
ing increased job satisfaction for employees working 12 h
shifts; these results are contrasted by larger studies, which
conclude that 12 h shifts are associated with higher rates of
burnout, job dissatisfaction and intention to leave.

4.2. Weekly hours of work

Two recent cross-sectional studies regarding the effect
of weekly hours of work and job performance and
wellbeing were included. Olds and colleagues’ work aimed
at examining the relationship between nurses’ weekly
work hours and self-reported adverse events and errors.
Overall 11,516 nurses from the US were included in the
sample. The results indicate that the likelihood of
observing or experiencing occasional or frequent (versus
never or rare) adverse events such as patient falls with
injury, nosocomial infections and medication errors was
increased respectively by 173, 14% and 28% when nurses
worked 40 or more hours per week, compared to working
less than 40 h per week (Olds and Clarke, 2010). After
fitting multiple regression models separated by sex of a
large sample deriving from a health survey, comprising
overall 7103 workers, Artazcoz and colleagues concluded
that in men, working 51–60 h per week was associated
with job dissatisfaction (aOR (adjusted odds ratio) = 2.05;
95% CI = 1.49–2.82), in comparison with those working
30–40 h per week (Artazcoz et al., 2008).

We conclude that there is limited evidence on the
association of weekly hours and job performance and
wellbeing; however, studies we reviewed concluded that
more than 40 weekly hours of shift work may have a
negative impact on employee’s performance and job
satisfaction.

4.3. Compressed working week

The compressed working week is a type of work
schedule in which the hours worked per day are extended,
whilst the days worked are reduced, so that the standard
number of weekly hours are worked in fewer days (Kambra
et al., 2008). This shift organisation links together two
features that have already been presented in our review:
shift length and weekly hours. It appears rather intuitive
that long shift lengths themselves might or might not lead
to negative consequences, while detrimental outcomes
might start to emerge only when long shifts are worked
and weekly hours are increased. The vast majority of
studies described focused on either shift length or weekly
hours; few looked at both characteristics simultaneously,
### Table 7
Results of the association of work hours factors and outcomes within non-health sector.

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Design</th>
<th>Participants and outcomes</th>
<th>Shift factor</th>
<th>Outcome (measurement)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baker et al. (1984)</td>
<td>Retrospective observational study</td>
<td>104 nuclear power workers, USA</td>
<td>Shift length (8 vs 12 h)</td>
<td>Number of operator errors (a) Job performance (b) Satisfaction with schedule (Shiftwork Survey questionnaire)</td>
<td>Working 12 h shifts is correlated with operator error ($R^2 = 0.20$, $p &lt; 0.05$) (a) No significant differences (b) 80% of the sample reported preferring 12 h shifts to 8 h shifts</td>
</tr>
<tr>
<td>Bickon et al. (1984)</td>
<td>Before and after study (evaluation 10 months after intervention was introduced)</td>
<td>41 miners, Canada</td>
<td>Shift length (introduction of 12 h shifts replacing 8 h shifts)</td>
<td>(a) Job performance (Behavioral performance battery) (b) Satisfaction with schedule (Shiftwork Survey questionnaire)</td>
<td>(a) 30% increase in mean number of errors made after a 12 h day shift, compared to an eight hour day shift; 50% increase in mean number of errors made after a 12 h night shift, compared to an eight hour night shift ($p &lt; 0.05$) (b) 12 h shifts were preferred by the majority of workers (no percentages or mean differences reported)</td>
</tr>
<tr>
<td>Mitchell and Williamson (2000)</td>
<td>Case-control study</td>
<td>27 electrical workers, Australia</td>
<td>Shift length (8 vs 12 h)</td>
<td>(a) Job performance (computerized performance test system) (b) Preference (Standard Shiftwork Index (SSI))</td>
<td>(a) No significant difference (b) No significant difference</td>
</tr>
<tr>
<td>Tucker et al. (1996)</td>
<td>Cross-sectional study</td>
<td>162 chemical workers, UK</td>
<td>Shift length (8 vs 12 h)</td>
<td>(a) Wellbeing (i.e., fatigue) (b) Alertness (SSI) (c) Job dissatisfaction (study survey)</td>
<td>For men, working 51–60 was associated with job dissatisfaction ($RR = 2.05$, 95% CI 1.49–2.82)</td>
</tr>
<tr>
<td>Aarts et al. (2009)</td>
<td>Cross-sectional study</td>
<td>7203 workers, surveyed for the 2006 Catalan Health Survey</td>
<td>Weekly hours of work (20-40 h vs 51-60 h)</td>
<td>(a) Wellbeing (i.e., fatigue) (b) Alertness (SSI) (c) Job dissatisfaction (study survey)</td>
<td>(a) No significant differences (b) No significant differences (c) When working the 12 h shift, police officers were more likely to report a significantly lower average level of alertness (mean = 6.11) than the average alertness levels among officers on the 8-h (mean = 6.74, p = 0.012), but not the 10-h (mean = 6.31, p = ns) shift</td>
</tr>
<tr>
<td>Arendade et al. (2011)</td>
<td>Randomised block experimental study</td>
<td>231 police officers, USA</td>
<td>Compressed working week (CWV) of 12 h/day vs 10 h/day and 8 h/day</td>
<td>(a) Job performance (b) Behavioral Personnel Assessment Device (BPAD) (c) Fatigue (Fitness for Duty Impairment Screener) (d) Alertness (self-reports and sleep diaries)</td>
<td>(a) No significant differences (b) No significant differences (c) When working the 12 h shift, police officers were more likely to report a significantly lower average level of alertness (mean = 6.11) than the average alertness levels among officers on the 8-h (mean = 6.74, p = 0.012), but not the 10-h (mean = 6.31, p = ns) shift</td>
</tr>
<tr>
<td>Vega and Gilbert (1997)</td>
<td>Experimental study</td>
<td>103 police patrol officers, USA</td>
<td>CWV of 3 days 13 h and 20 min shifts per week vs 5 days 8 h shifts</td>
<td>(a) Job performance (b) Behavioral Personnel Assessment Device (BPAD) (c) Fatigue (Fitness for Duty Impairment Screener) (d) Alertness (self-reports and sleep diaries)</td>
<td>Officers perceived the CWV as beneficial for them, but objective measures of productivity showed no change before and after the implementation of CWV.</td>
</tr>
<tr>
<td>Proctor et al. (1996)</td>
<td>Cross-sectional study</td>
<td>206 automotive workers, USA</td>
<td>Overtime (hours and/or days exceeding these scheduled)</td>
<td>Cognitive function (neurobehavioral test performance)</td>
<td>Overtime work resulted in an impaired test performance in the areas of attention and executive function ($p &lt; 0.05$)</td>
</tr>
</tbody>
</table>

making it difficult to discern whether there is an interaction between the two. The only exception was a study that included full time/part time status as a control variable, which takes some account of the weekly hours worked (Griffiths et al., 2014).

Three studies regarding compressed working week were identified, two of which were performed as experiments within the police sector. The oldest study, comprising a sample of 105 patrol officers, sought to describe the attitudinal and productivity effects of using a 'three 13 h shifts per week' schedule. Patrol officers perceived the compressed working week as beneficial for them, in terms of personal life and work performance, however, objective measures found that there was no change in productivity after the introduction of the compressed working week (Vega and Gilbert, 1997). A similar study, a randomised block experimental study on 231 police officers, evaluated the impact of different work schedule organisations (8 h/day days vs 10 h/day vs 12 h/3 days + 18 h/day every other week) on productivity and fatigue and reported no significant differences. However, when police officers worked the 12 h shift/3 days schedule, they were more likely to report a significantly lower average level of alertness (mean = 6.11) than the average alertness levels...
Table 4
Results of the association of fixed/rotating night shifts and rest opportunities and outcomes.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Design</th>
<th>Participants and setting</th>
<th>Shift factor</th>
<th>Outcome (measurement)</th>
<th>Results</th>
</tr>
</thead>
</table>
| Burch et al. (2009)| Cross-sectional | 376 healthcare workers, USA | Permanent night shifts            | (a) Job dissatisfaction (b) Absenteeism                                             | (a) Permanent night workers reported more job dissatisfaction than day workers ($p < 0.05$)  
(b) Permanent night workers reported higher rates of absenteeism than day workers ($p < 0.05$)  
Working 2 consecutive night shifts was associated with perceptual and motor ability, when compared to those working 4 consecutive nights ($p < 0.05$). |
| Chang et al. (2011)| Experimental study | 62 nurses, Asia          | Night shifts (2, 3 or 4 consecutive) | Cognitive performance (State-Trait Anxiety Inventory, Stanford Sleepiness Scale, Wisconsin Card Sorting Test, Taiwan University Attention Test, Digit Symbol Substitution Test, Symbol Search Test) Job performance (six-Dimension scale of Nursing Performance) Patient errors (nurse reported) | Sleep-deprived nurses reported a higher mean number of patient care errors than non-sleep-deprived nurses ($F = 7.0; df = 1, 218; p = 0.005$): an increase of 1 h of sleep reduces the estimated odds for 1 or more patient care errors by 25%.  
Error rate for night shift workers in the rotating shift group was 46% higher ($p < 0.001$) than that of fixed day shift workers. |
| Coffey et al. (1988)| Cross-sectional | 463 nurses, USA          | Fluid vs rotating shifts          | Job performance                                                                             | Job performance was lowest for nurses working rotating shifts ($p < 0.0001$) |
| Johnson et al. (2014)| Cross-sectional study | 289 Nurses, USA          | Night shift (sleep deprivation)   |                                                                                           | Sleep-deprived nurses reported a higher mean number of patient care errors than non-sleep-deprived nurses ($F = 7.0; df = 1, 218; p = 0.005$): an increase of 1 h of sleep reduces the estimated odds for 1 or more patient care errors by 25%.  
Error rate for night shift workers in the rotating shift group was 46% higher ($p < 0.001$) than that of fixed day shift workers. |
| Niu et al. (2013)  | Perspective, randomised study with parallel group comparisons | 62 nurses, Asia          | Fixed day shifts vs rotating shifts | Error (z test)                                                                            |                                                                                           |
| Han et al. (2014)  | Cross-sectional study | 58 nurses, USA          | Consecutive rotating vs fixed shifts | Fatigue (Occupational Fatigue Exhaustion Recovery scale)                                  | More nurses working rotating shifts had high levels of acute fatigue compared to those working fixed shifts ($p < 0.004$)  
(a) 58% indicated night shift negatively influences job satisfaction  
(b) 43% indicated night shifts had caused them to think about leaving Emergency Medicine  
(c) 36% were feeling fatigued because of night shifts  
Shift work experience played no role in determining shift work tolerance. |
| Smith-Coggins et al. (2014)| Longitudinal | 819 Emergency Medicine workers, USA | Perception of night shift work |                                                                                        |                                                                                           |
| Saksvik-Lehouiller et al. (2013) | Cross-sectional | 740 nurses, Northern Europe | Working night shifts for less than 1 year vs more than 6 years | Shift work tolerance (Dispositional Resilience Hardiness Scale-Revised (DRS-15) Scale) | 1. Having long off-duty times was not effective in reducing crash risk  
2. In a 10 h trip, taking 1 or 2 breaks of 30 min reduced accident risk. |
| Chen and Xie (2014) | Case-control observation (136 crashes; 271 non crashes) of truck drivers, USA | 407/136 crashes | 1. Off-duty time prior to a shift 2. Rest breaks during trip | Truck crashes                                                                            |                                                                                           |
| Ho et al. (2014)   | Longitudinal study | 1234 nurses, Northern Europe | Quick returns (shifts separated by $<11$ h) | Pathological fatigue (Chalder Fatigue Scale)                                              | The annual number of quick returns at T1 predicted the occurrence of pathological fatigue (OR = 1.01, 95% CI = 1.00–1.01) at T2 |
| Tucker et al. (1999) | Cross-sectional | 183 manufacturing workers, UK | Rest days                         | (a) Alertness (SGI) (b) Fatigue (SM)                                                   | (a) Having $>24$ h breaks within shifts was associated with higher means of alertness (unadjusted mean: 6.40 for breaks of $>24$ h and 0.15 for no breaks)  
(b) Lower means of fatigue (unadjusted mean: 2.62 for breaks of $>24$ h and 2.75 for no breaks) than having no such breaks  
Having at least 8 days off per month was associated with lower odds of burnout ($OR = 0.46, 95% CI = 0.35–0.68$) |
| Wierboski et al. (2014) | Cross-sectional | 2772 nurses, Asia | Days off per month | Burnout (MBI)                                                                             |                                                                                           |
among officers on the 8 h shift/5 days schedule (mean = 6.74, p = 0.012), but not the 16 h shift/4 days schedule (mean = 6.31, p = ns) (Amendola et al., 2011).

In the nursing sector, a cross-sectional study of 520 subjects, sampled through a nursing association, analysed the effect of the compressed working week (either 3 or 4 11-h shifts per week compared to 5 days of 7.5 h shifts) on the perceived quality of care provided to hospital patients and dissatisfaction with schedules, noting that negative associations were found only when the compressed working week was performed with rotating shifts (p < 0.001) (Hlavovic et al., 2002). A rotating schedule indicates that the employee rotates between day and night shifts.

Overall, these studies on the effects of the compressed working week provide mixed results. In terms of job performance, there do not seem to be any objective improvements after introducing the compressed working week, while some decrements in alertness have been reported.

4.4. Overtime

Working overtime is a shift characteristic intertwined with both shift length and weekly hours. For this reason, a frequent shortcoming in previous research has been the inability to analyse separately overtime working and long shifts, leading to uncertain results as to whether negative effects should be attributed to scheduled long hours or long hours resulting from overtime.

Overall, four studies have reported an effect for overtime working and job performance. A large cross-sectional study of 31,627 nurses from 12 European countries found an association between working overtime on a shift and increased likelihood of nurses reporting poor quality of care (OR = 1.33; 95% CI = 1.29–1.37), poor patient safety (OR = 1.67; 95% CI = 1.61–1.86) and higher rates of missed care (tasks not completed during last shift due to lack of time) (RR (relative risk) = 1.29, 95% CI = 1.27–1.31) (Griffiths et al., 2014).

Two further studies exploring the impact of overtime on errors produced within the nursing field. The cross-sectional study from Rogers and colleagues reported increased odds of making at least one error when the 393 nurses were working overtime (OR = 2.06, p = 0.0005) (Rogers et al., 2004). Results from the other study, using a cross-sectional design on 11,516 nurses, highlight that voluntary paid overtime was associated with self-reported medication errors both as a linear trend and with a cut point of regular voluntary paid overtime of 4 h or more in the average work week (OR = 1.30, 95% CI = 1.11–1.53) (Ocks and Clarke, 2010).

A cross-sectional study of 206 automotive workers found that overtime work resulted in decreased cognitive function, measured by a set of neuropsychological tests, in the areas of attention and executive function (p < 0.05) (Proctor et al., 1996).

In summary, studies indicate that there is a relationship between overtime working and increased likelihood of making errors, of having reduced cognitive function and of reporting poor quality of care, patient safety and higher rates of missed care.

4.5. Night work and fixed/rotating shifts

We report the results for night work and fixed/rotating shifts together because these two shift characteristics are linked to one another: studies in the literature come to different conclusions regarding night work, according to the presence or absence of rotation. It appears that the majority of the studies produced so far have not investigated night work per se; the focus is more often on the interaction between time of the day and whether night work is undertaken as part of a fixed schedule or if the employee rotates between day and night shifts. The rationale for this association is mainly that adaptation to night work tends to happen within one or two weeks of continuous night work (Possum et al., 2013), leading to resynchronisation (Wagstaff and Sigstad Lie, 2011).

Therefore, sleepiness, fatigue, and decreased alertness are more likely to be present when employees work rotating shifts, because adaptation to working nights might not occur.

Eight studies investigating night work and/or fixed/rotating shifts were included. An experimental study carried out on 62 nurses in a single hospital in Taiwan explored the effect of schedules that involved consecutive night shifts; nurses were randomly assigned to groups working 2.3 or 4 consecutive night shifts, with the purpose to test cognitive performance at the end of each shift. Subjects working 2 consecutive nights had poorer perceptual and motor ability (components of cognitive performance), when compared to those working 4 consecutive nights (p < 0.05) (Chang et al., 2011). When 463 nurses were surveyed to assess the relationship between type of schedule and job performance, measured with the Six-Dimension Scale of Nursing Performance, the results indicated that job performance was highest for nurses working fixed day shifts, while it was worst for those working rotating shifts (p < 0.0001) (Coffey et al., 1988). Similar results are reported from a randomised prospective study of 62 nurses in a medical centre: the error rate on a standard test for night shift workers in the rotating shift group was 44% higher (p < 0.001) than that of fixed day shift workers (Niu et al., 2013).

A cross-sectional study explored the interaction between being sleep deprived (defined by a nurse reporting needing more continuous sleep to feel rested than obtained during the past 24 h) and working the night shift and the effect this has on patient errors. The results indicate that 56% of 268 nurses in the sample were sleep deprived. Sleep-deprived nurses reported a higher mean number of patient care errors than non sleep-deprived nurses did (F = 7.9; df (degrees of freedom) = 1, 218; p = 0.005); moreover, an increase of 1 h of sleep reduced the estimated odds for 1 or more patient care errors by 25% (Johnson et al., 2014).

As regards fatigue, the results from a cross-sectional study of 58 nurses working 3 consecutive 12 h shifts, either on fixed nights (41%) or routinely rotating shifts (23%), highlight that nurses on rotating shifts had higher levels of acute fatigue (measured through the OGER scale) compared to those on fixed shifts (p = 0.04) (Han et al., 2014). A secondary analysis of data from 819 emergency medics
who were asked to report the status of night shift work and the effects they believed it had on fatigue showed that 36% of the sample believed that night work had an impact on their fatigue levels (Smith-Coggins et al., 2014).

The number of years of night shift work does not seem to have had an effect on shift work tolerance (the ability to adapt to shift work without adverse consequences). When 749 nurses were divided in two groups, one who had worked night shifts for less than a year and one who had worked night shifts for more than 6 years, no differences in shift work tolerance, described as the ability to work shifts without experiencing negative consequences thereof, including fatigue, were found (Saksvik-Lelouciller et al., 2013).

A study involving a sample of 376 healthcare workers highlights that permanent night workers (19% of the sample) were the most likely to report job dissatisfaction (p < 0.05) and absenteeism (p < 0.05), compared to all other workers (Burch et al., 2009).

From these studies, we conclude that there is evidence of the association of night work and disrupted performance when night work is performed as part of a rotating shift schedule. Results also suggest that working patterns of fixed night shifts is associated with increased job dissatisfaction.

4.6. Rest and breaks opportunities

Four studies from diverse occupational groups reported on rest opportunities, mainly between shifts but also within shifts as significant characteristics affecting fatigue and accidents.

A case-control study compared 136 concerning crash cases and 271 non-crash cases among truck drivers. These two groups were compared to assess whether they had different exposure to number of rest breaks and rest-break duration. Results indicated that in a 10 h trip, taking 1 or 2 breaks of 30 min reduced accident risk; having long off-duty times (>11 h) before undertaking a trip was not effective in reducing crash risk (Chen and Xie, 2014).

A cross-sectional study in the manufacturing sector investigated whether introducing a 24 h off-duty time between blocks of day and night shifts could have a beneficial effect on fatigue and alertness. Results indicate that having such time off within shifts was associated with higher means of alertness (unadjusted means: 6.40 for off-duty time of >24 h and 6.15 for no off-duty time) and lower means of fatigue (unadjusted means: 2.62 for off-duty time of >24 h and 2.75 for no off-duty time) than having no such off-duty time (Tucker et al., 1999).

A longitudinal study of 1224 nurses explored the impact of having quick returns (<11 h between shifts) on fatigue levels at baseline (T1) and after one year (T2); the annual number of quick returns at T1 predicted the occurrence of pathological fatigue (OR = 1.01, 95% CI 1.00 to 1.01) at T2 (Ho et al., 2014).

Wisebord and colleagues aimed to explore the association between burnout and number of days off within a sample of 2772 healthcare workers in a single hospital. They indicate that having at least 8 days off per month is associated with lower odds of burnout, compared to having fewer than 8 days off per month (OR = 0.6; 95% CI: 0.5–0.8) (Witek-Jursut et al., 2014).

Overall, these studies of relationships between rest opportunities and outcomes suggest that taking breaks can impact positively on employee fatigue and alertness, while quick returns between shifts appear to be detrimental for pathologic fatigue.

5. Discussion

This scoping review, set out to identify the characteristics of shift work that have an effect on employees’ job performance and wellbeing, included 35 papers overall. We found evidence of the association of six shift characteristics and employees’ job performance and wellbeing: shift length; weekly work hours; the compressed working week; overtime; night work/rotating or fixed shifts; and rest opportunities.

Shift length appears to be widely studied across occupational sectors, with some conflicting results reported. Overall, large scale and multi centre studies performed in the healthcare sector tend to report a negative effect of long shifts (>12 h) on employee’s performance and satisfaction, although some smaller studies report no difference in performance, but increased job satisfaction. However, it appears that these smaller studies have been frequently carried out in environments where employees had previously agreed on the introduction of 12 h shifts and in the immediate aftermath of their introduction, thus being possibly biased by the so-called "honeymoon effect" (Peacock et al., 1983). Smith and colleagues agree that if employees perceive 12 h shifts as beneficial, they may use greater effort to reduce any possible detrimental effects of increased fatigue (Smith et al., 1998). Studies reporting favourable findings for 12 h shifts schedules included in this review were performed after a few months of introducing these long shifts; it may be worthwhile evaluating whether employees’ attitudes change in the longer term once the honeymoon effect is over.

Despite limited evidence regarding weekly hours, studies we reviewed concluded that more than 40 weekly hours of shift work may have a negative impact on employee’s performance and job satisfaction, suggesting a yet untested but plausible link between long weekly hours and increased fatigue, and between fatigue and adverse events/errors.

The studies on the effects of the compressed working week provided mixed results. However, every study included in the review provided a different operationalization of compressed working week, in terms of different number of hours and different number of days worked per week in each study, which may partially explain the different results. Due to European legislations, which set an upper limit to weekly working hours (Directive, 2003/ 88/EC 2003), most of the studies on shift length probably included also a compressed working week. This would imply that when employees were working 12 h shifts, they were also reducing the number of work days in the week, in order to maintain a set number of weekly hours. Nonetheless, only the three studies included in the review
were explicitly mentioning the compressed working week, and we cannot assume that studies regarding 12 h shifts were involving a compressed working week.

All the studies on overtime report an association between overtime working and impairments of job performance, in terms of increased likelihood of making errors, of having reduced cognitive function and of reporting poor quality of care, patient safety and higher rates of missed care. One study reported that voluntary paid overtime was also associated with increased odds of making errors, suggesting that despite staff having control and choice on the hours they work, extending work hours in order to increase income may not be an ideal strategy.

Night work is associated with disrupted performance and safety indicators when such shifts are done as part of a rotating shift schedule, suggesting that permanent night work could be a good strategy to reduce circadian misalignment (i.e., disruption of the endogenous circadian rhythm and the sleep-wake schedule). However, results from another study suggest that working fixed night shifts, despite offering adaptation to these shifts on a cumulative basis, can be associated with increased job dissatisfaction (Perrucci et al., 2007). Whether employees should work fixed or rotating shifts represents a controversial case as regards the balance between employee productivity, wellbeing and satisfaction. However, links between fatigue and safety and error have been previously identified (Williamson et al., 2011), so that we can hypothesise that fixed shift patterns may reduce error and represent a safer option. Despite the risk of decreased job satisfaction, fixed shift patterns could be a favourable solution for reducing error.

Studies regarding rest opportunities, deriving from both the health sector and other occupational sectors, suggest that timely breaks can impact positively on employee fatigue and alertness, and in particular quick returns between shifts appear to be detrimental for pathologic fatigue. However, none of these studies were able to capture the quality of the rest breaks, in terms of activities performed when having a break or a day off. This could be a crucial factor in determining fatigue levels (Folkard et al., 2007). Furthermore, none of these studies considered interactions of rest breaks with other shift characteristics; future research should address these gaps.

Our review highlighted that fatigue is a potential mediator between shift length and adverse outcomes (i.e., impairments in job performance and safety). For example, Barker and Nusbaum concluded that long working hours were associated with fatigue and that fatigue was associated with decreased job performance (Barker and Nusbaum, 2011). This plausible link between shift work and fatigue and fatigue and decreased performance remains untested, and should be considered for future research.

Although some authors suggest that the impact of shift work characteristics on the outcomes is likely to be occupation specific (Ferguson and Dawson, 2012), our results suggest that there is not a systematic difference by occupational sector. In this respect, associations of shift characteristics and outcomes in the healthcare sector were similar to those found in other occupational sectors. For example, the detrimental effect of shifts of 12 h or longer on making errors was found both in the healthcare and in the nuclear sector. After the introduction of 12 h shifts, job satisfaction appeared to increase in some of the nursing studies and in the electrical sector studies, while some nursing studies report that 12 h shifts are associated with job dissatisfaction. However, the absence of industry specific effects may be due to the small number of studies from industries other than healthcare included in the review. Whilst overall associations may be similar regardless of occupational sector, it remains possible that there are different thresholds for the effect of long shifts on performance or wellbeing that are occupation specific.

Furthermore, it is possible that different operationalisations of the same variable (e.g. each of the three studies on compressed working week defined "compressed working week" in a different way) and different outcome measurements explain partly the variability in the findings.

Furthermore, there is a paucity of studies that examined or controlled for more than one shift characteristic at a time; no studies provided a comprehensive examination of all shift factors. However, shift work is better conceptualised as a complex interaction of factors, rather than a combination of linear characteristics (Ferguson and Dawson, 2012). A more multivariate examination that takes account of the complex interplay of shift characteristics is needed to embrace entirely the complexity of shift work, in which the role of moderating/mediating factors remains unexplored.

6. Limitations

We found that six different shift characteristics are associated with employee's performance and wellbeing; however, none of the included studies was able to control for all of these characteristics simultaneously. Our ability to draw firm conclusions about the effect of individual factors is also limited, owing to contrasting results; different measurements of outcomes and shift work factors; diverse populations and sample sizes.

Despite having developed a comprehensive search strategy and having drawn upon databases that were not specific to healthcare (e.g. SCOPUS), the majority of the studies found were in the healthcare sector. This limited our ability to explore the impact of shift work characteristics across different industries. Quality appraisal to determine the strength of studies according to methodological design is not part of a scoping review (Arksey and O'Malley, 2005) and this limited our conclusions about the strength of the evidence.

7. Conclusions

This review identified the complexity of shift work and the numerous characteristics that are associated with difference in employee performance and wellbeing. To our knowledge, this multiplicity has not been captured by any single study so far. This complexity highlights the challenges faced by managers organising shift work in healthcare and researchers seeking to understand it. While
Appendix D

recent focus has been on the length of the individual nursing shift, shift workers and their managers must also be mindful of other aspects of shift work including the total hours worked per week, overtime, shift rotation, night shifts and rest opportunities and the potential interaction between these factors. Introducing fixed shift patterns may represent an option to decrease employee circadian misalignment and improve safety. Managers should be cautious requesting nurses to work more than 40h per week, as this has been shown to associate with medication errors and patient falls with injuries and, therefore, could lead to patient safety issues (Olds and Clarke, 2010). Some consistent associations have emerged in the research, such as the absence of any clear evidence for benefits of introducing 12h shift schedules. Not only this shift pattern has not been associated with improvements in job performance in any study, but there is also evidence that it is associated with decreased job performance and poor safety outcomes.

However, it is still possible that these results are confounded by unmeasured factors including other aspects of shift work and working patterns. Future research should use techniques that can capture and explore the complexity of shift work considering shift patterns, total work hours and breaks between shifts and take into account intervening variables that may have an impact on employee’s performance and wellbeing.

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Conflict of interest. None declared.

Appendix A. Supplementary data
Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ijsu.2016.01.007.

References


Duret, 2003/IMBEcE.


Appendix D


Stimpfel, A.W., Skorne, D.M., Aiken, L.H., 2013. Longer the shifts for hospital nurses, the higher the level of burnout and patient dissatisfaction. Health Aff. 31 (12), 2921–2926.


Appendix E  Literature review search strategy

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Appendix F  Trust policy for management of the deteriorating patient

QUICK REFERENCE GUIDE

This policy must be followed in full to ensure that all patients within the Trust, who are acutely ill or at risk of physical deterioration, are identified and responded to promptly and appropriately at all times.

For quick reference the guide below is a summary of actions required. This does not negate the need for all staff to be aware of and follow the detail of this policy.

All patients admitted to the Trust will:

1. Have physiological observations recorded at the time of admission or initial assessment, immediately prior to transfer to another healthcare setting, for example ward to ward transfers, and within 15mins of arrival in the new healthcare setting

2. Have a clear written monitoring plan, determined by the appropriate Early Warning Scoring system that specifies which physiological observations should be recorded, and how often

3. Have physiological observations recorded at least every 12 hours and the frequency increased if abnormal physiology is detected. A rationale for deviation from this standard must be recorded in the patient’s notes by a senior doctor

4. Be monitored using a relevant physiological track and trigger system. The track and trigger system will identify the appropriate graded response to abnormal physiological observations recorded or guide clinicians who are concerned

5. Receive a graded response if they become acutely ill or are at risk of physical deterioration as per appropriate escalation protocol. The healthcare professional who has recognised a response is required must record their actions, related to the escalation, in the patient’s notes.

6. The communication tool ‘RSVP’ or ‘SBAR should be used to ensure effective communication occurs between healthcare professionals

7. The healthcare professional responding must document their actions and management plan clearly in the patient’s notes
8. The most senior doctor available should refer to Critical Care. The decision to admit to Critical Care will be made by consultant in critical care in consultation with the referring team.

9. The responsible consultant for the referring team should be aware and have agreed for the need for critical care referral.

Any patient transfers from critical care to general ward areas:

1. Should occur as early as possible during the day and whenever possible, be avoided between 22.00-07.00.

2. Should involve both a clear verbal handover and agreed written care plan to promote continuity of care.

3. Will be reviewed by the Critical Care Outreach.

1. INTRODUCTION

This policy reflects NICE guidance CG50 and NPSA Guidance relating to all aspects of the treatment and care of adults who are acutely ill or at risk of physical deterioration throughout the Trust. The key recommendations from the NICE CG50 form the basis for the structure of this policy.

This policy has also been developed to describe the process for managing and mitigating risks relating to all aspects of the treatment and care of adults who are acutely ill or at risk of physical deterioration.

In 2005, the National Patient Safety Agency undertook a detailed analysis of the 1,804 reported serious incidents which resulted in death. There were 576 events in which the death of the patient was, or might have been directly related to a patient safety incident. Of these reported incidents, 425 occurred in an acute/general hospital setting.

The analysis found the following themes:

- 71 were related to diagnostic errors (dealt with under a separate NPSA review).
- 43 involved a problem with resuscitation.
- 64 were related to unrecognised physical deterioration (14 – no observations; 30, no recognition of signs of deterioration or assistance sought; 17 delays in receipt of medical attention).

On the basis of this review, the key recommendations from the 64 incidents involving unrecognised patient deterioration are:

- Better recognition of patients at risk or who have deteriorated.
• Appropriate monitoring of vital signs
• Accurate interpretation of clinical findings
• Calling for help early and ensuring it arrives
• Training and skills development
• Ensuring appropriate drugs and equipment are available

2. PURPOSE

The aim of this policy is to standardise the processes by which the patients who are acutely ill or at risk of physical deterioration, are identified and responded to.

All patients admitted to the Trust will:

• Have physiological observations recorded at the time of admission or initial assessment;
• Have a clear written monitoring plan, determined by the appropriate Early Warning Scoring system that specifies which physiological observations should be recorded, and how often;
• Have physiological observations recorded at least every 12 hours and the frequency increased if abnormal physiology is detected;
• Be monitored using a relevant physiological track and trigger system. The track and trigger system will identify the appropriate graded response to abnormal physiological observations recorded or guide clinicians who are concerned;
• Receive a graded response if they become acutely ill or are at risk of physical deterioration as per appropriate escalation protocol

For patients requiring admission to critical care:

• The decision to admit to Critical Care will be made by consultant in critical care in consultation with the referring team consultant. Where involvement of the referring team consultant is not possible, referral should be made by the most senior doctor looking after the patient;

Patient transfers from critical care to general ward areas:

• Should occur as early as possible during the day and whenever possible, be avoided between 22.00-07.00;
• Should involve both a clear verbal handover and agreed written care plan to promote continuity of care;
• Will be reviewed by the Critical Care Outreach.

3. DEFINITIONS

Cardiopulmonary Resuscitation (CPR)
Cardiopulmonary Resuscitation is a combination of artificial ventilation, chest compressions, drug therapy and defibrillation.

### Classification of Critical Care Patients

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 0</td>
<td>Patients whose needs can be met through normal ward care in an acute hospital</td>
</tr>
<tr>
<td>Level 1</td>
<td>Patients at risk of their condition deteriorating, or those recently relocated from higher levels of care, whose needs can be met on an acute ward with additional advice and support from a critical care team.</td>
</tr>
<tr>
<td>Level 2</td>
<td>Patients requiring more detailed observation or intervention including support for a single failing organ system or post operative care, or those stepping down from higher levels of care.</td>
</tr>
<tr>
<td>Level 3</td>
<td>Patients requiring advance respiratory support alone or basic respiratory support together with support of at least 2 organ systems, includes all complex patients requiring support for multi organ failure.</td>
</tr>
</tbody>
</table>

### Clinical Staff

A member of staff whose duties involve elements of direct patient care.

### Critical Care Outreach

A multidisciplinary approach to the identification of patients at risk of developing critical illness and those patients recovering from a period of critical illness to enable early intervention or transfer (if appropriate) to an area suitable for care for that patient’s individual needs.

### Early Warning System (EWS)

EWS is a tool for bedside evaluation and is based on assigning a score to physiological parameters such as pulse; temperature; systolic blood pressure; respiratory rate; AVPU (the level to which the patient responds), oxygen saturation, plus the patient’s inspired oxygen requirements for adult patients. A EWS score should be recorded for every adult patient observation on VitalPAC™ (ViEWS).

The EWS used in PHT has the same physiological parameters and escalation criteria as the National Early Warning System (NEWS) for adult patients launched in July 2012 (10). Therefore PHT is compliant with NEWS.
Escalation Protocol for use with the appropriate Early Warning System (EWS)

Once the EWS has been completed the escalation protocol will prompt staff to take action depending on the EWS score.

High Dependency

Patients requiring observation, care and treatment interventions at Level 2.

Monitoring plan

The appropriate Early Warning Scoring System will detail which physiological observations should be recorded, and how often. In addition it should be recorded in the patient notes details of the on-going management of the patient and when they will be reviewed by nursing and medical staff.

RSVP - A communication tool used by clinical staff to structure communication when handing on information to a clinical colleague about a deteriorating patient. The RSVP communication tool is Reason, Story, Vital signs and Plan. (4)

SBAR - A communication tool used by clinical staff to structure communication when handing on information to a clinical colleague about a deteriorating patient. The SBAR communication tool is Situation, Background, Assessment, Recommendation.

VitalPAC™ - An electronic track and trigger system that provides a recording mechanism for patient’s vital signs and essential screening tools. The data entered generates an Early Warning Score (EWS) and when appropriate prompts the clinical practitioner to escalate the patient’s condition appropriately. The system also alerts the practitioner if a set of vital signs are overdue.

The recorded vital signs can be reviewed by authorised staff, along with EWS and laboratory data, to enable an accurate overview and prioritisation of patient assessment, treatment and discharge planning.

Vital Signs/ Physiological observations

Measures of various statistics taken by health professionals or their assistants in order to assess fundamental physiological functions. For the purposes for EWS this is pulse, temperature, systolic blood pressure, respiratory rate, AVPU (the level to which the patient responds) and oxygen saturation, plus the patient’s inspired oxygen requirements.

4. DUTIES AND RESPONSIBILITIES

Patient Safety Forum
The Patient Safety Forum is responsible, through the receipt of quarterly reports from the Deteriorating Patient Group, for monitoring that there is continuous and measurable improvement in the quality of the services provided.

**Deteriorating Patient Group**

The Deteriorating Patient Group is responsible for ensuring that:

- This procedural document is up to date, technically accurate, is in line with evidence-based best practice and has been produced following consultation with stakeholders.
- Through the Chair, assurance on the effectiveness of this policy and the Trust's procedures for the identification and management of the deteriorating patient, is provided through the receipt of quarterly reports to the Patient Safety Forum, including any necessary recommendations to address identified deficits;
- Processes are in place to enable an annual audit of compliance using the audit tool from the NICE Clinical Guideline 50 and that the actions identified as a result of those audits are implemented.

**Line Managers**

Line Managers are responsible for:

- Ensuring all clinical staff receive training in the use of™ on local induction to the clinical areas.
- Monitoring data from VitalPAC™ to ensure there is a local plan to address any areas for improvement such as number of overdue flags.
- Ensuring that the clinical staff they are responsible for are aware of and apply this policy into clinical practice.

**5. PROCESS**

**Identification of patients at risk of deterioration**

The Trust uses an Early Warning Scoring (EWS) and graded response system to detect and monitor patients who are acutely ill or at risk of physical deterioration. During an adult in-patient episode all patient observations are recorded and scored as per EWS systems.

All physiological observations must be recorded and acted upon by staff that have been trained to undertake these procedures and understand their clinical relevance. Registered and unregistered nursing staff caring for adult patients will undertake the relevant competency assessment.
All patients must have physiological observations recorded at the time of admission or initial assessment, including patients in the Emergency Department.

The appropriate Early Warning Scoring System will detail which physiological observations should be recorded, and how often. In addition it should be recorded in the patient notes details of the on-going management of the patient and when they will be reviewed by nursing and medical staff.

All patients must have physiological observations recorded at least every 12 hours and the frequency should increase if abnormal physiology is detected as per escalation protocol.

The exception to this will be individual patients who, following senior medical review, have the frequency of observations decreased. The rationale for this change in frequency must be documented in the patient’s notes.

**Escalation Protocol and graded response**

All patients will be monitored using the appropriate physiological track and trigger system. The track and trigger system will identify the appropriate graded response to abnormal physiological observations recorded or guide clinicians who are concerned.

By using the appropriate escalation protocol as a framework it will ensure that a clinician with the expertise to respond is called and asked to attend within a specified timeframe. This will make sure that patients who are acutely ill or at risk of physical deterioration receive prompt care and decisions are made in a timely manner.

The person recording the vital signs and triggering an escalation response must document their actions in the patient’s notes.

The person responding must document their actions and management plan in the patient’s notes.

**Communicating Deterioration (RSVP or SBAR)**

To improve communication it is recommended that the person calling for help uses a structured communication tool. There are two commonly used tools in healthcare RSVP (Reason-Story-Vital Signs-Plan) or SBAR (Situation-Background-Assessment-Recommendation) which are easy to remember in an emergency and ensures the essential information is communicated enabling an appropriate timely response.
Patient transfers

The member of staff responsible for patient care prior to transfer to a new location, must ensure a complete set of vital signs and an early warning score has been recorded immediately prior to transfer.

The escalation protocol must be followed and if the nurse in charge or doctor have been informed of an increased EWS score (>3) they must assess the patient to determine if the transfer should be delayed for clinical reasons.

The member of staff responsible for patient care in the new location must complete set of vital signs and an early warning score within 15 minutes of the patient’s arrival in the new locality.

Patient transfers from critical care to general ward areas should occur as early as possible during the day and whenever possible be avoided between 22.00-07.00.

The critical care area transferring team and the receiving ward team should work together to ensure the patient is transferred safely. They should jointly ensure there is continuity of care through a formal structured handover of care from critical care area staff to ward staff (including both medical and nursing staff). This must be supported by a written plan and the receiving ward, with support from Critical Care Outreach if required, to ensure the ward can deliver the agreed plan.

Referral to Critical Care Outreach

A referral to Critical Care Outreach (CCO) should be 'considered' for:
• Any acutely ill or deteriorating ward in-patient who is causing concern (excludes the Emergency Department, Obstetrics, NICU and Paediatrics);
• As prompted by the EWS escalation protocol.

Critical Care Outreach can be contacted between the hours of 07.00 - 20.30 via Bleep 1676 and between 20.30-07.00 a CCO review should be requested via Nervecentre.

Referral to Critical Care

For patients requiring admission to critical care:
• For urgent help bleep the critical care registrar on 1987;
• If the critical care registrar is uncontactable or referral does not require an immediate response, please phone extension 5752, alternatively extension 6385 or 6035. State you wish to make a referral and ask to speak to the critical care registrar. If unavailable you will be passed on to another member of the team
• The referral should be made by the most appropriate senior doctor involved in the patient care at that time.
• The decision to admit to Critical Care will be made by consultant in critical care in consultation with the referring team;
• The responsible consultant for the referring team should be aware and have agreed for the need for critical care referral.

All relevant patient information will be required by critical care including:
• referring clinicians name and grade
• patients name and hospital number
• patient’s location
• relevant patient history
• current vital signs and EWS score
• recent important investigations and treatment should be at hand when you make the call.

Patients discharged from Critical Care

All patients discharged from Critical Care will be reviewed by the Critical Care Outreach team to monitor progress and provide support to the ward staff.

After the decision to transfer a patient from a critical care area to the general ward has been made, the patient should be transferred as early as possible during the day. Transfer from critical care areas to the general ward between 22.00 and 07.00 should be avoided whenever possible, and should be documented as an adverse incident if it occurs.
6. TRAINING REQUIREMENTS

An introduction to VitalPAC™ and all Early Warning Systems is included on Trust Induction.

All Line Managers have a responsibility to ensure that following induction all clinical staff received additional training relevant to their role, level of responsibility and clinical area. For areas using VitalPAC™, this must include recording vital signs, responding to the escalation prompts appropriately and care and maintenance of the equipment.

All Registered and Unregistered Practitioners caring for adult patients must undertake competency assessments in the taking, recording and assessment of vital signs in Adults and Assessing the Physical Well-being of an Adult Patient as per current Generic Competency Framework for Registered and Unregistered Practitioners.

All Trust Resuscitation Training embodies the statements and guidelines published by the Resuscitation Council (UK). This recommends that resuscitation training incorporates the identification of patients at risk of deterioration, EWS and the escalation protocol. All clinical staff must be trained annually in cardiopulmonary resuscitation to a level appropriate to their clinical roles and responsibilities, which will include an annual update in aspects of care of the deteriorating patient and calling for help, including the relevant Early warning System.
Appendix G  R scripts for datasets creation

G.1 Script for sickness absence

# Analyse sickness absence

setwd("/workforceresearch.files.soton.ac.uk/MissedCareStudyData/Chiara analysis")

library(Rcpp)
library(doBy)
library(lme4)
library(lubridate)
library(arm)
library(ggplot2)

sourceCpp("WorkedAbsencePerNurse.cpp")
source("f.reformat_eroster.R")
source("f.time.R")
source("f.define_study_times.R")

# Function just greps out columns that start with "Day"
# from a dataframe

GetPrevDayCols <- function(x)
{
  return(grep("^Day",

    x,}
# Function merges in data from eRoster

AddCorrespondingShiftData <- function(d, x, number.of.previous.days)
{

# Columns to extract from eRoster

sel_cols <-
c( 
    "Type",
    "Date_Rel",
    "Start_Actual_Rel",
    "End_Actual_Rel",
    "name_id",
    "Hours_calculated",
    "mapped_ward_code",
    "Grade_type",
    "Outcome"
)

# Add eRoster columns for both start and end of sickness spell

for (i in grep("idx", names(d), value = T))
{

}
for (j in sel_cols)
{
    new_var <- paste0(i, ",", j)
    d[[new_var]] <- x[j][d[i]]
}
}

# Get index values for X days prior to sickness period
prev_days <- GetIdxOfLastXDays(
x$name_id,
x$Start_Actual_Rel,
x>Type,
d$first.day.idx.name_id,
d$first.day.idx.Start_Actual_Rel,
prev_days = number.of.previous.days
)

# Add these index columns to data frame
for (i in names(prev_days))
{
    d[[i]] <- prev_days[[i]]
}

# Merge in eRoster columns for each of the previous days
for (i in grep("Day", names(d), value = T))
{
    # Add whether has a record in eRoster (could be worked or sick)
    d[[paste0(i, ".worked")]] <- ifelse(!is.na(d[[i]]), 1, 0)

    for (j in sel_cols)
    {
        new_var <- paste0(i, ".", j)
        d[[new_var]] <- x[j][d[i]]
    }
}

# Sum up worked shifts
worked_days <- grep("worked", GetPrevDayCols(names(d)), value = T)

d$past_days.number.worked <- rowSums(d[, worked_days], na.rm = T)

d$past_days.number.daysoff <-
    number.of.previous.days - d$past_days.number.worked

# Add night shift flag based on shift ending before 8am
for (i in grep("End_Actual_Rel", names(d), value = T))
{
  new_var <- paste0(i, ".nightshift")
  d[[new_var]] <- ifelse(d[[i]] - floor(d[[i]]) < 8 / 24, 1, 0)
}

# Create sum of night shifts for previous days
prev_night_cols <- grep("nightshift",
    GetPrevDayCols(names(d)),
    value = T,
    perl = T)
d$past_days.number.nightshifts <-
  rowSums(d[, prev_night_cols], na.rm = T)

# Define columns where hours worked are recorded
hour_cols <- grep("Hours_calculated/\z",
    names(d),
    value = T,
    perl = T)

# Create sum of total hours worked for previous days
prev_hour_cols <- GetPrevDayCols(hour_cols)

d$past_days.Hours_calculated <- rowSums(d[, prev_hour_cols], na.rm = T)

# Classify shift lengths and tag long shifts
for (i in hour_cols)
{
  new_var <- paste0(i, ".shiftlength")
  new_var_long <- paste0(i, ".longshift")

  # Encode shift type variable
  d[[new_var]] <- NA
  d[[new_var]][d[i] == 0] <- "Zero"
  d[[new_var]][d[i] <= 8.25] <- "<=8"
  d[[new_var]][d[i] > 8.25 & d[i] < 12] <- "8-<12"
  d[[new_var]][d[i] >= 12] <- ">=12"
  d[[new_var]] <- as.factor(d[[new_var]])

  # Encode long shift variable
  d[[new_var_long]] <- NA
  d[[new_var_long]][d[i] < 12] <- 0
  d[[new_var_long]][d[i] >= 12] <- 1
}

# Create sum of long shifts for previous days
longshift_cols <- grep(".longshift",
                     GetPrevDayCols(names(d)),
                     value = T,
                     perl = T)

d$past_days.number.longshifts <-
   rowSums(d[, longshift_cols], na.rm = T)

# Sum up bank shifts
outcome.cols <- grep("Outcome", GetPrevDayCols(names(d)), value = T)

for (i in outcome.cols)
{
  new.var <- paste0(i,".is_bank")
  d[[new.var]] <- ifelse(d[[i]]!="eRoster", 1,0)
}

bankshift.cols <- grep(".is_bank", GetPrevDayCols(names(d)), value = T)

# print(bankshift.cols)

d$past_days.number.bankshifts <-
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\[
\text{rowSums}(d[, \text{bankshift.cols}], \text{na.rm} = T)
\]

return(d)

}

# Generates sickness periods by call to C++ function

\[
\text{GenerateSicknessEpisodes} <-
\]

function(x,

    sickness_codes,
    number.of.previous.days)

{

d <- \text{C_GenerateSicknessEpisodes}(x$name_id,

    x$Start_Actual_Rel,
    x$Type,
    sickness_codes)

# Convert to dataframe

d = \text{as.data.frame}(d)

d <- \text{AddCorrespondingShiftData}(d, x, number.of.previous.days)

return(d)

}

# Creates a "absence period" style data frame for worked shifts
GenerateWorkedEpisodes <-

function(x, worked_codes, number.of.previous.days)
{
    # Take subset of x to get worked shifts
    y <- x[x$Type %in% worked_codes,]

    y$idx <- 1:nrow(y)

    d <- data.frame(  
                      first.day.idx = y$idx,  
                      last.day.idx = y$idx,  
                      absence.length = 0,  
                      absence.length.sickness = 0  
                      )

    # x needs to be passed through unchanged!
    d <- AddCorrespondingShiftData(d, x, number.of.previous.days)

    return(d)
}

# Plots distribution of lengths of absence
PlotAbsenceLength <- function(x)
{

# Group them

```
x$absence.length.group <- cut(x$absence.length, 
    breaks = c(seq(0, 7, 1), 14, max(x$absence.length)), 
    include.lowest = T)
```

# Median per group

```
y <- summaryBy(
    absence.length ~ absence.length.group, 
    data = x, 
    FUN = c(mean, median)
)
```

# Create group names

```
group.names <- 
    c(y$absence.length.median[1:7], 
    as.character(y$absence.length.group[8:9]))
```

```
barplot(
    prop.(table(x$absence.length.group)) * 100, 
    col = "#0050FF", 
    border = "#0050FF", 
    names.arg = group.names, 
    las = 1, 
    xlab = "Days absent", 
)
ylab = "% of sickness/unauthorised absence periods",
ylim = c(0, 20)
)

# Plots distribution of shift types for day previous
# to absence period
PlotShiftType <- function(x)
{
  barplot(
    prop.table(table(x$Day.1.Type)) * 100,
    col = "#0050FF",
    border = "#0050FF",
    names.arg = group.names,
    las = 1,
    xlab = "Shift",
    ylab = "% of sickness/unauthorised absence periods",
    cex.names = 0.4
  )
}

PlotTmp <- function(x, raw_eroster)
{
  x$tmp <- 0
# For each day before calculate summary statistics

for (i in hour_cols)
{
    hours_median <- round(median(x[[i]], na.rm = T), 2)
    hours_mean <- round(mean(x[[i]], na.rm = T), 2)

    nna <- length(which(is.na(x[[i]])))
    perc_nna <- round(100 * nna / length(x[[i]]), 2)

    print(paste(i, hours_median, hours_mean, perc_nna, sep = ";"))
}

y <- summaryBy(
    Hours_calculated ~ name_id,
    data = subset(raw_eroster,
        Type != "SK"
        &
        Type != "UA"),
    FUN = c(sum))
y$Hours_calculated.sum.days.group <- cut(
    y$Hours_calculated.sum / 24,
    breaks = seq(0, 800, 100),
    include.lowest = T
)

barplot(
    prop.table(table(y$Hours_calculated.sum.days.group)) * 100,
    col = "#0050FF",
    border = "#0050FF",
    names.arg = group.names,
    las = 1,
    xlab = "Total number of days worked",
    ylab = "% of staff",
    cex.names = 0.7
)

# Read eroster here
# all_eroster <- read.csv("eroster.csv", as.is=T)

# Read bank shifts here
# all_bank_and_agency <- read.csv("bank.csv", as.is=T)
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all_eroster <- readRDS("eroster.rds")

all_bank_and_agency <- read.csv("bank_bookings.csv", as.is=T)

# Get shift type classification
shift_type <- GetShiftTypeMap()

# Add extra from_agency field to eRoster so data can be identified if required
all_eroster$from_agency <- F
all_eroster$Outcome <- "eRoster"

# Reformat eroster
all_eroster_reformat <-
  ReformatEroster(all_eroster, shift_type, study_start)

# Re-format bank and agency
all_bank_and_agency_reformat <- Agency2ERoster(all_bank_and_agency, shift_type, study_start)

# Reduce to just filled bank shifts where staff is also present in eRoster
reduced_bank <- subset(all_bank_and_agency_reformat, Outcome=="Bank Filled" & name_id %in% unique(all_eroster_reformat$name_id) )
# Now merge the bank with the eRoster

combined_eroster_bank <- rbind(reduced_bank, all_eroster_reformat)

# Clean up

rm(all_eroster_reformat, all_bank_and_agency_reformat, reduced_bank)

# Free memory

gc()

# Define sickness shift codes

sickness_codes <- c("SK", "UA")

all_eroster_reduced <- subset(
  combined_eroster_bank,
  (Type_worked == T
   | Type %in% sickness_codes)
   & !(Grade_type %in% c("UNKNOWN", "ADMIN"))
)

# Add in sickness flag

all_eroster_reduced$sick <- 0
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all_eroster_reduced$sick[all_eroster_reduced$Type %in% sickness_codes] <- 1

# Define number of previous days to analysis
number.of.previous.days <- 7

# Define worked shifts as anything that is not sickness
worked_codes <-
  all_eroster_reduced$Type[!(all_eroster_reduced$Type %in% sickness_codes)]
worked_codes <- unique(worked_codes)

# Generate data frame of sickness periods
sickness_episodes <-
  GenerateSicknessEpisodes(all_eroster_reduced, sickness_codes,
  number.of.previous.days)

# Generate data frame of worked shifts
worked_episodes <-
  GenerateWorkedEpisodes(all_eroster_reduced, worked_codes,
  number.of.previous.days)

# Set flags
sickness_episodes$sickness <- 1
worked_episodes$sickness <- 0

# Merge sickness and worked data frames
all_episodes <- rbind(sickness_episodes, worked_episodes)
all_episodes$staff_id <-
  as.factor(all_episodes$first.day.idx.name_id)

all_episodes2 <- subset(all_episodes, past_days.number.worked != 0)

#include <Rcpp.h>
using namespace Rcpp;
using namespace std;

// This is a simple example of exporting a C++ function to R. You can
// source this function into an R session using the Rcpp::sourceCpp
// function (or via the Source button on the editor toolbar). Learn
// more about Rcpp at:

//
//  http://www.rcpp.org/
//  http://adv-r.had.co.nz/Rcpp.html
//  http://gallery.rcpp.org/

class Shift
{
  public:
    int name_id, idx;
    double start_rel;
    string shift_code;
bool is_first;

static bool Compare(const Shift &s1, const Shift &s2)
{
    if (s1.start_rel < s2.start_rel)
        return true;

    return false;
}

class AbsencePeriod
{
public:
    int start_idx, end_idx, name_id, absence_length, absence_length_sickness;
    string shift_code;
};

class Day
{
public:
    double hours_worked;
    double hours_sick;
}
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Day()
{
    this->hours_sick = 0;
    this->hours_worked = 0;
}

};

map< int,vector<Shift> > CreateStaffMap(const IntegerVector &name_id,
                       const NumericVector &start_rel,
                       const CharacterVector &shift_code)
{
    map< int,vector<Shift> > staffmap;

    for ( int i = 0; i < name_id.size(); i++)
    {
        static Shift s;
        s.name_id = name_id[i];
        s.start_rel = start_rel[i];
        s.idx = i;
        s.shift_code = as<string>(shift_code[i]);
        staffmap[s.name_id].push_back(s);
    }

    return staffmap;

// [[Rcpp::export]]

DataFrame GetIdxOfLastXDays(const IntegerVector &name_id,
                          const NumericVector &start_rel,
                          const CharacterVector &shift_code,
                          const IntegerVector &target_name,
                          const NumericVector &target_days,
                          const int prev_days)
{
  map<string, IntegerVector> result;

  // Index actual roster
  const map<int, vector<Shift> > staffmap = CreateStaffMap(name_id,
                                                  start_rel,
                                                  shift_code);

  // Initialise results list
  for (int i = 1; i <= prev_days; i++)
  {
    stringstream ss;
    ss << "Day." << i;
    result[ss.str()] = IntegerVector(target_days.size(), NA_INTEGER);
  }

for (int i = 0; i < target_name.size(); i++)
{
    const int &tn = target_name[i];
    const int &td = static_cast<int>(floor(target_days[i]));
    vector<Shift> found;

    // Find relevant member of staff
    map<int,vector<Shift>>::const_iterator fit = staffmap.find(tn);
    if (fit == staffmap.end())
        stop("Staff member not found. This should never happen!\n");

    // Get list of shifts
    const vector<Shift> &l = fit->second;

    // Find all relevant shifts
    for (size_t j = 0; j < l.size(); j++)
    {
        const Shift &s = l[j];
        const int sday = static_cast<int>(floor(s.start_rel));
        const int diff = td - sday;

        // If shift is within X days and before target day
        // Note that this will not deal with duplicates
if (diff <= prev_days && sday < td)
{
    // Rcout << td << " " << sday << " " << diff << endl;
    stringstream ss;
    ss << "Day." << diff;
    result[ss.str()][] = s.idx+1;
}

return wrap(result);

AbsencePeriod CalcAbsencePeriod(const vector<Shift> &current_absence, const Shift &s)
{
    AbsencePeriod a;

    const Shift &first = current_absence.front();
    const Shift &last = current_absence.back();

    a.start_idx = first.idx;
    a.end_idx = last.idx;
// Rcout <<  s.name_id << " " << first.start_rel << " " << last.start_rel << " " << s.start_rel;

// Define length of absence as
// The first day back at work minus the first day of absence
int first_day = static_cast<int>(floor(first.start_rel));
int day_back = static_cast<int>(floor(s.start_rel));
a.absence_length = day_back - first_day;

// Define absence sickness as just number of sickness shifts
a.absence_length_sickness = static_cast<int>(current_absence.size());

// Rcout << " " << a.absence_length << " " << a.absence_length_sickness << endl;

return(a);
}

// [[Rcpp::export]]
List C_GenerateSicknessEpisodes(const IntegerVector &name_id,
                               const NumericVector &start_rel,
                               const CharacterVector &shift_code,
                               const CharacterVector &sickness_codes)
{
    map<string, vector<double> > result_map;
    vector<AbsencePeriod> all_absence;

set<string> sel_codes;

// Store sickness codes
for (int i = 0; i < sickness_codes.size(); i++)
    sel_codes.insert(as<string>(sickness_codes[i]));

// Create mapping of shifts
map<int, vector<Shift>> staffmap = CreateStaffMap(name_id,
                                                start_rel,
                                                shift_code);

for (map<int, vector<Shift>>::iterator it = staffmap.begin();
    it != staffmap.end(); it++)
{
    vector<Shift> &l = it->second;
    vector<Shift> current_absence;
    bool is_sick = 0;
    Shift s;

    // Sort in day order
    sort(l.begin(), l.end(), Shift::Compare);
for (size_t j = 0; j < l.size(); j++)
{
    s = l[j];

    set<string>::const_iterator fit = sel_codes.find(s.shift_code);

    // Flag shift as sick or not
    if (fit != sel_codes.end())
        is_sick = 1;
    else
        is_sick = 0;

    // If sick, then add to current absence
    if (is_sick)
        current_absence.push_back(s);
    else
    {
        // If the absence list contains shifts, then store them
        if (current_absence.size() > 0)
        {
            const AbsencePeriod &a = CalcAbsencePeriod(current_absence, s);

            all_absence.push_back(a);
            current_absence.clear();
        }
// Get last one
if (current_absence.size() > 0)
{
    const AbsencePeriod &a = CalcAbsencePeriod(current_absence, s);

    all_absence.push_back(a);
    current_absence.clear();
}

// Convert to map
for (size_t i = 0; i < all_absence.size(); i++)
{
    const AbsencePeriod &a = all_absence[i];

    result_map["first.day.idx"].push_back(a.start_idx+1);
    result_map["last.day.idx"].push_back(a.end_idx+1);
    result_map["absence.length"].push_back(a.absence_length);
    result_map["absence.length.sickness"].push_back(a.absence_length_sickness);
// You can include R code blocks in C++ files processed with sourceCpp
// (useful for testing and development). The R code will be automatically
// run after the compilation.

/*** R

source("f.time.R")
source("f.define_study_times.R")

# Re-format eRoster data and add columns
ReformatEroster <- function(x, shift_type, study_start)
{
  x$Date.POSIX <- strptime_wrapper(x$Date)

  # Calculate relative times for staff
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```r
x$Date_Rel <- DifftimeRelativeToStart(x$Date_POSIX, study_start)
x$Date_String <- format(x$Date_POSIX, "%F")
x$Start_POSIX <- strftime_wrapper(x$Start)
x$End_POSIX <- strftime_wrapper(x$End)

# Create actual starts/ends
x$Start_Actual <-
  paste(x$Date_String, format(x$Start_POSIX, "%T"))
x$Start_Actual_POSIX <- strftime_wrapper(x$Start_Actual)
x$End_Actual <-
  paste(x$Date_String, format(x$End_POSIX, "%T"))
x$End_Actual_POSIX <- strftime_wrapper(x$End_Actual)

# Where is end less than start?
less_than_start <- x$End_Actual_POSIX < x$Start_Actual_POSIX

# Increase date by 1 day for those where end < start
x$End_Actual_POSIX[less_than_start] <- x$End_Actual_POSIX[less_than_start] +
  24*60*60

x$Start_Actual_Rel <- DifftimeRelativeToStart(x$Start_Actual_POSIX, study_start)
x$End_Actual_Rel <- DifftimeRelativeToStart(x$End_Actual_POSIX, study_start)

# Calculate hours worked (or absent!)
x$Hours_calculated <- (x$End_Actual_Rel - x$Start_Actual_Rel)*24
```
# STRIP OUT space from F3

x$mapped_ward_code <-

gsub("\s+", "", x$mapped_ward_code)

# Classify shift type as worked/not-worked

x$Type_worked <-

shift_type$worked_TF[match(x$Type, shift_type$shift.code)]

# Categorise staff (e.g. HCAs, nurses, ward clerks)

x$Grade_type <- NA

x$Grade_type[which(grepl("XN", x$Grade))] <- "ADMIN"

# Nursing assistants

for (i in 1:4)
{

    sel_pat <- paste0("XR0", i)

    x$Grade_type[which(grepl(sel_pat, x$Grade))] <- "HCA"

}

# Registered nurses

for (i in 5:8)
{

    sel_pat <- paste0("XR0", i)

    x$Grade_type[which(grepl(sel_pat, x$Grade))] <- "RN"
# Change to grade unknown
for (sel_pat in c("DA02", "HA22", "JD01"))
{
  x$Grade_type[which(grepl(sel_pat, x$Grade))] <- "UNKNOWN"
}

return(x)

GetShiftTypeMap <- function()
{
  # Read classification of shift types
  shift_type <- read.csv("shift_type_final.csv", as.is = T)
  shift_type$worked_TF <-
  grepl("y", shift_type$Worked., ignore.case = T) # fix to T/F
  shift_type$shift.code <-
  toupper(shift_type$shift.code) # fix any lower case shift codes

  return (shift_type)
}

Agency2ERoster <- function(orig_agency, shift_type, study_start)
{
# Read in mapping from Excel sheet

```r
agency_mapping_excel <- readRDS("agency_to_eroster_mapping.rds")
agency_column_mapping <- agency_mapping_excel$agency_column_mapping
agency_ward_mapping <- agency_mapping_excel$agency_ward_mapping
agency_shift_mapping <- agency_mapping_excel$agency_shift_mapping
```

# Create data frame

```r
all_agency_as_eroster <-
data.frame(from_agency = rep(T, nrow(orig_agency)),
stringsAsFactors = FALSE)
```

# Copy equivalent columns

```r
# Copy equivalent columns
for (i in 1:nrow(agency_column_mapping))
{

eroster_col <- agency_column_mapping$eroster[i]
agency_col <- agency_column_mapping$agency[i]
all_agency_as_eroster[[eroster_col]] <- NA

if (!is.na(agency_col))
{
    all_agency_as_eroster[[eroster_col]] <- orig_agency[[agency_col]]
}
}
```
# Map shift type

all_agency_as_eroster$Type <-
    agency_shift_mapping$eroster[match(all_agency_as_eroster$Type,
                                   agency_shift_mapping$agency)]

# Map ward codes

all_agency_as_eroster$mapped_ward_code <-
    agency_ward_mapping$eroster[match(all_agency_as_eroster$mapped_ward_code,
                                       agency_ward_mapping$agency)]

# Map grades

all_agency_as_eroster$Grade[which(all_agency_as_eroster$Grade == "Qualified")] <-
    "XR05" # qualified as Band 5s

all_agency_as_eroster$Grade[which(all_agency_as_eroster$Grade == "Unqualified")] <-
    "XR03" # unqualified as Band 3s

# Re-format hours for compatibility

Hours_num <- as.numeric(all_agency_as_eroster$Hours)

all_agency_as_eroster$Hours <-
    sprintf("1899-12-30 %02d:%02d:00.000",
            floor(Hours_num),
            round(((Hours_num - floor(Hours_num)) * 60))

# Remove shifts from unmapped wards

all_agency_as_eroster_reduced <-
    subset(all_agency_as_eroster,is.na(mapped_ward_code))
# Run eRoster re-formatting

all_agency_as_eroster_reduced_reformat <-

  ReformatEroster(all_agency_as_eroster_reduced, shift_type, study_start)

return(all_agency_as_eroster_reduced_reformat)

}

library(lubridate)

# Function to call difftime and return
# variable as numeric in days

DifftimeDays <- function(x, y)
{
  return(as.numeric(difftime(x, y, units = "days")))
}

# Function to return POSIX date as
# time from start of study

DifftimeRelativeToStart <- function(x, start)
{
  DifftimeDays(x, rep(start, times = length(x)))
}
# Function as wrapper to parse_date_time in lubridate package

# Should cope with datetimes in 2 different formats

strptime_wrapper <- function(x)
{
  return(parse_date_time(
    as.character(x),
    orders = c("Ymd HMS", "dour HMS"),
    tz = "GMT"
  ))
}

# Convert times back to actual date

RelTime2AbsTime <- function(x, start)
{
  return(start + x * 24 * 60 * 60)
}

# Define start and end of study

study_start <- strptime("2012-04-01", "%F", tz = "GMT")

study_end <- strptime("2015-03-31", "%F", tz = "GMT")

# Define these as relative

study_start_rel <- DifftimeRelativeToStart(study_start, study_start)

study_end_rel <- DifftimeRelativeToStart(study_end, study_start)
# models with proportions

all_episodes_2$prop_longshifts_rounded <- round(all_episodes_2$proplongshifts, 2)

# categorising proportion of long shifts
all_episodes_2$prop_long_shifts<-NA
all_episodes_2$prop_long_shifts[all_episodes_2$prop_longshifts_rounded == 0 ]<-1 #0
all_episodes_2$prop_long_shifts[all_episodes_2$prop_longshifts_rounded > 0.1 &
all_episodes_2$prop_longshifts_rounded <= 0.29]<-2 #0.1-0.2
all_episodes_2$prop_long_shifts[all_episodes_2$prop_longshifts_rounded > 0.29 &
all_episodes_2$prop_longshifts_rounded <= 0.54]<-3 #0.3
all_episodes_2$prop_long_shifts[all_episodes_2$prop_longshifts_rounded > 0.54 &
all_episodes_2$prop_longshifts_rounded <= 0.79]<-4 #0.6
all_episodes_2$prop_long_shifts[all_episodes_2$prop_longshifts_rounded > 0.79]<-5 #0.8

all_episodes_2$prop_long_shifts <- as.factor(all_episodes_2$prop_long_shifts)
levels(all_episodes_2$prop_long_shifts) <- c("0", "25%", "50%", "75%", "100%")

# proportion of bank shifts

all_episodes_2$prop_bankshifts_rounded <- round(all_episodes_2$propbankshifts, 2)
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```r
all_episodes_2$prop_bank_shifts <- NA

all_episodes_2$prop_bank_shifts[all_episodes_2$prop_bankshifts_rounded == 0] <- 1 # 0
all_episodes_2$prop_bank_shifts[all_episodes_2$prop_bankshifts_rounded > 0.1 & all_episodes_2$prop_bankshifts_rounded <= 0.29] <- 2 # 0.1-0.2
all_episodes_2$prop_bank_shifts[all_episodes_2$prop_bankshifts_rounded > 0.29 & all_episodes_2$prop_bankshifts_rounded <= 0.54] <- 3 # 0.3
all_episodes_2$prop_bank_shifts[all_episodes_2$prop_bankshifts_rounded > 0.54 & all_episodes_2$prop_bankshifts_rounded <= 0.79] <- 4 # 0.6
all_episodes_2$prop_bank_shifts[all_episodes_2$prop_bankshifts_rounded > 0.79] <- 5 # 0.8

all_episodes_2$prop_bank_shifts <- as.factor(all_episodes_2$prop_bank_shifts)
levels(all_episodes_2$prop_bank_shifts) <- c("0", "25%", "50%", "75%", "100%")

# proportion of night shifts

all_episodes_2$prop_nightshifts_rounded <- round(all_episodes_2$prop_nightshifts, 2)

all_episodes_2$prop_night_shifts <- NA
all_episodes_2$prop_night_shifts[all_episodes_2$prop_nightshifts_rounded == 0] <- 1 # 0
all_episodes_2$prop_night_shifts[all_episodes_2$prop_nightshifts_rounded > 0.1 & all_episodes_2$prop_nightshifts_rounded <= 0.29] <- 2 # 0.1-0.2
all_episodes_2$prop_night_shifts[all_episodes_2$prop_nightshifts_rounded > 0.29 & all_episodes_2$prop_nightshifts_rounded <= 0.54] <- 3 # 0.3

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all_episodes_2$prop_night_shifts[all_episodes_2$prop_nightshifts_rounded > 0.54 & all_episodes_2$prop_nightshifts_rounded <= 0.79] <- 4 #0.6

all_episodes_2$prop_night_shifts[all_episodes_2$prop_nightshifts_rounded > 0.79] <- 5 #0.8

all_episodes_2$prop_night_shifts <- as.factor(all_episodes_2$prop_night_shifts)
levels(all_episodes_2$prop_night_shifts) <- c("0", "25%", "50%", "75%", "100%")

# proportion of worked days

all_episodes_2$prop_workedshifts_rounded <- round(all_episodes_2$propworkedshifts, 2)

all_episodes_2$prop_worked_shifts <- NA
all_episodes_2$prop_worked_shifts[all_episodes_2$prop_workedshifts_rounded <= 0.29] <- 1 #0.1-0.2

all_episodes_2$prop_worked_shifts[all_episodes_2$prop_workedshifts_rounded > 0.29 & all_episodes_2$prop_workedshifts_rounded <= 0.54] <- 2 #0.3

all_episodes_2$prop_worked_shifts[all_episodes_2$prop_workedshifts_rounded > 0.54 & all_episodes_2$prop_workedshifts_rounded <= 0.79] <- 3 #0.6

all_episodes_2$prop_worked_shifts[all_episodes_2$prop_workedshifts_rounded > 0.79] <- 4 #0.8

all_episodes_2$prop_worked_shifts <- as.factor(all_episodes_2$prop_worked_shifts)
levels(all_episodes_2$prop_worked_shifts) <- c("25\%", "50\%", "75\%", "100\%")
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G.2 R script for missed and delayed observations dataset creation

```r
setwd("/workforceresearch.files.soton.ac.uk/MissedCareStudyData/Chiara analysis")

library(Rcpp)
library(lubridate)

source("CalculateSHMI.R")
source("f.time.R")
source("f.define_study_times.R")
source("f.reformat_eroster.R")

sourceCpp("CalculateLateFlag.cpp", rebuild = T)
sourceCpp("ConsolidateAdmissionsAndTransfers.cpp", rebuild = T)

ConvertPasWard2ErosterWard <- function(x, mapping)
{
  return(mapping$eroster[match(x, mapping$pas)])
}

# Functions adds missing SHMI codes from additional file
AddMissingSHMI <- function(x)
{
  y <- read.csv("adms_shmi_corrections.csv", as.is = T)

  # Copy old shmi (for checking)
  x$shmi_grp_old <- x$shmi_grp
  x$shmi_ccs_old <- x$shmi_ccs

  # Find selected patients
  sel_pts <- match(x$epis_sg2,y$epis_sg2)

  x$shmi_grp_new <- y$shmi_grp[sel_pts]
}
```

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```r
x$shmi_ccs_new <- y$shmi_ccs[sel_pts]

x$shmi grp <- ifelse(is.na(x$shmi_grp_new), x$shmi_grp_old, x$shmi_grp_new)
x$shmi ccs <- ifelse(is.na(x$shmi_ccs_new), x$shmi_ccs_old, x$shmi_ccs_new)

return(x)
```

# Re-format admissions data and add columns
ReformatPas <- function(x, mapping, events) {

# Convert admissions
x$AdmitDate_POSIX <- strptime_wrapper(x$AdmitDate)
x$AdmitDate_String <- format(x$AdmitDate_POSIX, "%F")
x$AdmitDate_Rel <-
  DifftimeRelativeToStart(x$AdmitDate_POSIX, study_start)

x$DischDate_POSIX <- strptime_wrapper(x$DischDate)
x$DischDate_String <- format(x$DischDate_POSIX, "%F")
x$DischDate_Rel <-
  DifftimeRelativeToStart(x$DischDate_POSIX, study_start)

x$LOS <- x$DischDate_Rel - x$AdmitDate_Rel

# Calculate age at admission
x$dob_trunc_POSIX <- strptime_wrapper(x$dob_trunc)
x$Age_adm <- DifftimeDays(x$AdmitDate_POSIX, x$dob_trunc_POSIX) / 365.25

# Add eRoster mapped ward
x$Ward_eroster <- ConvertPasWard2ErosterWard(x$Ward, mapping)

# Tag this as admission ward
x$Admit_Ward <- x$Ward eroster

# Add missing SHMI codes
x <- AddMissingSHMI(x)
```
# Add index
x$idx <- 1:nrow(x)

x <- CalculateSHMI(x)

# Convert time for events
events$EVENT_DT <- strptime_wrapper(events$EVENT_DT)

# Order events by epis_sg2 and time
events <- events[order(events$epis_sg2, events$EVENT_DT), ]

# Find first match for each pt
matched.event <- match(x$epis_sg2, events$epis_sg2)

# Add first event and type
x$FIRST_DT <- events$EVENT_DT[matched.event]
x$FIRST_TYPE <- events$EVENT_TYPE[matched.event]
x$FIRST_DT_Rel <- DifftimeRelativeToStart(x$FIRST_DT, study_start)

# Add adverse event column
x$ADVERSE <- 0
x$ADVERSE[which(x$FIRST_TYPE !="none")]<- 1

return(x)

# Re-format transfers data and add columns
ReformatTransfers <- function(x, mapping)
{
  # Convert dates in transfers
  x$TransDate_POSIX <-
      strptime_wrapper(x$TransDate)
  x$TransDate_String <-
      format(x$TransDate_POSIX, "%F")
  x$TransDate_Rel <-
      DifftimeRelativeToStart(x$TransDate_POSIX, study_start)
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```r
x$ToWard_eroster <- ConvertPasWard2ErosterWard(x$ToWard, mapping)
x$FromWard_eroster <-
    ConvertPasWard2ErosterWard(x$FromWard, mapping)

# Add index
x$sidx <- 1:nrow(x)

return(x)
}

# Re-format VitalPAC data and add columns
ReformatVitalPAC <- function(x, mapping)
{
    # Calculate relative times for VitalPAC data and age at admission
    x$time_of_reading_POSIX <-
        strptime_wrapper(x$time_of_reading)

    x$prev_time_of_reading_POSIX <-
        strptime_wrapper(x$prev_time_of_reading)

    x$time_of_reading_Rel <-
        DifftimeRelativeToStart(x$time_of_reading_POSIX, study_start)

    x$prev_time_of_reading_Rel <-
        DifftimeRelativeToStart(x$prev_time_of_reading_POSIX, study_start)

    # Reset all MAU wards
    x$ward_code <-
        ifelse(grepl("MAU", as.character(x$ward_code)),
            "MAU",
            as.character(x$ward_code))

    x$ward_code_eroster <-
        ConvertPasWard2ErosterWard(x$ward_code, mapping)

    # This is a modified version of PM's encoding
    x$late_mod <- CalculateLateFlag(x$time_of_reading_Rel,
        x$prev_time_of_reading_Rel,
        x$prev_time_of_reading_Rel,
```
# This is based purely on time
x$late_time <- CalculateLateFlagTime (x$time_of_reading_Rel,
   x$prev_time_of_reading_Rel,
   x$TTNO_prev,
   x$late)

return(x)

########################################################
# NEED TO READ IN TO DATA AS FOLLOWS:
# 1. create all_eroster data frame (e.g. select * from eRoster)
# 2. create all_pas data frame (e.g. select * from adms)
# 2. create all_transfers data frame (e.g. select * from transfers)
# 2. create all_obs data frame (e.g. select * from std_obs)

all_eroster <- readRDS("eroster.rds")
all_bank_and_agency <- read.csv("bank_bookings.csv", as.is=T)
all_pas <- read.csv("adms.csv")
all_obs <- read.csv ("std_obs.csv")
all_transfers <- read.csv("transfers.csv")

# Define age cutoff
study_age_cutoff <- 16

# Remove all unfilled shifts in new bank/agency
all_bank_and_agency <-
   subset(all_bank_and_agency,
   !grepl("unfilled", Outcome, ignore.case = T))

# Mapping from PAS/VitalPAC to e-Roster
pas_eroster_mapping <-
   read.csv("paserostermapping.csv", as.is = T)
shift_type <- GetShiftTypeMap()

# Add extra from_agency field to eRoster so data can be identified if required
all_eroster$from_agency <- F
all_eroster$Outcome <- "eRoster"

# Map modes of admission
meth_adm <- read.csv("meth_adm.csv", as.is = T)
all_pas$MethAdm_Elective <-
    meth_adm$AdmType[match(all_pas$MethAdm, meth_adm$METH.ADM)]

# Map modes of discharge
meth_dis <- read.csv("meth_dis.csv", as.is = T)
all_pas$DischMethod_Death <-
    meth_dis$death_at_discharge[match(all_pas$DischMethod, meth_dis$DSCH.CODE)]

# Read events file
events <- read.csv("events.csv", as.is=T)

# Re-format data
all_eroster <- ReformatEroster(all_eroster, shift_type, study_start)
all_bank_and_agency_as_eroster <- Agency2ERoster(all_bank_and_agency, shift_type, study_start)
all_pas <- ReformatPas(all_pas, pas_eroster_mapping, events)
all_transfers <-
    ReformatTransfers(all_transfers, pas_eroster_mapping)
all_obs <- ReformatVitalPAC(all_obs, pas_eroster_mapping)

# Combine PAS and transfers
pas_plus_transfers <-
    ConsolidateAdmissionsAndTransfers(all_pas, all_transfers)

# Define study wards (need to do this here for F3)
study_wards <- unique(all_eroster$mapped_ward_code)

# Combine Agency and eRoster into one
all_eroster_plus_agency <- rbind(all_bank_and_agency_as_eroster, all_eroster)
# Reduce to just study wards
all_eroster_plus_agency <- subset(all_eroster_plus_agency, mapped_ward_code %in% study_wards)

# Now we need to select out the data set based:
# 1. only patients >=16
# 2. only ward spells within the study period
# 3. only ward spells on study wards
# 4. Remove patients where discharge Method is NA
patient_population <- subset(
pas_plus_transfers,
pas_Age_adm >= study_age_cutoff
    & stop > 0
    & start < study_end_rel
    & !is.na(Ward_eroster_current)
    & !is.na(pas_DischMethod)
)

# Now select out all spells for those patients
sel_pas_plus_transfers <- subset(pas_plus_transfers,
                                pas_epis_sg2 %in% unique(patient_population$pas_epis_sg2))
rm(patient_population)

# Reduce all_obs to selected patients
# and remove any observations not in study period
# sel_obs <- subset(
#    all_obs,
#    epis_sg2 %in% sel_pas_plus_transfers$pas_epis_sg2 &
#    time_of_reading_POSIX >= study_start &
#    time_of_reading_POSIX <= study_end &
#    !is.na(ward_code_eroster)
#)

# Run garbage collection
# Need to remove data frames not used to free memory
# rm(all_agency, all_agency_as_eroster, all_obs, all_pas, all_transfers)
gc()

library(Rcpp)
library(survival)
library(doBy)
library(XLConnect)

sourceCpp("CreateSurvivalTimeColumns.cpp")
sourceCpp("WardHoursPerShift.cpp")
sourceCpp("ExposureByPatient.cpp")
sourceCpp("PatientDayIndex.cpp")
sourceCpp("DataframeExtract.cpp")
sourceCpp("CumulativeSumByPatient.cpp")
# sourceCpp("OnlyStudyWardPatients.cpp")
sourceCpp("AdmissionsByWardDay.cpp")
sourceCpp("GetIdxMaxByPatientDay.cpp")
sourceCpp("GetRelevantPatients.cpp")

# Function reads and calculates establishment hours
GetEstablishment <- function(study_start_rel, study_end_rel)
{
  wb <-
  loadWorkbook("AggregateEstablished_shifts.xlsx")
  x <-
  readWorksheet(wb, sheet = "Sheet1")

  # Calculate established per ward
  x$Nurse.Establishment.Hours <-
  x$nurse_early_shift_Mode * 8 + x$nurse_late_shift_Mode * 8 +
  x$nurse_night_shift_Mode * 12
  x$HCA.Establishment.Hours <-
  x$hca_early_shift_Mode * 8 + x$hca_late_shift_Mode * 8 + x$hca_night_shift_Mode * 12

  # Divide both to get in days for consistency with raw staffing data
# (converted back to days later)
x$Nurse.Establishment.Days <- x$Nurse.Establishment.Hours/24
x$HCA.Establishment.Days <- x$HCA.Establishment.Hours/24

# Create 2 dataframes, one for RNs and one for HCAs
both <- list()

# For nurses and HCAs
for (i in c("Nurse.Establishment.Days", "HCA.Establishment.Days"))
{
  d <- data.frame(Day=seq(study_start_rel, study_end_rel,1))

  # Add column for each ward with staffing
  for(j in unique(x$ward))
  {
    d[[j]] <- x[[i]][x$ward==j]
  }

  # Add to list
  both[[i]] <- d
}

return(both)

PlotLevels <-
  function(staff_levels,
          pt_levels,
          nursing_hours_per_ptday)
  {
    pdf("sample_wards.pdf", paper = "a4r")
    par(mfrow = c(3, 3))

    xmax <- max(staff_levels$Day)
    # xmax <- 14

    for (i in names(staff_levels))
    {
      d <- data.frame(Day=seq(study_start_rel, study_end_rel,1))
      for(j in unique(x$ward))
      {
        d[[j]] <- x[[i]][x$ward==j]
      }

      # Add to list
      both[[i]] <- d
    }

    return(both)
  }
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if (i == "Day")
        next

plot(
        staff_levels$Day,
        staff_levels[[i]],
        type = "p",
        pch = 16,
        col = "blue",
        las = 1,
        main = i,
        xlab = "Study day",
        ylab = "Nursing days",
        xlim = c(0, xmax),
        ylim = c(0, max(staff_levels[[i]], na.rm = T))
    )

plot(
        pt_levels$Day,
        pt_levels[[i]],
        type = "p",
        pch = 16,
        col = "red",
        las = 1,
        main = i,
        xlab = "Study day",
        ylab = "Patient days",
        xlim = c(0, xmax),
        ylim = c(0, max(pt_levels[[i]], na.rm = T))
    )

plot(
        pt_levels$Day,
        nursing_hours_per_ptday[[i]],
        type = "p",
        pch = 16,
        col = "purple",
        las = 1,
        main = i,
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xlab = "Study day",
ylab = "Nursing hours per patient day",
xlim = c(0, xmax),
ylim = c(0, max(nursing_hours_per_ptday[[i]], na.rm = T))
)

par(mfrow = c(1, 1))
dev.off()
}

CalcNursingHoursPerPatientDay <- function(staff_levels, pt_levels, plot_it = F, quiet = T)
{
  nursing_hours_per_ptday <- data.frame(Day = staff_levels$Day)
  for (i in names(staff_levels))
  {
    if (i == "Day")
      next
    ward_median <- median(pt_levels[[i]], na.rm=T)
    # Set to NA if pt_levels are less than 0.25 times median
    this_ward <- ifelse(pt_levels[[i]]<0.25*ward_median, NA, pt_levels[[i]])
    nursing_hours_per_ptday[[i]] <-
      hours_per_shift * staff_levels[[i]] / this_ward
    # Set to NA if no patients
    nursing_hours_per_ptday[[i]] <-
      ifelse(!is.finite(nursing_hours_per_ptday[[i]]), NA, nursing_hours_per_ptday[[i]])
  }
}

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if (plot_it)
  PlotLevels(staff_levels, pt_levels, nursing_hours_per_ptday)

return(nursing_hours_per_ptday)

CalcNursingHours <- function(staff, quiet = T)
{
  staff_levels <-
  WardHoursPerShift(
    staff$mapped_ward_code,
    staff$Start_Actual_Rel,
    staff$End_Actual_Rel,
    staff$name_id,
    last_day = study_end_rel,
    quiet = quiet
  )

  for (i in names(staff_levels))
  {
    if (i == "Day")
      next
    staff_levels[[i]] <- hours_per_shift * staff_levels[[i]]
  }

  return(staff_levels)
}

# Function takes raw NHPPD and transforms into quantiles
# of staffing per ward
# Similar functions can be written for difference transformations
TransformNHPPD_Quantiles <- function(x)
{
  exposure_quantiles <- data.frame(Day = x$Day)
for (i in names(x))
{
    if (i == "Day")
        next

    exposure_quantiles[[i]] <- NA

    ward_quantiles <- quantile(x[[i]],
                                probs = seq(0, 1, 0.1),
                                na.rm = T)
    # print(i)
    # print(ward_quantiles)
    # print(length(ward_quantiles))

    # Add quantiles (This now deals with duplicates)
    for (j in seq(length(ward_quantiles), 1,-1))
    {
        value <- j - 1
        sel <- x[[i]] <= ward_quantiles[j]
        exposure_quantiles[[i]][sel] <- value
    }
}

return(exposure_quantiles)
}

# Function takes raw NHPPD and transforms into proportion
# of mean for that ward
TransformNHPPD_MeanProp <- function(x)
{
    exposure_quantiles <- data.frame(Day = x$Day)
    for (i in names(x))
    {
        if (i == "Day")
            next

        mean_for_ward <- mean(x[[i]], na.rm = T)
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```r
exposure_quantiles[[i]] <- x[[i]] / mean_for_ward
# print(paste(i, round(24/mean_for_ward, 1)))
```

```r
return(exposure_quantiles)
```

```r
# Function takes raw NHPPD and transforms into proportion
# of establishment for that ward
# eb = establishment data frame
# sel_col = selected column (e.g. Nurse.Establishment.Hours)
TransformNHPPD_MeanEstablish <- function(actual, expected)
{
  exposure_quantiles <- data.frame(Day = actual$Day)
  for (i in names(actual))
  {
    if (i == "Day")
      next

    exposure_quantiles[[i]] <- actual[[i]] / expected[[i]]
  }

  return(exposure_quantiles)
}

AddProps <- function(x)
{
  total_cols <- grep("_*TOTAL$", names(x), value = T)
  raw_wards <- gsub("_*TOTAL$", "", total_cols)
  for (i in raw_wards)
  {
    prop_var <- paste(i, "PROP", sep = ".")
    x[[prop_var]] <-
      x[[paste(i, "NBELOW", sep = ".")]] / x[[paste(i, "TOTAL", sep = ".")]]
    
    # Reset Nan
```
x[[prop_var]] <- ifelse(is.nan(x[[prop_var]]), 0, x[[prop_var]])

return(x)

AddExposure <- function(pdi, exposure, exposure.col.name) {
  matched_wards <- match(pdi$ward, names(exposure))
  matched_days <- match(pdi$Day, exposure$Day)

  # print(paste(length(matched_wards), length(matched_days)))

  pdi[[exposure.col.name]] <-
    exposure[cbind(matched_days, matched_wards)]

  return(pdi)
}

CreateExpectedNHPPD <- function(pts, eb, sel_col) {
  # Calculate number of pts per day
  x <-
    WardHoursPerShift(
      pts$Ward_eroster_current,  
      pts$start,  
      pts$stop,  
      pts$pas_epis_sg2,  
      last_day = study_end_rel,  
      quiet = T
    )

  exposure_quantiles <- data.frame(Day = x$Day)
  for (i in names(x)) {
    if (i == "Day")
      next
    
    exposure_quantiles[[i]] <-
      exposure[cbind(matched_days, matched_wards)]
  }

  return(exposure_quantiles)
}
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# Extract total hours
eb_for_ward <- eb[[sel_col]][eb$ward == i]

# Divide the 2
exposure_quantiles[i] <- eb_for_ward / x[i]

# Correct infinite values
exposure_quantiles[i] <-
  ifelse(is.infinite(exposure_quantiles[i]),
    NA,
    exposure_quantiles[i])

# print(paste(i, round(24/mean_for_ward, 1)))
}

return(exposure_quantiles)

CreateExpectedNHPPDWithAverage <- function(nhppd)
{
  normalised <- data.frame(Day = nhppd$Day)
  for (i in names(nhppd))
  {
    if (i == "Day")
      next

    normalised[[i]] <- mean(nhppd[[i]], na.rm = T)
  }

  normalised[[i]] <-
    ifelse(!is.finite(normalised[[i]]),
      NA,
      normalised[[i]])

  return(normalised)
}

CalcPatientsPerNurse <- function(x)
{  
  # Initialise days  
exposure_quantiles <- data.frame(Day = x$Day)  
for (i in names(x))  
{  
  if (i == "Day")  
    next  

  exposure_quantiles[[i]] <- hours_per_shift / x[[i]]  
exposure_quantiles[[i]][which(is.infinite(exposure_quantiles[[i]]))] <- NA  
}  
return(exposure_quantiles)  
}  

# Calculates ward turnover  
# Turnover calculated as nurses per admission  
CalculateWardTurnoverAPN <-  
function(x,  
nursing_days,  
pt_levels,  
study_end_rel,  
normalise = T)  
{  
  ptsperday <- AdmissionsByWardDay(x$Ward_eroster_current,  
x$start,  
   study_end_rel)  

  # Initialise days  
turnover <- data.frame(Day = nursing_days$Day)  
for (i in names(nursing_days))  
{  
  exposure_quantiles[[i]] <- hours_per_shift / x[[i]]  
exposure_quantiles[[i]][which(is.infinite(exposure_quantiles[[i]]))] <- NA  
}  
return(exposure_quantiles)  
}
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if (i == "Day")
    next

# Calculate staff per admission
turnover[[i]] <- ptsperday[[i]] / nursing_days[[i]]

# Correct infinite values
turnover[[i]] <-
    ifelse(!is.finite(turnover[[i]]), NA, turnover[[i]])

# Set to NA if there are no patients according to PAS
turnover[[i]][pt_levels[[i]] == 0] <- NA

# Normalise as fraction of mean for ward
if (normalise == T) turnover[[i]] <- turnover[[i]] / mean(turnover[[i]], na.rm = T)
}

return(turnover)

# Function removes duplicate entries for patient days
# For model variable columns, it takes the worse (i.e. low staffing)
# For all others, it is essentially random
ReduceSurvivalData <- function(x, cfc)
{
    # Find indexes to extract
    reduced_idx <- GetIdxMaxByPatientDay(x, "Day", "epis_sg2", cfc)

    # build up new data frame
    new_survival <- data.frame(Day = x$Day[reduced_idx$Day])

    for (i in names(x))
    {
        if (exists(i, reduced_idx))
        {

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```r
{ this_idx <- reduced_idx[[i]]
}
else
{
    this_idx <- reduced_idx$Day
}

new_survival[[i]] <- x[[i]][this_idx]
}

return(new_survival)
}

# Gets first news for each patient
GetFirstNEWS <- function(x, surv_data_pts)
{
    x <- x[order(x$epis_sg2, x$time_of_reading_Rel),]

    matched_rows <-
        match(as.character(surv_data_pts), as.character(x$epis_sg2))

    return(x$ews_incomplete_max[matched_rows])
}

ThresholdColumns <- function(x)
{
    # Apply threshold functions
cols_for_thresholds <- c("Nursing.Exposure.Derived",
                            "HCA.Exposure.Derived",
                            "Nursing.Exposure.Estab",
                            "HCA.Exposure.Estab")
threshold_values <- c(75, 80, 100)

    for (i in cols_for_thresholds)
    {
        for (j in threshold_values)
        {
            # Initialise new variable
```
new_var <- paste0(i, ".Model.Below.", j)
x[[new_var]] <- 0

# Find those with low exposure
sel_days <- which(x[[i]] <= j / 100)
x[[new_var]][sel_days] <- 1
}

# For quantiles
cols_for_centiles <-
grep("centile",
    names(x),
    ignore.case = T,
    value = T)
for (i in cols_for_centiles)
{
    new_var <- paste0(i, ".Model.Below.20th")
    x[[new_var]] <- 0
    sel_days <- which(x[[i]] <= 2)
    x[[new_var]][sel_days] <- 1
}

return(x)

CusumColumns <- function(x)
{
    # Get columns to calculate cumulative sum
    cols_for_cusum <-
        grep("model", names(x), ignore.case = T, value = T)

    x <- ReduceSurvivalData(x, cols_for_cusum)

    for (i in cols_for_cusum)
    {

# Look at first 5 days and who
le of admission

for (j in c(5, 2000))
{
  new_var <- paste0(i, ".cusum.", j)

  y <- CumulativeSumByPatient(x$epis_sg2,
                               x$Day,
                               x[[i]],
                               x$pas_DischMethod_Death_10,
                               j)
  x[[new_var]] <- y$CUSUM
  x$Day_Admit <- y$Day_Admit
  x$Day.of.Death <- y$Day.of.Death
}

return(x)

# Function sets each ward day in exclusion
# time periods to NA
ExcludeDays <- function(x)
{
  wb <- loadWorkbook("excluded_ward_days.xlsx")
  excluded <- readWorksheet(wb, sheet = "excluded_ward_days")

  for (i in 1:nrow(excluded))
  {
    sel_days <- x$Day >= excluded$start[i] & x$Day <= excluded$end[i]
    sel_ward <- excluded$ward[i]

    x[[sel_ward]][sel_days] <- NA
  }

  return(x)
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}  

######### Define hours per shift #########
hours_per_shift <- 24

######## Define whether using death or first event ####
use.death <- T

# Create subset of working RNs
nurses_worked_all <- subset(all_eroster_plus_agency, 
   End_Actual_Rel >= 0 
   & Grade_type == "RN" 
   & Type_worked == T)

# Create subset of working HCAs
hcas_worked_all <- subset(all_eroster_plus_agency, 
   End_Actual_Rel >= 0 
   & Grade_type == "HCA" 
   & Type_worked == T)

# Add option to exclude bank/agency
exclude.bank.and.agency <- F
if (exclude.bank.and.agency) 
{
   
   nurses_worked <- subset(nurses_worked_all, from_agency == F)
   hcas_worked <- subset(hcas_worked_all, from_agency == F)
}
else
{
   
   nurses_worked <- nurses_worked_all
   hcas_worked <- hcas_worked_all
}
rm(nurses_worked_all, hcas_worked_all)

# Get just bank and agency (separate nurses and hcas)
temps_nurses_worked <- subset(nurses_worked, from_agency==T)
temps_hcas_worked <- subset(hcas_worked, from_agency==T)
\# Calculate total bank/agency hours
temps_nurses_days <-
  WardHoursPerShift(
    temps_nurses_worked$mapped_ward_code,
    temps_nurses_worked$Start_Actual_Rel,
    temps_nurses_worked$End_Actual_Rel,
    temps_nurses_worked$name_id,
    last_day = study_end_rel,
    quiet = T
  )

\# Calculate total bank/agency hours
temps_hcas_days <-
  WardHoursPerShift(
    temps_hcas_worked$mapped_ward_code,
    temps_hcas_worked$Start_Actual_Rel,
    temps_hcas_worked$End_Actual_Rel,
    temps_hcas_worked$name_id,
    last_day = study_end_rel,
    quiet = T
  )

\# Calculate total nursing hours
nursing_days <-
  WardHoursPerShift(
    nurses_worked$mapped_ward_code,
    nurses_worked$Start_Actual_Rel,
    nurses_worked$End_Actual_Rel,
    nurses_worked$name_id,
    last_day = study_end_rel,
    quiet = T
  )

\# Calculate total HCA hours
hca_days <-
  WardHoursPerShift(
    hcas_worked$mapped_ward_code,
    hcas_worked$Start_Actual_Rel,
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```
    hcas_worked$End_Actual_Rel,
    hcas_worked$name_id,
    last_day = study_end_rel,
    quiet = T
  )

# Calculate pt levels on each ward (all non-eroster wards are NA.)
pt_levels <-
  WardHoursPerShift(
    sel_pas_plus_transfers$Ward_eroster_current,
    sel_pas_plus_transfers$start,
    sel_pas_plus_transfers$stop,
    sel_pas_plus_transfers$pas_epis_sg2,
    last_day = study_end_rel,
    quiet = T
  )

# Calculate establishment in days
estab_days <- GetEstablishment(study_start_rel, study_end_rel)
estab_nursing_days <- estab_days$Nurse.Establishment.Days
estab_hca_days <- estab_days$HCA.Establishment.Days
rm(estab_days)

# Set all days excluded from the study to NA
nursing_days <- ExcludeDays(nursing_days)
hca_days <- ExcludeDays(hca_days)
temps_nurses_days <- ExcludeDays(temps_nurses_days)
temps_hcas_days <- ExcludeDays(temps_hcas_days)
estab_nursing_days <- ExcludeDays(estab_nursing_days)
estab_hca_days <- ExcludeDays(estab_hca_days)

# Calculate actual NHPPD
actual_NHHPD_nursing <-
  CalcNursingHoursPerPatientDay(nursing_days, pt_levels)
actual_NHHPD_hca <-
  CalcNursingHoursPerPatientDay(hca_days, pt_levels)
actual_NHHPD_temps_nursing <-
  CalcNursingHoursPerPatientDay(temps_nurses_days, pt_levels)
```
actual_NHHPD_temps_hcas <-
  CalcNursingHoursPerPatientDay(temps_hcas_days, pt_levels)

# Convert actual quantiles
actual_NHHPD_nursing_quantiles <-
  TransformNHPPD_Quantiles(actual_NHHPD_nursing)
actual_NHHPD_hca_quantiles <-
  TransformNHPPD_Quantiles(actual_NHHPD_hca)

# Convert to patients per RN/HCA
actual_NHHPD_nursing_ratio <-
  CalcPatientsPerNurse(actual_NHHPD_nursing)
actual_NHHPD_hca_ratio <- CalcPatientsPerNurse(actual_NHHPD_hca)

# Calculate derived NHPPD
derived_NHHPD_nursing <-
  CreateExpectedNHPPDWithAverage(actual_NHHPD_nursing)
derived_NHHPD_hca <-
  CreateExpectedNHPPDWithAverage(actual_NHHPD_hca)
derived_NHHPD_temps_nursing <-
  CreateExpectedNHPPDWithAverage(actual_NHHPD_temps_nursing)
derived_NHHPD_temps_hcas <-
  CreateExpectedNHPPDWithAverage(actual_NHHPD_temps_hcas)

# Convert establishment to NHPPD
estab_NHHPD_nursing <- CalcNursingHoursPerPatientDay(estab_nursing_days, pt_levels)
estab_NHHPD_hca <- CalcNursingHoursPerPatientDay(estab_hca_days, pt_levels)

# Calculate turnover as nurses per admission
turnover.npa <-
  CalculateWardTurnoverAPN(sel_pas_plus_transfers, nursing_days, pt_levels, study_end_rel)
# Calculate turnover as hcas per admission

```r
turnover.hpa <-
  CalculateWardTurnoverAPN(sel_pas_plus_transfers,
      hca_days,
      pt_levels,
      study_end_rel)
```

# Or select everyone

```r
only_study_wards <- sel_pas_plus_transfers
```

# Define column to use for first event

```r
first.event.col <- "pas_DischDate_Rel"
if (use.death==F) first.event.col <- "pas_FIRST_DT_Rel"
```

# Create skeleton dataframe for patient days

```r
for_survival <- PatientDayIndex(
    only_study_wards$epis_sg2.y,
    only_study_wards$Ward_eroster_current,
    only_study_wards$start,
    only_study_wards$stop,
    only_study_wards[[first.event.col]],
    study_end_rel)
```

# Add first NEWS value

```r
for_survival$First.NEWS <-
  GetFirstNEWS(all_obs, for_survival$epis_sg2)
```

# Add turnover variables

```r
for_survival <-
  AddExposure(for_survival, turnover.npa, "Nurses.Per.Admission.Turnover")
for_survival <-
  AddExposure(for_survival, turnover.hpa, "Hcas.Per.Admission.Turnover")
```

# Add turnover threshold variable

```r
{
```
for (j in c(125))
{
    # Initialise new variable
    new_var <- paste0(i, ".Model.Above.", j)
    for_survival[[new_var]] <- 0

    # Find those with raised cutoff
    sel_days <- which(for_survival[[i]] >= j / 100)

    for_survival[[new_var]][sel_days] <- 1
}

# Add nursing NHHPDs
for_survival <- AddExposure(for_survival, derived_NHHPD_nursing, "NHPPD.Nursing.Derived")
for_survival <- AddExposure(for_survival, estab_NHHPD_nursing, "NHPPD.Nursing.Estab")
for_survival <- AddExposure(for_survival, actual_NHHPD_nursing, "NHPPD.Nursing.Actual")
for_survival <- AddExposure(for_survival,
    actual_NHHPD_nursing_quantiles,
    "NHPPD.Nursing.Centile")
for_survival <- AddExposure(for_survival,
    actual_NHHPD_nursing_ratio,
    "Ratio.Patients.Nursing")

# Add HCA NHHPDs
for_survival <- AddExposure(for_survival, derived_NHHPD_hca, "NHPPD.HCA.Derived")
for_survival <- AddExposure(for_survival, estab_NHHPD_hca, "NHPPD.HCA.Estab")
for_survival <- AddExposure(for_survival, actual_NHHPD_hca, "NHPPD.HCA.Actual")
actual_NHHPD_hca_quantiles, "NHPPD.HCA.Centile")

for_survival <- AddExposure(for_survival, actual_NHHPD_hca_ratio, "Ratio.Patients.HCA")

# Add temps NHPPDs
for_survival <-
  AddExposure(for_survival, derived_NHHPD_temps_nursing, "NHPPD.Temps.Nursing.Derived")
for_survival <-
  AddExposure(for_survival, actual_NHHPD_temps_nursing, "NHPPD.Temps.Nursing.Actual")

for_survival <-
  AddExposure(for_survival, derived_NHHPD_temps_hcas, "NHPPD.Temps.HCA.Derived")
for_survival <-
  AddExposure(for_survival, actual_NHHPD_temps_hcas, "NHPPD.Temps.HCA.Actual")

# Add raw exposure
for_survival$Nursing.Exposure.Derived <-
  for_survival$NHPPD.Nursing.Actual / for_survival$NHPPD.Nursing.Derived
for_survival$Nursing.Exposure.Estab <-
  for_survival$NHPPD.Nursing.Actual / for_survival$NHPPD.Nursing.Estab
for_survival$HCA.Exposure.Derived <-
  for_survival$NHPPD.HCA.Actual / for_survival$NHPPD.HCA.Derived
for_survival$HCA.Exposure.Estab <-
  for_survival$NHPPD.HCA.Actual / for_survival$NHPPD.HCA.Estab

# Calculate absolute difference from mean
# Called model so picked up by cusum
# (need to multiply by -1 to reverse for cusum to work)
for_survival$HCA.Exposure.Derived.Diff.Model <-
  -1 * (for_survival$NHPPD.HCA.Derived - for_survival$NHPPD.HCA.Actual)
for_survival$Nursing.Exposure.Derived.Diff.Model <-
\[-1 \times (\text{for\_survival$NHPPD$Nursing$Derived} - \text{for\_survival$NHPPD$Nursing$Actual})\]

# Set all NAs to zero (or we have problems with the sum!)
for\_survival$HCA$Exposure$Derived$Diff$Model[is.na(for\_survival$HCA$Exposure$Derived$Diff$Model)] <- 0
for\_survival$Nursing$Exposure$Derived$Diff$Model[is.na(for\_survival$Nursing$Exposure$Derived$Diff$Model)] <- 0

# Truncate values under zero (which are actually overstaffing now)
for\_survival$HCA$Exposure$Derived$Diff$Model.0 <-
  ifelse(  
    for\_survival$HCA$Exposure$Derived$Diff$Model < 0,  
    0,  
    for\_survival$HCA$Exposure$Derived$Diff$Model
  )
for\_survival$Nursing$Exposure$Derived$Diff$Model.0 <-
  ifelse(  
    for\_survival$Nursing$Exposure$Derived$Diff$Model < 0,  
    0,  
    for\_survival$Nursing$Exposure$Derived$Diff$Model
  )

# Add bank/agency threshold as absolute NHPPD
for (i in c("NHPPD$Temps$Nursing$Actual", "NHPPD$Temps$HCA$Actual"))
{
  for (j in c(25, 50, 100, 125, 150))
  {
    # Initialise new variable
    new\_var <- paste0(i, ".Model.Above.", j)
    for\_survival[[new\_var]] <- 0

    # Find those with raised cutoff
    sel\_days <- which(for\_survival[[i]] >= j/100)

    for\_survival[[new\_var]][sel\_days] <- 1
  }
}

# Add demographic data
demographic_cols <-
c("pas_MethAdm_Elective",
"pas_Age_adm",
"pas_CCI",
"pas_DischMethod_Death",
"pas_Admit_Ward",
"pas_DisWard",
"pas_Sex",
"pas_LOS",
"pas_shmi_grp",
"pas_AdmitDate_Rel",
"pas_DischDate_Rel",
"has_transfers",
"pas_shmi_score",
"pas_shmi_score_minus_intercept",
"pas_ADVERSE"
)
for (i in demographic_cols)
{
  for_survival[[i]] <-
  only_study_wards[[i]][for_survival$orig.idx]
}

# Add mortality is 1 or 0
for_survival$pas_DischMethod_Death_10 <-
  ifelse(for_survival$pas_DischMethod_Death == "dead", 1, 0)

# Correct this to adverse if not using death
if (use.death==F) for_survival$pas_DischMethod_Death_10 <-
  for_survival$pas_ADVERSE

# Map Discharge ward to eroster
for_survival$pas_DisWard_mapped <-
  ConvertPasWard2ErosterWard(for_survival$pas_DisWard, pas_eroster_mapping)
# Perform garbage collection
gc()

# Add threshold columns
for_survival <- ThresholdColumns(for_survival)

# Add cumulative sum columns
for_survival <- CusumColumns(for_survival)

# Reverse sign for difference cusum variables
for (i in grep("Derived.Diff.Model.cusum", names(for_survival), value = T))
{
  for_survival[[i]] <- -1 * for_survival[[i]]
}

# Define set of patients where staffing exposure is present
exposure_present <-
  GetRelevantPatients(for_survival$epis_sg2, for_survival$NHPPD.Nursing.Actual, required_minimum = 1)

# Reduce to only patients with valid exposure variables
for_survival_reduced <- 
  subset(for_survival, epis_sg2 %in% exposure_present)

# Create set for emergency patients
for_survival_reduced_emer <- subset(for_survival_reduced, pas_MethAdm_Elective=="NonElective")

# Create data set for patients with length of stay >= 5 days
for_survival_reduced_emer_over5 <- subset(for_survival_reduced_emer, pas_LOS>=5)

setwd("//workforceresearch.files.soton.ac.uk/MissedCareStudyData/Chiara analysis")

library(Rcpp)
library(lme4)
sourceCpp("WardHoursPerShift.cpp", rebuild = T)
sourceCpp("LateObservationsPerDay.cpp", rebuild = T)
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PlotDistribution <- function(x)
{
  obs_prop <- prop.table(table(x$late_time, x$TTNO_prev / 60), 1)
  # obs_prop <- table(x$late_time, x$TTNO_prev / 60)
  custom_colours <- c("yellow", "orange", "red", "green")

  print(obs_prop)

  barplot(
    obs_prop * 100,
    beside = T,
    legend.text = T,
    col = custom_colours,
    border = custom_colours,
    las = 1,
    xlab = "Previous time to next observation (hours)",
    ylab = "% on time/late",
    ylim = c(0, 80)
  )
}

AddNHPPD <- function(nhppd, x)
{
  # Match column
  col_num <- match(as.character(x$ward), names(nhppd))

  # Match row
  row_num <- match(as.character(x$Day), as.character(nhpppd$Day))

  y <- nhppd[cbind(row_num, col_num)]

  return(y)
}

# Take a copy of all observations
x <- all_obs
# Create matrix of observations per day, grouped by ward
obs_levels <- LateObservationsPerDay(
  x$ward_code_erooster,
  x$time_of_reading_Rel,
  x$late_time,
  x$ews_incomplete_max,
  x$epis_sg2,
  last_day = study_end_rel
)

# Reduce to just study wards
obs_levels <-
  subset(obs_levels,
    ward %in% unique(all_eroстер_plus_agency$mapped_ward_code))

# Remove temporary data frame to free memory
rm(x)
gc()

# Calculate total nursing hours for 12 hours shifts
nurses_worked.long = subset(nurses_worked, Hours_calculated>=12)
nursing_days.long <-
  WardHoursPerShift(
    nurses_worked.long$mapped_ward_code,
    nurses_worked.long$Start_Actual_Rel,
    nurses_worked.long$End_Actual_Rel,
    nurses_worked.long$name_id,
    last_day = study_end_rel,
    quiet = T
  )
nursing_days.long <- ExcludeDays(nursing_days.long)
actual_NHHPD_nursing.long <-
  CalcNursingHoursPerPatientDay(nursing_days.long, pt_levels)
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HCA_worked.long = subset(hcas_worked, Hours_calculated>=12)

HCA_days.long <- WardHoursPerShift(
    HCA_worked.long$mapped_ward_code,
    HCA_worked.long$Start_Actual_Rel,
    HCA_worked.long$End_Actual_Rel,
    HCA_worked.long$name_id,
    last_day = study_end_rel,
    quiet = T
)

HCA_days.long <- ExcludeDays(HCA_days.long)
actual_HCA_nursing.long <-
    CalcNursingHoursPerPatientDay(HCA_days.long, pt_levels)

# Add actual staffing columns
obs_levels$Nursing.Actual = AddNHPPD(actual_NHHPD_nursing, obs_levels)
ob_levels$HCA.Actual = AddNHPPD(actual_NHHPD_hca, obs_levels)
ob_levels$Nursing.Actual.Long = AddNHPPD(actual_NHHPD_nursing.long, obs_levels)
ob_levels$HCA.Actual.Long = AddNHPPD(actual_HCA_nursing.long, obs_levels)

rm(nurses_worked.long, nursing_days.long)

# Add derived staffing columns
obs_levels$Nursing.Derived <-
    AddNHPPD(derived_NHHPD_nursing, obs_levels)
ob_levels$HCA.Derived <- AddNHPPD(derived_NHHPD_hca, obs_levels)

# Divide the 2
obs_levels$Nursing.Actual.By.Derived <-
    obs_levels$Nursing.Actual / obs_levels$Nursing.Derived
obs_levels$HCA.Actual.By.Derived <-
    obs_levels$HCA.Actual / obs_levels$HCA.Derived

# Add cutoffs
for (i in c(75, 80, 100))
{
  new_var <- paste0(j, ".", i)
  obs_levels[[new_var]] <- 0
  obs_levels[[new_var]] <- ifelse(obs_levels[[j]] <= i / 100, 1, 0)
}

obs_levels$turnover.npa <- AddNHPPD(turnover.npa, obs_levels)
obs_levels$Patient.Actual <- AddNHPPD(pt_levels, obs_levels)

# Calculate numbers of high and low risk observations per day
highrisk.obs <-
  grep("high",
       names(obs_levels),
       value = T,
       ignore.case = T)

print(highrisk.obs)

mediumrisk.obs <- grep("medium|high",
                        names(obs_levels),
                        value = T,
                        ignore.case = T)

lowrisk.obs <- grep("low",
                    names(obs_levels),
                    value = T,
                    ignore.case = T)

obs_levels$total.high <-
  rowSums(obs_levels[, highrisk.obs], na.rm = T)
obs_levels$total.medium <-
  rowSums(obs_levels[, mediumrisk.obs], na.rm = T)
obs_levels$total.low <-
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```r
rowSums(obs_levels[, lowrisk.obs], na.rm = T)
obs_levels$total.all <-
  rowSums(obs_levels[, c("total.high", "total.medium", "total.low")], na.rm = T)

obs_levels$NOT.OT.All <-
  obs_levels$total.all - obs_levels$OT.High - obs_levels$OT.Medium -
  obs_levels$OT.High - obs_levels$OT.VeryHigh

# Count all late high/very high risk observations
obs_levels$NOT.OT.All.High <-
  obs_levels$total.high - obs_levels$OT.High - obs_levels$OT.VeryHigh
obs_levels$NOT.OT.All.High.Prop <-
  obs_levels$NOT.OT.All.High / obs_levels$total.high

# Count high risk observations
obs_levels$L2.All.High <-
  obs_levels$L2.High + obs_levels$L2.VeryHigh

obs_levels$L1.All.High <-
  obs_levels$L2.All.High + obs_levels$L1.High + obs_levels$L1.VeryHigh

obs_levels$L0.All.High <-
  obs_levels$L0.High + obs_levels$L0.VeryHigh

obs_levels$L1.All.High <-
  obs_levels$L2.All.High + obs_levels$L1.High + obs_levels$L1.VeryHigh

# Calculate proportion of high risk observations
obs_levels$L2.All.High.Prop <-
  obs_levels$L2.All.High / obs_levels$total.high

obs_levels$Prop.Unwell <-
  obs_levels$total.medium / (obs_levels$total.low + obs_levels$total.medium)

reduced_obs_levels <-
  subset(obs_levels,
```
(is.na(Nursing.Actual) & Nursing.Actual > 0)

# Rescale variables
#reduced_obs_levels$Nursing.Actual <- reduced_obs_levels$Nursing.Actual /10
#reduced_obs_levels$HCA.Actual <- reduced_obs_levels$HCA.Actual /10

reduced_obs_levels$Nursing.HCA.Interaction <- reduced_obs_levels$HCA.Actual * 
reduced_obs_levels$Nursing.Actual

reduced_obs_levels_nozero = subset(reduced_obs_levels, total.high>0)
reduced_obs_levels_nozero$ward = factor(reduced_obs_levels_nozero$ward)

#proportions of 12 h shifts

reduced_obs_levels_nozero$prop_HCA.Long <-
reduced_obs_levels_nozero$HCA.Actual.Long/reduced_obs_levels_nozero$HCA.Actual

reduced_obs_levels_nozero$prop_Nursing.Long <-
reduced_obs_levels_nozero$Nursing.Actual.Long/reduced_obs_levels_nozero$Nursing.Actual
Appendix H  R scripts for data analysis

data$Location <- as.factor(data$Location)

table(data$Hours_calculated)

summary(data$Hours_calculated)

# shift categories

data$Shcat <- NA

data$Shcat[data$Hours_calculated <=8.05]<-1 #"<8"
data$Shcat[data$Hours_calculated >8.05 & data$Hours_calculated <12]<-2 #"8-12"
data$Shcat[data$Hours_calculated >= 12 ]<-3 #"12"

data$Shcat <- as.factor(data$Shcat)

levels(data$Shcat)<-c( "<8", "11-12", ">12")

# type of shift --> day/night

data$tysh <-NA

data$tysh [data$Shift.end > 8 ] <- 0 #day
data$tysh [data$Shift.end <=8 ] <- 1 #night
data$tysh<-as.factor(data$tysh)

levels(data$tysh)<-c( "day", "night")
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table(data$Shcat, data$tysh)

#ee <-aggregate(Shcat~ tysh,data=data, summary)

data$grade <-NA

data$grade [data$Grade == "XR01" | data$Grade == "XR02" | data$Grade == "XR03" | data$Grade == "XR04"] <- 0 #unqualified

data$grade [data$Grade == "XR05" | data$Grade == "XR06" | data$Grade == "XR07" | data$Grade == "XR08"] <- 1 #qualified

data$grade<-as.factor(data$grade)

levels(data$grade)<-c( "unqualified", "qualified")

table(data$Shcat, data$tysh)

ggplot(na.omit(all_episodes_2), aes(sickness, fill = prop_long_shifts))+ geom_bar(position = "fill")

# ward

table(data$Location)

table(data$Shcat, data$Location)
ggplot(data, aes(Ward, fill = Shcat)) + geom_bar(position = "fill")

ggplot(all_episodes2, aes(abslength, fill = past_days.number.bankshifts)) +
geom_bar(position = "fill")

aa <- aggregate(Shcat ~ Location, data = data, summary)

# Grade

table(data$Grade)

table(data$Shcat, data$Grade)

summary(data$Shift.length [data$Outcome %in% "SK",])

# Sick leave

data$name_id <- as.factor(data$name_id)

ff <- aggregate(Shcat ~ Type, data = data[data$Type %in% "SK",], summary)

# Scatterplot

p <- ggplot(all_episodes2, aes(abslength, past_days.number.longshifts))
p + geom_jitter()
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p + geom_point()

ff <- aggregate(Shift.length ~ Location, data = data, summary)

funny <- function(x){
  mean.x <- mean(x)
  median.x <- median(x)
  q25.x <- as.numeric(quantile(x, probs = c(25)/100))
  q75.x <- as.numeric(quantile(x, probs = c(75)/100))
  min.x <- min(x)
  max.x <- max(x)
  ct.x <- length(x)
  res <- cbind(mean.x, median.x, q25.x, q75.x, min.x, max.x, ct.x)
  names(res) <- c("mean", "median", "q25", "q75", "min", "max", "ct")
  res
}

# to save tables in excel
# ee <- aggregate(Shcat ~ St, data = data, summary)
# write.table(ee, "ee.xls", sep = "\t")

d <- density(all_eroster_reduced$Hours_calculated_rounded) # returns the density data
plot(d) # plots the results

hist(all_eroster_reduced$Hours_calculated_rounded)

x <- all_eroster_reduced$Hours_calculated_rounded
h<-hist(x, breaks=24, col="green", xlab="Shift Length",
main="Shift length distribution")
xfit<-seq(min(x),max(x),length=24)
yfit<-dnorm(xfit,mean=mean(x),sd=sd(x))
yfit <- yfit*diff(h$mids[1:2])*length(x)

ggplot(data, aes(sickness, fill = Shcat))+ geom_bar(position = "fill")

data$sickness <- NA
data$sickness [data$Type %in% "SK"]<-1="# sick"
data$sickness[!(data$Type %in% "SK")]<-0="# not sick"
data$sickness <- as.factor(data$sickness)

levels(data$sickness) <- c("sick", "not sick")

#table(data$sickness, data$Grade)

sick<- table(data$sickness, data$Shcat)
chisq.test(sick)
# boxplots

prop.table(table(all_episodes2$past_days.number.worked, all_episodes2$abslength), 2)

qplot(abslength, past_days.number.longshifts, data = all_episodes2, geom="boxplot")

qplot(abslength, past_days.number.bankshifts, data = all_episodes2, geom="boxplot")

all_episodes_2$prop_worked_shifts <- as.factor(all_episodes_2$prop_worked_shifts)

levels(all_episodes_2$prop_worked_shifts) <- c("25%", "50%", "75%", "100%")

M0 <- glmer(sickness ~ prop_longshifts_rounded*prop_longshifts_rounded + (1 | staff_id), data = all_episodes_2, family = binomial(), control=glmerControl(optimizer="bobyqa"))

M1 <- glmer(sickness ~ prop_long_shifts + (1 | staff_id), data = all_episodes_2, family = binomial(), control=glmerControl(optimizer="bobyqa"))

M2 <- glmer(sickness ~ prop_bank_shifts + (1 | staff_id), data = all_episodes_2, family = binomial(), control=glmerControl(optimizer="bobyqa"))

M3 <- glmer(sickness ~ prop_worked_shifts + (1 | staff_id), data = all_episodes_2, family = binomial(), control=glmerControl(optimizer="bobyqa"))
M4 <- glmer(sickness ~ prop_night_shifts + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M5 <- glmer(sickness ~ prop_bank_shifts + prop_long_shifts + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M6 <- glmer(sickness ~ prop_bank_shifts + prop_long_shifts + prop_bank_shifts * prop_long_shifts + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M7 <- glmer(sickness ~ prop_long_shifts + totalhours + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M8 <- glmer(sickness ~ prop_long_shifts + totalhours + prop_long_shifts * totalhours + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M9 <- glmer(sickness ~ prop_bank_shifts + totalhours + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M10 <- glmer(sickness ~ prop_bank_shifts + totalhours + prop_bank_shifts * totalhours + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M11 <- glmer(sickness ~ prop_long_shifts + prop_night_shifts + first.day.idx.Grade_type + prop_worked_shifts + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))
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M12 <- glmer(sickness ~ prop_long_shifts + prop_night_shifts + prop_worked_shifts + first.day.idx.Grade_type + (1 | staff_id), data = data, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M13 <- glmer(sickness ~ prop_long_shifts + prop_long_shifts + prop_night_shifts + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M14 <- glmer(sickness ~ prop_long_shifts + prop_bank_shifts + prop_worked_shifts + first.day.idx.Grade_type + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M15 <- glmer(sickness ~ prop_bank_shifts + prop_long_shifts + prop_night_shifts + first.day.idx.Grade_type + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M16 <- glmer(sickness ~ prop_bank_shifts + prop_long_shifts + first.day.idx.Grade_type + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M17 <- glmer(sickness ~ prop_bank_shifts + prop_long_shifts + totalhours + first.day.idx.Grade_type + (1 | staff_id), data = all_episodes_2, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

all_episodes_2$abslength <- NA
all_episodes_2$abslength[all_episodes_2$absence.length == 0] <- NA
all_episodes_2$abslength[all_episodes_2$absence.length >= 1 & all_episodes_2$absence.length < 7] <- 0 # short
all_episodes_2$abslength[all_episodes_2$absence.length >= 7] <- 1 # long
all_episodes_2$abslength <- as.factor(all_episodes_2$abslength)
levels(all_episodes_2$abslength)<-c("short", "long")

all_episodes_2$abslength <- as.factor(all_episodes_2$abslength)

all_episodes_2$sel <- 0
all_episodes_2$sel [all_episodes_2$abslength == "long"] <- 1
shortabsence <- subset(all_episodes_2, sel == 0)

all_episodes_2$sele <- 0
all_episodes_2$sele [all_episodes_2$abslength == "short"] <- 1
longabsence <- subset(all_episodes_2, sele == 0)

#M1 <- glmer(sickness ~ first.day.idx.Hours_calculated.longshift + (1 | staff_id), data = shortabsence,family = binomial(),control=glmerControl(optimizer="bobyqa"))
M1 <- glmer(sickness ~ first.day.idx.Hours_calculated.shiftlength + (1 | staff_id), data = shortabsence,family = binomial(),control=glmerControl(optimizer="bobyqa"))

M2 <- glmer(sickness ~ + past_days.number.longshifts+ (1 | staff_id), data = shortabsence,family = binomial(),control=glmerControl(optimizer="bobyqa"))

M3 <- glmer(sickness ~ + past_days.number.bankshifts+ (1 | staff_id), data = shortabsence,family = binomial(),control=glmerControl(optimizer="bobyqa"))

M4 <- glmer(sickness ~ past_days.number.worked + (1 | staff_id), data = shortabsence,family = binomial(),control=glmerControl(optimizer="bobyqa"))
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M5 <- glmer(sickness ~ past_days.number.nightshifts + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M6 <- glmer(sickness ~ totalhours + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M7 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.bankshifts + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M8 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.bankshifts + past_days.number.longshifts*past_days.number.bankshifts + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M9 <- glmer(sickness ~ totalhours + past_days.number.longshifts + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M10 <- glmer(sickness ~ totalhours + past_days.number.longshifts + totalhours*past_days.number.longshifts + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M11 <- glmer(sickness ~ totalhours + past_days.number.bankshifts + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M12 <- glmer(sickness ~ totalhours + past_days.number.bankshifts + totalhours*past_days.number.bankshifts + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))
M13 <- glmer(sickness ~ past_days.number.worked + past_days.number.longshifts + past_days.number.bankshifts + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M14 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.nightshifts + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M15 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.nightshifts + past_days.number.longshifts*past_days.number.nightshifts + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M16 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.worked + past_days.number.bankshifts + first.day.idx.Grade_type + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M17 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.bankshifts + past_days.number.nightshifts + first.day.idx.Grade_type + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M18 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.bankshifts + first.day.idx.Grade_type + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M19 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.bankshifts + totalhours + first.day.idx.Grade_type + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

#M1 <- glmer(sickness ~ first.day.idx.Hours_calculated.longshift + (1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))
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M1 <- glmer(sickness ~ prop_long_shifts + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M12 <- glmer(sickness ~ prop_long_shifts + prop_night_shifts + prop_worked_shifts + first.day.idx.Grade_type + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M14 <- glmer(sickness ~ prop_long_shifts + prop_night_shifts + prop_worked_shifts + first.day.idx.Grade_type + (1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M15 <- glmer(sickness ~ prop_long_shifts + prop_night_shifts + prop_worked_shifts + first.day.idx.Grade_type + (1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M13 <- glmer(sickness ~ prop_long_shifts + prop_night_shifts + prop_long_shifts*prop_night_shifts + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M1 <- glmer(sickness ~ first.day.idx.Hours_calculated.shiftlength + (1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M2 <- glmer(sickness ~ first.day.idx.Hours_calculated.shiftlength + (1 | staff_id), data = shortabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M2 <- glmer(sickness ~ past_days.number.longshifts + (1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))
M3 <- glmer(sickness ~ + past_days.number.bankshifts+ (1 | staff_id), data = longabsence, family = binomial(), control=glmerControl(optimizer="bobyqa"))

M4 <- glmer(sickness ~ past_days.number.worked + (1 | staff_id), data = longabsence, family = binomial(), control=glmerControl(optimizer="bobyqa"))

M5 <- glmer(sickness ~ past_days.number.nightshifts+ (1 | staff_id), data = longabsence, family = binomial(), control=glmerControl(optimizer="bobyqa"))

M6 <- glmer(sickness ~ totalhours + (1 | staff_id), data = longabsence, family = binomial(), control=glmerControl(optimizer="bobyqa"))

M7 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.bankshifts+ (1 | staff_id), data = longabsence, family = binomial(), control=glmerControl(optimizer="bobyqa"))

M8 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.bankshifts+ past_days.number.longshifts*past_days.number.bankshifts+ (1 | staff_id), data = longabsence, family = binomial(), control=glmerControl(optimizer="bobyqa"))

M9 <- glmer(sickness ~ totalhours + past_days.number.longshifts+(1 | staff_id), data = longabsence, family = binomial(), control=glmerControl(optimizer="bobyqa"))

M10 <- glmer(sickness ~ totalhours + past_days.number.longshifts+ totalhours*past_days.number.longshifts+(1 | staff_id), data = longabsence, family = binomial(), control=glmerControl(optimizer="bobyqa"))
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M11 <- glmer(sickness ~ totalhours + past_days.number.bankshifts+ (1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M12 <- glmer(sickness ~ totalhours + past_days.number.bankshifts+ totalhours*past_days.number.bankshifts+ (1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M13 <- glmer(sickness ~ past_days.number.worked + past_days.number.longshifts+ past_days.number.bankshifts+(1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M14 <- glmer(sickness ~ past_days.number.longshifts+ past_days.number.nightshifts+(1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M15 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.nightshifts+ past_days.number.longshifts*past_days.number.nightshifts + (1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M16 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.worked+ past_days.number.bankshifts+ first.day.idx.Grade_type+(1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M17 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.bankshifts+ past_days.number.nightshifts+ first.day.idx.Grade_type+ (1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))

M18 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.bankshifts+ first.day.idx.Grade_type+ (1 | staff_id), data = longabsence, family = binomial(), control = glmerControl(optimizer = "bobyqa"))
M19 <- glmer(sickness ~ past_days.number.longshifts + past_days.number.bankshifts+totalhours+first.day.idx.Grade_type+(1 | staff_id), data = longabsence,family = binomial(),control=glmerControl(optimizer="bobyqa"))

#crosssectionalanalysis

#save.image("cross.RData",compress=T)
#load("cross.RData")

setwd("//workforceresearch.files.soton.ac.uk/MissedCareStudyData/Chiara analysis")

data<-read.table("sicknesscrosssectional.csv", sep="", header=TRUE)

data$bank_cat <- NA

data$bank_cat[data$prop_bank == 0 ]<-1 #"8"
data$bank_cat[data$prop_bank > 0 & data$prop_bank <=25]<- 2 #mixed
data$bank_cat[data$prop_bank > 25 & data$prop_bank <= 50]<-3="#8-12"
data$bank_cat[data$prop_bank > 50 & data$prop_bank <= 75]<-4="#8-12"
data$bank_cat[data$prop_bank > 75 ]<-5="#8"

data$bank_cat <- as.factor(data$bank_cat)

data$twelve <- NA
data$twelve[data$Prop_12 == 0] <- 1 #no
data$twelve[data$Prop_12 > 0 & data$Prop_12 <= 25] <- 2 #no
data$twelve[data$Prop_12 > 25 & data$Prop_12 <= 50] <- 3 #no
data$twelve[data$Prop_12 > 50 & data$Prop_12 <= 75] <- 4 #no
data$twelve[data$Prop_12 > 75] <- 5 #"12"

data$twelve <- as.factor(data$twelve)

data$rotating <- NA

data$rotating[data$prop_night <= 1] <- 1 #"fixed day"
data$rotating[data$prop_night > 1 & data$prop_night < 95] <- 2 #mixed
data$rotating[data$prop_night >= 95] <- 3 #"fixed night"

data$rotating <- as.factor(data$rotating)

M1 <- glmer(number_episodes ~ twelve + (1 | Ward), data = data, family = poisson(), control = glmerControl(optimizer = "bobyqa"))

M2 <- glmer(number_episodes ~ bank_cat + (1 | Ward), data = data, family = poisson(), control = glmerControl(optimizer = "bobyqa"))
M3 <- glmer(number_episodes ~ rotating + (1 | Ward), data = data,family = poisson(),control=glmerControl(optimizer="bobyqa"))

M4 <- glmer(number_episodes ~ Grade + (1 | Ward), data = data,family = poisson(),control=glmerControl(optimizer="bobyqa"))

M5 <- glmer(number_episodes ~ twelve + bank_cat+(1 | Ward), data = data,family = poisson(),control=glmerControl(optimizer="bobyqa"))

#M6 <- glmer(number_episodes ~ twelve + bank_cat +twelve*bank_cat + (1 | Ward), data = data,family = poisson(),control=glmerControl(optimizer="bobyqa"))

M7 <- glmer(number_episodes ~ twelve + bank_cat+rotating+(1 | Ward), data = data,family = poisson(),control=glmerControl(optimizer="bobyqa"))

M8 <- glmer(number_episodes ~ twelve + bank_cat+rotating+Grade+(1 | Ward), data = data,family = poisson(),control=glmerControl(optimizer="bobyqa"))

table(all_obs$late_time)

table(all_obs$ward_code_eroster)

table(all_obs$obs_ward, all_obs$late_time)
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table(all_obs$MEWS_Score, all_obs$late_time)

write.table(reduced_obs_levels_nozero, "reduced obs.xls", sep="\t")

table(reduced_obs_levels_nozero$prop.nurs.long)

table(reduced_obs_levels_nozero$prop.Hca.long)

#categories for descriptives - RN

reduced_obs_levels_nozero$longcatrn <- NA

reduced_obs_levels_nozero$longcatrn[reduced_obs_levels_nozero$prop_Nursing.Long <=0.25]<-1

reduced_obs_levels_nozero$longcatrn[reduced_obs_levels_nozero$prop_Nursing.Long >0.25 & reduced_obs_levels_nozero$prop_Nursing.Long<=0.50]<-2

reduced_obs_levels_nozero$longcatrn[reduced_obs_levels_nozero$prop_Nursing.Long >0.50 & reduced_obs_levels_nozero$prop_Nursing.Long<=0.75]<-3

reduced_obs_levels_nozero$longcatrn[reduced_obs_levels_nozero$prop_Nursing.Long >0.75 ]<-4

reduced_obs_levels_nozero$longcatrn<-as.factor(reduced_obs_levels_nozero$longcatrn)

levels(reduced_obs_levels_nozero$longcatrn)<-c("25", "50", "75", "100")

#categories for descriptives - HCA
reduced_obs_levels_nozero$longcathca <- NA

reduced_obs_levels_nozero$longcathca[reduced_obs_levels_nozero$prop_HCA.Long <=0.25]<-1
reduced_obs_levels_nozero$longcathca[reduced_obs_levels_nozero$prop_HCA.Long >0.25 & reduced_obs_levels_nozero$prop_HCA.Long<=0.50]<-2
reduced_obs_levels_nozero$longcathca[reduced_obs_levels_nozero$prop_HCA.Long >0.50 & reduced_obs_levels_nozero$prop_HCA.Long<=0.75]<-3
reduced_obs_levels_nozero$longcathca[reduced_obs_levels_nozero$prop_HCA.Long>0.75 ]<-4

reduced_obs_levels_nozero$longcathca<-as.factor(reduced_obs_levels_nozero$longcathca)
levels(reduced_obs_levels_nozero$longcathca)<-c( "25", "50", "75", "100")

M1 <- glmer(L1.All.High ~ offset(log(total.high))+prop_Nursing.Long+(1|ward), data = reduced_obs_levels_nozero, family = poisson())

M11 <- glmer(L1.All.High ~ offset(log(total.high))+prop_HCA.Long+(1|ward), data = reduced_obs_levels_nozero, family = poisson())

M22 <- glmer(L2.All.High ~ offset(log(total.high))+prop_HCA.Long+(1|ward), data = reduced_obs_levels_nozero, family = poisson())

M2 <- glmer(L2.All.High ~ offset(log(total.high))+prop_Nursing.Long+(1|ward), data = reduced_obs_levels_nozero, family = poisson())
Appendix I  ERGO approval

The association of shift characteristics and nursing missed vital observations and absenteeism: a retrospective observational study

Submission ID: 187811

Submission Overview | IRGA Form | Attachments | Peer Feedback | History | Adverse Incident

Amendment History
- Original Submission

Current Status
- Approved

Category: Research.
Click here for more information on research categories.

Submission Checklist
- IRGA Form: Complete
- Ethics Form: Attached
- Risk Form: Attached

Comments

Co-ordinators
Chiara Callora
Appendix J  Trust policy for absence management

1.  INTRODUCTION

The Trust is committed to promoting and maintaining the health, safety and wellbeing of all employees and recognise that a supportive and understanding approach towards staff who are unable to attend work due to ill health and will take into consideration individual circumstances as appropriate in the application of this policy.

It is also widely acknowledged that the impact of ill health and sickness absence can significantly affect service delivery and patient care as well as having a direct financial impact on the Trust. It is therefore important that any absence is managed appropriately to minimise the impact of absence on patient care, service delivery, the employee, their colleagues and the associated financial cost to the Trust.

2.  PURPOSE

The purpose of this policy is to formalise arrangements for managing sickness absence, in a manner that recognises the need to minimise the impact of the absence on both the individual and the operation of services. This policy provides managers with a flexible framework which promotes good employment practice, embodies the main principles of employment legislation, and adopts a proactive approach to the Trust values whilst supporting fully the Trust's core business.

3.  SCOPE

The policy establishes guidelines for managers and staff in relation to sickness absence and relates to all employment categories of staff and all types of sickness absence. It sets the lead responsibility for the management of all absence and ill health issues with line managers, who will be supported by HR and Occupational Health. Procedural guidelines, which form the basis for the implementation of this policy, are also provided.

‘In the event of an infection outbreak, flu pandemic or major incident, the Trust recognises that it may not be possible to adhere to all aspects of this document. In such circumstances, staff should take advice from their manager and all possible action must be taken to maintain ongoing patient and staff safety’

4.  DEFINITIONS

4.1 Bradford Index - is a measure of the disruption caused by absence. This is calculated using the formula \((o \times o) \times d\), where \(o\) = the number of occasions the employee has been absent in the last 52 weeks and \(d\) = the total number of calendar days of}
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absence during the same period. A Bradford Index ready reckoner is available on the Intranet. The trust triggers for absence are a Bradford Index of 200 and/or 3 episodes of absence in 3 months

4.2 Short term absence - is a period away from the normal working environment due to illness for any period up to four weeks. The length of absence is calculated commencing with the first date of absence and ending on the date when the employee notifies the manager that they are fit for work or the date that they actually return to work.

4.3 Persistent short term absence – is multiple periods of short term sickness absence e.g. for 1 to 3 days at a time.

4.4 Long term absence - is when an employee has had a period of continuous sickness absence (of 4 weeks or more) or multiple episodes for the same reason or is unable to sustain the full duties of their job due to ill health.

4.5 Reasonable adjustment - a reasonable adjustment is an alteration that an employer could make that would enable a disabled person to continue to carry out their duties without being at a disadvantage to others

5. DUTIES AND RESPONSIBILITIES

5.1 EMPLOYEES

5.1.1 Attendance at work

Employees are responsible for their attendance at work and should take appropriate action to ensure that their good health and well-being is maintained.

5.1.2 Notification of absence

Employees are required to notify their manager when they are unable to attend work on the first day of any absence and at least one hour prior to the commencement of their working hours. Reporting absence must also be in accordance with any local departmental protocol for sickness absence reporting. To ensure an absence is calculated correctly where an employee does not work a Monday to Friday shift pattern and is absent due to ill health, employees are responsible for informing their line manager that they are fit to work on a non-working day.

5.1.3 Certification

Employees must provide certificates (both self-certificates and Statements of Fitness to Work/Fit Note) for all sickness absences longer than three days. Certificates must be provided in a timely manner and, except in exceptional circumstances must be obtained at
the time of the illness, rather than being back-dated. Where an employee fails to comply with the notification procedure, either by contacting their manager on their first day of absence or by failing to provide the relevant certificates correctly, this will result in the absence being regarded as unauthorised and therefore unpaid. Such breaches of procedure will be dealt with under the Trust’s Staff Discipline policy. Managers should retain a photocopy of the certificate on the employees file and the original returned to the employee for their records and safe-keeping.

5.1.4 Establishing & Maintaining Contact

Employees must establish and maintain regular contact with their manager to keep their manager regularly informed of their progress and the likely date of their return. If travelling abroad for medical treatment, employees must also agree the method and regularity of communication with their manager in advance of travelling.

5.1.5 Conduct whilst absent

Employees must not conduct themselves in a manner which is inconsistent with their stated illness or injury or undertake any activity which in the reasonable opinion of the Trust could delay recovery, exacerbate their medical condition or compromise their return to work. The employee risks losing their entitlement to sick pay and/or formal disciplinary action may be taken, where this is identified.

5.1.6 Other work whilst sick

Where an employee is unable to attend work due to sickness, or is on a phased return as part of a rehabilitation programme, they must not undertake work for any other employer without the prior written authorisation of the Director of Workforce and Organisational Development or delegated manager. If it is established that an employee has worked on the bank, for NHSP or any other agency, or continued or commenced work with another employer without the Trusts’ prior agreement, this will be considered as gross misconduct and will be dealt with under the Trust’s Staff Discipline Policy. This action may also constitute a criminal offence of Fraud, contrary to the Fraud Act 2006. Such instances will also be referred to the Trust’s Local Counter Fraud Specialist who will consider whether further criminal action is appropriate in respect of any offences identified. The matter will be dealt with in line with the Trust’s Fraud and Corruption Policy.

5.1.7 Occupational Health referral

Where an employee is referred to the Health and Safety and Wellbeing Service, they are expected to attend and to co-operate fully with such referrals: this is a contractual requirement.
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5.2 LINE MANAGERS

5.2.1 Managers are responsible for ensuring that employees are made aware of both the local protocols for reporting absence and the contents of this guide, including certification. This should form part of the employee’s induction on joining the department. Managers are also responsible for managing their employee’s absence in accordance with the Management of Attendance policy.

5.2.2 Maintaining Contact whilst sick

Managers must ensure that they maintain regular contact with their employees when they are unable to attend work. This will include forwarding pay slips, Team Brief, minutes of team meetings etc. on to employees who are on long term absence and may involve home visits as appropriate. Managers are responsible for the application of this policy, for managing absence in line with it and for ensuring that employees are aware of how their attendance will be managed.

Managers must ensure that contact is made if the employee either fails to return to work when expected or if they fail to attend for work without notification and follow up with appropriate action and with advice from the Operational HR Team as required.

5.2.3 Return to Work meetings

Managers are responsible for undertaking return to work meetings, which must be carried out on the employee’s first day back at work wherever possible.

5.2.4 Recording Absence

Managers are responsible for ensuring any periods of absence are recorded appropriately, using the method of recording appropriate to that ward or department. Managers will be responsible for ensuring each period of absence is closed on the appropriate reporting system on the employees return to work. This is a mandatory requirement for all managers.

5.2.5 Occupational Health Referrals

Managers are responsible for making referrals to the Health, Safety and Wellbeing Service, to assess an individual’s fitness to work, in a timely manner. Managers are also responsible for informing the employee of the reasons for the referral and discussing any referrals fully with the employee concerned prior to making the referral.

5.2.6 Reasonable adjustments
Managers are responsible for ensuring that where service needs allow reasonable adjustments to jobs and workplaces for employees are put in place and maintained for the required time, either on a temporary or permanent basis. This is to ensure all employees have equal opportunities in applying for and staying in work. Reasonable adjustments will be considered to the employees’ substantive role and/or redeployment may be sought at any stage and ratified at a formal hearing, with advice from Occupational Health.

5.2.7 Stress and Musculoskeletal referrals

Managers must ensure that employees who are absent because of a musculoskeletal problem are referred to Occupational Health on the first day of the employee reporting his or her absence stating the reason for referral is Musculoskeletal. Employees absent due to stress or depression should be referred to Occupational Health on production of a fit note and/or more than 7 days absence, or earlier in appropriate circumstances.

5.2.8 Departmental trends

Managers are responsible for investigating any factors that may contribute to the levels and patterns of absence, with particular reference to environmental and/or job related factors e.g. high levels of dependant clients with complex needs, high levels of back injuries, needle stick injuries.

5.3 HUMAN RESOURCES

5.3.1 Advice and guidance

The Operational HR team are responsible for advising all parties on the implementation of this policy and for providing specific management and staff guidance. Members of the Operational HR team will provide advice and guidance to the manager and act as HR representative at formal meetings and reviews where appropriate.

5.3.2 Training

The Operational HR team are responsible for training managers on the key principles of the Management of Attendance Policy and associated guidance.

6. PROCESS

6.1 PROCEDURE FOR MANAGING PERSISTENT SHORT TERM ABSENCE

Persistent short term absences (PSTA) may impact upon patient and service delivery requirements and also place additional work and stress on colleagues. Where there is no underlying medical condition causing short term persistent absence and/or significant trends in the pattern of absence, the following procedure will be used.
Employees who fail to maintain regular and reliable attendance where there is an underlying medical condition or conditions will be managed in accordance with section 6.2.

6.1.1 Trust Triggers

The following procedure will commence when an employee has breached Trust triggers for absence of;

- 3 separate periods of absence in a rolling 3 month period, or
- has breached a Bradford Index of 200.

6.1.2 Informal Meeting

When an employee meets or exceeds one of the Trust triggers the manager should arrange to meet with the employee informally to discuss the recent sickness absences and to explore ways in which the employee can be supported to improve their attendance in the future. The meeting will provide an opportunity for;

• the manager to advise the employee of the concern regarding their level of absence,
• the employee to identify if there is an underlying cause or underlying health condition,
• the manager to consider any support or assistance that can be offered to alleviate any problems identified,
• the manager to consider if a management referral to Occupational Health is required,
• the manager to advise the employee of the expected standards of attendance and how any further absences may be managed.

At this meeting the manager should consider issuing an informal warning for persistent short term absence for a period of up to 6 months and/or detail a plan for improvement in attendance. There is no appeal available against an informal warning. In some exceptional circumstances it may be appropriate to hold more than one informal meeting prior to moving to the formal stages.
6.1.3 Stage 1 - Formal Capability Hearing (PSTA)

Progression to the formal hearing stage should be considered when an employee has failed to meet the agreed improvement plan or continues to breach Trust triggers. This action will be identified, and the employee notified, at either the return to work meeting or at an informal meeting. The manager will be required to present their management case to an independent panel. The hearing will provide an opportunity for the panel to consider:

- relevant evidence from both staff and management side,
- the consequences of the individual’s attendance pattern,

The outcome of the meeting may be either to:

- To take no further action, or,
- To award a first formal written warning for a period of up to 12 months (or any longer period explained to the employee at the time)

6.1.4 Stage 2 - Formal Capability Hearing (PSTA)

If a satisfactory improvement is not achieved within a reasonable time period and/or the employee breaches the specific terms of their formal written warning the manager should convene a formal Stage 2 hearing. The manager will be required to present their management case to an independent panel. The hearing will provide an opportunity for the panel to consider:

- relevant evidence from both staff and management side, and
- the consequences of the individual’s attendance pattern,

The outcome of the meeting may be either to:

- To take no further action
- To extend the first formal written warning
- To issue a final written warning for up to 36 months

6.1.5 Stage 3 - Formal Final Capability Hearing (PSTA)

If a satisfactory improvement is not achieved within a reasonable time period and/or the employee breaches the specific terms of their formal final written warning the manager should convene a Stage 3 Final Capability hearing where action up to and including
dismissal on the grounds of capability due to persistent short term absence will be considered. The hearing will provide an opportunity for;

- the panel to consider relevant evidence from both staff and management side, and
- the panel to consider the consequences of the individual's attendance pattern,

The outcome of the meeting may be either to;

- To take no further action
- To extend the final written warning
- To dismiss on grounds of ill health capability due to persistent short term absence

6.2 PROCEDURE FOR MANAGING SHORT TERM ABSENCE AS A RESULT OF AN UNDERLYING HEALTH CONDITION

The following procedure will be used when an employee has multiple periods of absence due to an underlying health condition(s). This procedure may also apply to employees requiring planned or emergency surgery or treatment.

6.2.1 Stage 1 - Informal Meeting

When an employee meets or exceeds one of the Trust triggers the manager should arrange to meet with the employee informally to discuss the recent sickness absences and to explore ways in which the employee can be supported to improve their attendance in the future. The meeting will provide an opportunity for;

- the employee to identify the underlying health condition,
- the manager to consider any support or assistance that can be offered to alleviate any problems identified,
- the manager to consider if a management referral to Occupational Health is required,
- the manager to advise the employee of the expected standards of attendance and how any further absences may be managed.

Where possible at this meeting the manager should ensure the following is available;

- A current Occupational Health report,
• If reasonable adjustments may be required, details of how this may be accommodated within the CSC/Department. (e.g. temporary redeployment or alternative duties)

In some exceptional circumstances it may be appropriate to hold more than one informal meeting prior to moving to the formal stages.

6.2.2 Stage 2 - Formal Capability Meeting

If the employee’s ill health continues and they are unable to sustain regular and reliable attendance or fulfil the full range of their duties the manager should arrange a formal review meeting with the employee.

The purpose of the meeting will be to discuss the employee’s current situation and latest Occupational Health report. The employee should provide information on the progress of their condition and details of any other factors which may affect recovery. The manager should consider all available options and any reasonable adjustments.

Where it is unlikely that the employee will be able to return to the full duties of their substantive role or to alternative employment within the foreseeable future arrangements should be made to continue to a Stage 3 Final Capability Hearing.

6.2.3 Stage 3 - Formal Final Capability Hearing

If the employee’s health will not improve sufficiently in order to maintain a satisfactory level of attendance or sustain the full duties of their job the employee may be referred to a stage 3 formal final capability hearing where the employee may be dismissed on the grounds of capability due to ill health. The hearing will be chaired by an independent panel.

The purpose of the hearing is to explore the following factors;

• the nature of their job,

• the medical prognosis from the OH and/or other medical source,

• whether suitable alternative employment is recommended, available or acceptable,

• reasonable adjustments,

• the effect and cost the absence is causing to the service delivery,

• the need to have the work done,
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- whether in the circumstances, a reasonable employer could be expected to wait any longer,
- the nature, length and impact of the employee’s illness or incapacity,
- whether OH recommends an application for Ill Health Benefits from the NHS Pensions Agency.

The outcome of the meeting may be either to;

- agree or extend a review period and reconvene a further hearing
- to dismiss on ill health grounds and agree permanent redeployment (in line with Redeployment Policy) within the employees notice period.
- to dismiss on the grounds of capability due to ill health with pay in lieu of notice.

6.3 PROCEDURE FOR MANAGING LONG-TERM ABSENCE

This procedure becomes effective when an employee has had a period of continuous long term sickness absence (of 4 weeks or more) or is unable to sustain the full duties of their job due to ill health.

6.3.1 Stage - 1 Informal Meeting (LTS)

The line manager should arrange an informal discussion with the employee. The meeting may take place in the workplace, at the employee’s home or a mutually convenient location.

At this meeting the manager should ensure the following is available;

- a current Occupational Health report,
- if reasonable adjustments may be required, details of how this may be accommodated within the CSC/Department. (e.g. temporary redeployment or alternative duties),
- an up to date ‘Statement for Fitness to Work’ note.

The meeting may result in one or more of the following outcomes;

- a return to work on a specified date,
- a return to work at a later unspecified date following convalescence, in which case, progress should be reviewed on a regular basis.
• a phased return to work on modified duties and/or reduced hours for a period of up to 4 weeks.

• a return to work but temporarily redeployed into suitable alternative employment (as recommended by OH).

• where it is unlikely that the employee will be able to return to their substantive role or to alternative employment within the foreseeable future arrangements should be made to commence the formal stages of the management of attendance policy.

6.3.2 Stage 2 - Formal Capability Meeting (LTS)

If the employee has not returned to work within a reasonable time frame, is not likely to return to work in the foreseeable future or is unable to sustain the full duties of their job the manager should arrange a formal meeting with the employee. This meeting should typically be held at around 8 weeks of absence as a guide.

The purpose of the meeting will be to discuss the employee’s current situation and to consider what options remain to be explored. The following may also be required;

• An up to date Occupational Health report,

• A ‘Statement for Fitness to Work’ note,

• If reasonable adjustments may be required, details of how this may be accommodated within the CSC/Trust. (e.g. temporary redeployment or alternative duties),

• Any local departmental information to share with the employee.

The meeting may result in one or more of the following outcomes;

• A return to work or return to full duties on a specified date,

• A return to work or to full duties at a later unspecified date following convalescence, in which case, progress should continue to be reviewed on a regular basis,

• A phased return to work on modified duties and/or reduced hours for a period of up to 4 weeks,

• A return to work but temporarily redeployed into suitable alternative employment.

• Where it is unlikely that the employee will be able to return to the full duties of their substantive role or to alternative employment within the foreseeable future arrangements should be made to continue to a Stage 3 Final Capability Hearing.
6.3.3 Stage 3 - Formal Final Capability Hearing (LTS)

If the employee’s health will not improve sufficiently in order to resume work in the foreseeable future, and/or maintain a satisfactory level of attendance or sustain the full duties of their job the employee may be referred to a stage 3 formal final capability hearing where the employee may be dismissed. This hearing should typically be held at around 6 months of absence as a guide but maybe held earlier if appropriate.

The hearing will be chaired by an independent panel who will explore the following factors;

- the effect and cost the absence is causing to the service delivery,
- the nature of their job,
- the nature, length and impact of the employee’s illness or incapacity,
- the medical prognosis from OH and/or other medical source,
- the need to have the work done,
- whether suitable alternative employment is recommended,
- reasonable adjustments,
- whether OH recommends an application for Ill Health Benefits from the NHS Pensions Agency.

The outcome of the meeting may be either to;

- agree or extend a review period and reconvene a further hearing,
- to agree permanent redeployment,
- to dismiss on ill health grounds and agree permanent redeployment (in line with Redeployment Policy) within the employees notice period,
- to dismiss on the grounds of capability due to ill health with pay in lieu of notice.

6.4 HEALTH, SAFETY AND WELLBEING SERVICE

The Health, Safety and Wellbeing Service should be involved as appropriate throughout the process to offer medical advice and opinion.

6.5 PROGRESSION
Although the policy contains progressive warnings which may lead to dismissal, it may be decided to commence the process at any stage deemed appropriate, depending on the reason for absence and impact on service delivery and patient care.

6.6 RIGHT OF REPRESENTATION

Employees are entitled to choose and be accompanied to any formal meeting or hearing by a trade union or staff-side representative or a work colleague. A member of the Operational HR Team may also be in attendance at any formal stage.

6.7 APPEAL PROCESS

An employee has a right of appeal against the sanction of any formal stage in accordance with the Appeals Policy.

6.8 ILLNESS AT WORK

If an employee becomes ill whilst at work, the guidance in the Trust’s First Aid at Work Policy should be followed. If an employee attends work but requests to leave due to illness after completing at least 50% of their daily hours/shift then this would not be recorded on ESR for payroll purposes. However a local departmental record in line with the notification of absence and return to work procedures should be maintained for monitoring purposes.

7. TRAINING REQUIREMENTS

1.1 Appropriate training will be provided to managers in the application of this policy and particularly the principles to be adopted. This will be provided as part of the Leadership and Management Development programme.

7.2 It is important that if a failure in standards of attendance management occur because of a weakness in the Trust’s systems or processes, learning takes place across the Trust. This will take place at a number of different levels; individual, departmental, divisional and Trust-wide.

7.3 Guidelines for managers and staff will therefore be continually improved in the light of operational practice and experience.

8. REFERENCES AND ASSOCIATED DOCUMENTATION
Appendix J

ACAS Code of Practice > managing staff absence;

Employment Act 2008

Employment Rights Act 1996

Data Protection Act 1998

Handling Concerns and Disciplinary Procedures for Doctors and Dentists

Staff Discipline Policy

Guide to Attendance and Wellbeing

Appeals Procedure

Equality Policy for Staff

Quality of care

Working together

No waste

This policy should be read and implemented with the Trust Values in mind at all times
## Appendix K

### Mean shift length week by week

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Appendix K

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Appendix L  Worked shift categories by study year

L.1  Shift categories by ward in Year 1
L.2  Shift categories by ward in Year 2
L.3  Shift categories by ward in Year 3
## Appendix M  Sickness shifts by ward

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### Appendix N  Sickness episodes by ward

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### Appendix O Competency framework for vital signs observations

#### Competency Statement: Taking, recording and assessment of vital signs in Adults

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<td>Demonstrate ability to</td>
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<td>Demonstrate knowledge of</td>
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<td>and record frequency of</td>
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<td>safely apply these</td>
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<td>guidelines. Describe why</td>
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<td>techniques in practice</td>
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<td>apply in practice e.g.</td>
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<td>c) Describe the factors that</td>
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<td>c) Direct health care</td>
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<td>c) Discuss and apply the</td>
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<td>d) Identify the interventions</td>
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<td>to any advanced role</td>
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<td>correct process for</td>
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<td>need to perform lying/standing</td>
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<td>discuss your role in this</td>
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<td>undertaking vital signs</td>
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<td>BP measurements on</td>
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<td>e) Demonstrate the ability</td>
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<td>e) Facilitate learning of</td>
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<td>using the appropriate</td>
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Competency profiling[4]432

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<table>
<thead>
<tr>
<th>Task</th>
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<tr>
<td>f) Demonstrate ability to accurately record vital signs on VitalPAC™ or on a paper-vital signs chart in the patient record.</td>
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<td>g) Demonstrate the ability to recognise abnormal vital signs and report to appropriate healthcare professional activating NEWS escalation protocol as appropriate.</td>
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<td>h) Increase frequency of recordings as per NEWS algorithm and/or individualised nursing/medical plan</td>
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<td>i) Recognise the limitations of your scope of practice and role and get help from a senior member of staff to ensure patient safety as required</td>
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<td>j) Keep patient and relatives informed of all actions &amp; potential for further monitoring</td>
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<td>k) Locate and demonstrate an understanding of the guidelines for recording vital signs in the Marston Manual</td>
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<td>e) Correctly undertake immediate comprehensive patient assessment: Level 1 - utilise the A, B, C, D, E approach</td>
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<td>f) Describe pulse points that can be palpated when checking a patient's BP. Describe the technique for palpating a systolic BP</td>
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<td>g) Demonstrate ability to observe, record and monitor a patient's neurological condition ensuring observation of: Level of consciousness using AVPU and GCS, Pupillary reaction, motor function and sensory function.</td>
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<td>h) Interpret information from assessment and identify risk factors</td>
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<td>i) Report significant changes and escalate care to relevant healthcare professional as per the NEWS protocol</td>
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<td>j) Accurately record comprehensive patient assessment in patient's notes</td>
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<td>k) Perform further assessment and monitoring as required for the patient</td>
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<td>l) To educate others about vital sign recording techniques.</td>
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<td>m) Demonstrate the measurement procedure for lying &amp; standing BP² for orthostatic hypotension including theoretical recognition of clinical signs and symptoms</td>
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<td>n) Implement a system of audit to ensure safe and effective practice</td>
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<tr>
<td>o) Ensure that all staff have received education and training and are competent in recording vital signs.</td>
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<td>p) Ensure that systems are in place in the clinical environment to safely monitor and record patient vital signs.</td>
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<tr>
<td>q) Act as an expert resource advising, teaching and supporting members of the healthcare team, patient and relatives/significant others.</td>
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<tr>
<td>r) Ensure that systems are in place in the clinical environment to safely monitor and record patient vital signs.</td>
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Competency proforma@AC23

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<td>BEACH™ course for HCSNs</td>
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<td>Observation Chapter 11 Maraden Manual</td>
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<td>Quick Reference Guide. Acutely ill patients in hospital</td>
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<td>Outreach Critical Skills Workshop</td>
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Authors: Beverley Stockwell Department: ALERT™ HQ  
Review Date: Sept 2018
Record of Achievement.
To verify competence please ensure that you have the appropriate level signed as a record of your achievement in the boxes below.

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References to Support Competency
NICE (2007) Acutely Ill Patients in Hospital: Recognition and Response to Acute Illness in Adults in Hospital www.nice.org.uk
Waterhouse C (2005) The Glasgow Coma Scale and other neurological observations, Nursing Standard, 19, 33, 56-64
Appendix P  Roster management policy in the Trust

1. INTRODUCTION

The provision of a well-planned staff rota, based on the resources available and the needs of the ward or departments patients, is essential to ensure the provision of safe effective care. A poorly designed rota can lead to over or under-staffing (dependent of current establishment) of a ward with critical implications for both quality of care and resource utilisation. (Silvestro & Silvestro 2000) In order for managers to make the most effective use of staff time, they need to take into account the effect of shift patterns on individuals and how shift work can meet the needs of the organisation. (Wilson 2002)

This policy details the minimum standards required to achieve an effective roster within wards and departments.

It should be noted that the Trust is supportive of innovative approaches to rostering that enable staff to work more flexibly whilst still providing the optimum staffing levels required to care for our patients and to meet service requirements.

The minimum standards described, require that all rosters are recorded via e-Rostering, commence on a Monday in 4 week cycles in line with the Week 1 start date of 18th January 2016, ideally completed at least 6 weeks in advance.

2. PURPOSE

• To ensure safe & appropriate staffing levels for all wards and departments using fair and consistent duty rota planning

• Minimise clinical risk associated with the level and skill mix of nursing & midwifery staffing levels.

• To provide effective management of the nursing & midwifery establishments, improving efficiencies in the workforce across all wards and departments.

• To provide clear guidance to ward/unit managers responsible for roster development and management of the minimum standards required.

• To improve the utilisation of existing staff to maintain consistent duty rotas.

• To improve planning of clinical and non-clinical working days e.g. annual leave (inc Bank Holiday), sickness, study leave.
Appendix P

• To standardise break allowances
• To ensure provision of senior nursing cover daily.
• To enable flexible working patterns and a positive work life balance in line with service requirements where service needs allow
• Promote the well-being of staff by the provision of fair rosters
• To introduce standardisation of roster management whilst enabling specialty specific flexibility
• This policy should be read in conjunction with local and corporate HR policies and guidance

3. SCOPE

The policy applies to all nurses, midwives and operating theatre practitioner staff involved in the development and management of rosters for wards and departments

‘In the event of an infection outbreak, flu pandemic or major incident, the Trust recognises that it may not be possible to adhere to all aspects of this document. In such circumstances, staff should take advice from their manager and all possible action must be taken to maintain ongoing patient and staff safety’

4. DEFINITIONS

Trust = Portsmouth Hospitals NHS Trust
Ward = Ward, Department or Unit
Ward Manager = Ward Manager, Ward Sister, Charge Nurse, Clinical Lead
Non-effective working days = relates to days that staff are not available for the roster i.e. leave, study days, management days, sickness
One request = One day off or one shift on request
Permanent staff = Staff who have permanent contracted hours
Temporary staff = NHSP/Bank/Agency Staff
Variations in shifts = Differing start and finish times to the regular shifts
Headroom = Relates to the percentage of non-effective working days that are included in each establishment

Personal Pattern – Every week the member of staff works the same shift on the same day

Roster = Duty Rota

EWTD = European Working Times Directive

WTE = Whole time equivalent

E-Rostering = Electronic rostering system

Oceans Blue = Time management tool

5. DUTIES AND RESPONSIBILITIES

Heads of Nursing have responsibility for providing assurance that all staff responsible for the development, implementation and monitoring of rosters, are aware of the requirements within this policy. They are also responsible for ensuring that rosters in their CSCs meet roster policy requirements and that any use of temporary workforce or overtime is within budgeted establishments or variance can be evidenced.

Matrons are responsible for ensuring all ward managers are aware of and have a detailed understanding of the requirements within this policy. They are also responsible for identifying any training needs of the ward manager relating to roster development and accessing appropriate training if required. Matrons are required to scrutinise and sign off all rosters for their clinical areas. Matrons are required to manage the use of temporary staff and report variance against establishment to the Heads of Nursing.

Ward managers (or designated deputy) are responsible for providing a roster that complies with this policy. They are also responsible for the management of non-effective working time (annual leave etc.) in line with this policy and the reduction of the accumulation of Paid Contracted hours and the responsibility to ensure that any hours owed are worked within the next 4 week roster.

Individuals are responsible for ensuring they check rosters as they are published and ensure they are on time for the shifts they are allocated. Individuals are also responsible for ensuring that they work their contracted hours and that they highlight to their manager if they are not allocated the correct hours in the roster.
6. PROCESS

Planning the roster

To maintain consistency and so staff know in advance the shifts they are working, rosters will be completed and published at least 4 weeks in advance, ideally 6 weeks.

Prior to publication rosters will be signed off by the ward manager (or designates deputy) and the Matron.

When writing the roster the following rules should apply:

• An identified nurse in charge will be rostered and highlighted on each shift

• There will be an appropriate agreed skill mix on each shift which should be spread evenly throughout the 7 day working week.

• Staff numbers on shifts will be consistent in line with essential or optimum numbers.

• Roster requests will be agreed and prioritised by the ward manager, provided that roster rules in regard to cover, skill mix and annual leave can be met.

• Requests will be granted in a fair and equitable way. E-Rostering will facilitate an equitable allocation of requests to individual staff.

• Only in exceptional circumstances will staff who are employed on set hours or term time contracts, request alternative shifts or days off. This will require negotiation with another member of staff to cover their set shift.

• Flexibility will be promoted within the ward team

• Any duty rota changes must be legible, trackable and agreed with the ward manager or designated deputy.

• The annual leave allocation will not exceed or drop below the agreed weekly quota for each individual area (see section Annual Leave)

• Careful consideration by the Ward Manager and Matron, should be given to the appropriateness of rostering two members of staff who are in personal relationship, onto the same shifts. This should be discussed fully with the staff in question.

The following details should be displayed on each duty roster:

• Trust logo
• Ward/Department/Unit name
• First name and surname of each member of staff
• Clinical grade of each member of staff
• Professional qualification of each member of staff i.e. RN
• WTE and hours per week for each member of staff
• Actual hours rostered for the roster period for each member of staff
• Tally of actual numbers of RN’s on each shift.
• Tally of actual numbers of HCSW’s on each shift
• Ongoing tally of hours worked i.e. show positive or negative balance of hours worked by staff
• Vacancies expressed in wte for each grade
• Signature of ward manager
• Signature of matron
• Show a key of the abbreviations and times of shifts worked in that ward area
• Clearly show meal break allowances for each shift

Ward Managers Shift Patterns

To facilitate effective leadership, availability and visibility, the ward manager should work a:

• Minimum of 4 day shifts each week, ideally 5 day shifts
• Maximum one late shift per week
• Maximum 9.5 hour clinical shifts, ideally 7.5 hour shifts
• Maximum 2 weekend shifts each 4 week period
• Not work regular night shifts unless there is an exceptional clinical need or unresolved staffing problem.
• Ward managers supervisory or management day shifts must be 7.5 hrs.

This is based on 1 wte, if job share in place then shifts should be determined based on wte.
Appendix P

Band 7s who work in departments where they do not fulfill the ward manager role will be expected to work the shifts required by the department

Student Nurses

Student nurses are required to work a minimum number of hours in practice before they are eligible to register on completion of their training. Evidence of shifts worked by student nurses should be clearly shown on the duty rota, applying the same codes for any absences.

Student nurses should be rostered to work a minimum of 40% of their shifts with their mentor.

When not working with their mentor students should be rostered to work with a buddy or other suitably qualified member of staff.

Self Rostering

Self rostering is an approach to rostering that allows staff to design their own roster.

For self rostering to be successful the ward manager will first need to:

• Calculate essential available shift coverage from staff currently in post. (This will be different from optimum shift numbers, if the ward is carrying some vacancies)

• Ensure an even shift coverage of shifts available for selection

• Determine grade and skills required of staff required for each shift

• Determine popular and unpopular shifts, set local rules of minimum number of the unpopular shifts each member of staff is required to work, adapted to WTE.

Shift Patterns and European Working Directive

All shifts and time off must be recorded on the duty roster. A code should be assigned to each shift. The codes are determined within the e-Rostering system

EARLY SHIFTS

An early shift should be a max 8 hours in length with a 30 minute unpaid break. To conform to EWTD this break must be taken during the shift and not at the end or beginning of the shift. The start and finish times for an early shift will be determined by each individual ward or department.
Example early shifts

- 07.00 – 15.00 (1 x 30 minute break) – 7.5 hrs paid
- 07.30 – 15.30 (1 x 30 minute break) – 7.5 hrs paid
- 07:30 – 14:30 (1 x 30 minute break) – 6.5 hrs paid
- 07:30 – 14:00 (1 x 30 minute break) – 6 hrs paid

LATE SHIFTS

A late shift should be a maximum 8 hours in length with a 30 minute unpaid break. To conform to EWTD this break must be taken during the shift and not at the end or beginning of the shift. The start and finish times for a late shift will be determined by each individual ward or department.

Example late shifts

- 13.00 – 21.00 (1 x 30 minute break) – 7.5 hrs paid
- 13.30 – 21.30 (1 x 30 minute break) – 7.5 hrs paid
- 13:00 – 20:00 (1 x 30 minute break) – 6.5 hrs paid
- 13:30 – 20:00 (1 x 30 minute break) – 6 hrs paid

LONG DAY

A long day should be a maximum of 12.5 hours with 60 minutes unpaid break. The break should be taken as 2 x 30 minute breaks, although this can be negotiated in exceptional circumstances. To conform to EWTD this break must be taken during the shift and not at the end or beginning of the shift. The start and finish times for a long day shift will be determined by each individual ward or department. In order to meet service needs a long day shift may be shorter in length than 12.5 hours but not as short as an early shift (max 8 hrs).

Example 12.5 hour shifts:

- 07:30 – 20:00 (2 x 30 minute breaks) – 11.5 hrs paid

If the 12.5 hour shift pattern is chosen a full-time member of staff will be required to work 13 x 12.5 hour shifts over a 4 week period.

Due to service demands and to provide shift flexibility in some areas that require the same number of nurses on duty at night as in the day, there may be a need to consider...
extending the 12.5 (11.5 hours paid) hour shift to a 13 (12 hours paid) hour shift. Any areas who may need to utilise the 13 hour shift must seek approval through their CSC management team.

NIGHT SHIFTS

A night shift should be a maximum of 12.5 hours with 60 minutes unpaid break. To conform to EWTD this break must be taken during the shift and not at the end or the beginning of the shift. The start and finish times for a night shift will be determined by each individual ward or department. In order to meet service needs. A night shift may be shorter in length than 12.5 hours should the ward or department work Early & Late shift patterns.

Example night shifts

19.30 – 08.00 (12.5 hours, 60 minute break) – 11.5 hrs paid
21.00 – 08.00 (11 hours, 60 minute break) – 10 hrs paid

TWILIGHT SHIFT

Wards and departments may wish to utilise the twilight shift. A twilight shift should be a maximum of 8 hours in length with a 30 minute unpaid break. To conform to EWTD this break must be taken during the shift and not at the end or the beginning of the shift. The start and finish times for a late shift will be determined by each individual ward or department.

Example twilight shifts

15.00 – 23.00 (1 x 30 minute break) - 7.5 hrs paid
16.30 – 00.30 (1 x 30 minute break) – 7.5 hrs paid
18.00 – 02.00 (1 x 30 minute break) – 7.5 hrs paid

There is no compulsory break entitlement for shifts of 6 hours or less. However working times can be adjusted to accommodate an unpaid break if required

Due to European Working Time Directives, the use of the E/L (long day - LLD) shift has been phased out. The E/L shift can only be used in times of emergency service need, at short notice, when NHSP, agency and overtime shift fill is not available. If this situation does occur, the E/L shift should be allocated a 60 minute unpaid break. To confirm the EWTD this break must be taken during the shift and not at the end or beginning of the shift. No more than one E/L shift should be worked consecutively.

DAY SHIFT
Departments such as theatres and outpatients are likely to use day shifts as their main shift requirement. These shift times will depend on service requirements. The principles of EWTD and taking unpaid breaks still apply to these shifts.

Example day shifts

08.00-18.00 (1 x 30 minute break) – 9.5 hrs paid
10.00-19.00 (1 x 30 minute break) – 8.5 hrs paid

Breaks

All breaks are unpaid breaks and must be taken during the shift, not at the start or end of the shift. Guidance can be found in the Trust guidance document on Working Time Regulations.

Complimentary Breaks

There is no entitlement to a complimentary break. Complimentary breaks can only be allocated at the Matrons or Ward Manager’s discretion should an exceptional situation or need arise. Complimentary breaks cannot be used routinely for any shift pattern.

Best Practice and Minimum Standard Rostering Guidelines

All based on a full time worker.

Best Practice Minimum Standard

8 hour shifts

Minimum 2 days off per week

An early shift should be rostered prior to days off or annual leave

A late shift or night shift should be rostered to follow days off or annual leave

No more than eight days to be worked consecutively

Minimum 4 days off per 14 day period

No more than 10 days worked consecutively

12.5 hour day and night shifts

No more than 2 day shifts to be rostered consecutively

No more than 4 night shifts to be rostered consecutively
Appendix P

Staff should expect 1 day off prior to annual leave

Staff should expect 2 x 30 minute breaks during a day shift

Staff should expect a 60 minute break during a night shift

No more than 5 night shifts to be worked consecutively if working 12.5 hour night shifts

No more than 7 night shifts to be worked consecutively if working 11 hour night shifts

Staff should expect 2 x 30 minute breaks during a day shift

Staff should expect a 60 minute break during a night shift

Mixed short and long day shift patterns

Full time staff should work 2 x long days and 2 x short days in a week

No more than 2 long day shift consecutively

No more than 4 night shifts consecutively

No more than 5 night shifts consecutively

No more than 3 long day or 2 long days and 1 short day shifts consecutively

Internal rotation to night duty

Staff should not work more than 50% of their shifts on night duty unless otherwise negotiated. This excludes staff who work predominately night’s shifts.

Night duty should not be mixed with day shifts more than once in a 7 day period.

Staff will not work more than 10 night shifts per 4 week rota period, unless otherwise negotiated and excluding staff who work, predominately night shifts.

Night duty should not be mixed with day shifts more than once in a 7 day period, unless negotiated with manager.

Weekends

No more than 4 weekend shifts to be worked consecutively, excluding staff who work predominately weekends, or staff who have agreed requests to work more

No more than 6 weekend shifts to be worked in a 4 week period

One complete weekend off per 4 week period, excluding staff who work predominately weekends, or staff who have agreed requests to work more
Changes to a published rota

It is the responsibility of the ward manager to maintain an accurate record of any absences and amendments to the roster. This must be kept up to date electronically utilising the E-Rostering system.

Any changes that are made to the printed roster prior to being updated on the electronic roster MUST be approved and signed by the ward manager or one designated deputy. All changes must be recorded in a format that provides a clear audit trail of the changes and authorising manager. The Matron should monitor these changes on a weekly basis.

Shift changes should be kept to a minimum. Any changes to the published rota should be made in negotiation with the staff involved. The changes must be published as soon as the change has been made.

Staff are responsible for negotiating any shift swap requests once the roster has been published. Shift swaps must be with a member of staff of equal grade, with consideration for the overall mix of shifts allocated. A shift swap is a request and MUST be approved by the ward manager or their one designated deputy in their absence.

Staff rostered to carry the unit bleep can not make changes to their shift without first ensuring that an appropriate colleague can cover the shift for them.

Staff allocated to work with a student should not change their shift without ensuring the student is able to change their shift or is allocated to another appropriate member of staff.

Any changes in a member of staff’s accumulative hours over the roster period will need to be recalculated to reflect the change in shift.

Non-Effective Working Time

Annual Leave

Annual leave will be calculated in hours and will include bank holiday entitlements for all clinical staff. Refer to HR annual leave calculator for leave allocation calculated to exact WTE.

Service Annual Leave Entitlement (inc BH)

Less than 5 year 1 WTE = 262.5 hours

5 – 10 years 1 WTE = 277.5

More than 10 years 1 WTE = 307.5
The ward manager, or one designated deputy, will approve all annual leave

Each ward should calculate how many qualified and unqualified staff must be on annual leave in any one week. (See example below) This should be calculated in hours the agreed annual leave hours per week must be adhered to, to ensure all staff are able to take their allocated leave in the annual leave year. Should this number not be met, by way of requests, the ward manager will allocate leave following discussions with the staff concerned.

The annual leave for each ward should be calculated on staff in post NOT establishment. This leave calculation will require regular review to accommodate starters and leavers. Approval of maximum leave for a year ahead will result in over allocation of leave as soon as a member of staff leaves and is not immediately replaced.

All ward areas should agree a local policy that facilitates equal access to annual leave, it is the responsibility of the ward manager to ensure all staff are aware of this local policy.

No holidays or travel arrangements should be made until the ward manager has sanctioned the annual leave request. Local rules should be developed that are clear to employees and provide evidence that annual leave has been sanctioned.

All requests for annual leave longer than 2 weeks in length must be made in writing and requires agreement from the relevant Matron.

It should NOT be assumed that annual leave for new starters will be honoured. This will need to have been raised at interview and negotiated to ensure ward requirements are met.

The total amount of annual leave should not be increased over school holiday periods, unless it is due to service requirements and approved by the relevant Head of Nursing.

Allocation of leave over school holiday periods should be equitable to all staff making a request for leave over this period. Local rules should be developed that are clear and equitable to all staff.

The allocation of annual leave over the Christmas and New Year period will not differ from any other week’s allocation.

Staff on rotational programmes should take annual leave proportionate to each placement.
Managers should aim for staff to take 75% of leave by the end of December. It is expected that staff should only have 25% of their leave entitlement outstanding at the commencement of the final three months of the annual leave year except:

- By prior arrangement with the ward manager
- Due to the needs of the service
- As a result of ill health/maternity leave

Any approval for staff to take greater than 25% of their leave in the final 3 months of the year, will need to be offset by other staff taking greater than 75% of their leave in the first 9 months of the year.

Please refer to the Annual Leave and Planned Absences Policy for further information.

Example Guide for annual leave allocation

Ward X has 12.8 WTE registered nurses and 8.2 WTE non-registered staff in post

Total Leave for trained staff to be taken each week

\[ 12.8 \times 282 \text{ hours} = 3610 \] (282 is the average yearly leave allocation per WTE)

\[ = 3610 \div 52 \text{ weeks in a year} = 69 \]

= 69 hours of annual leave per week

Ward X should have 69 hours of leave allocated to registered staff every week

Total Leave for untrained staff to be taken each week

\[ 8.2 \times 282 \text{ hours} = 2312 \] (282 is the average yearly leave allocation per WTE)

\[ = 2312 \div 52 \text{ weeks per year} = 44 \]

= 44 hours of annual leave per week

Ward X should have 44 hours of leave allocated to non-registered staff every week.

This calculation should be adjusted if the exact leave allowance is known for each member of staff and if staff have leave carried over from previous year or been allocated extra leave for long service.

Study Leave

Study days should be a maximum of 7.5 hrs long with the exception of the ALS course which is 9 hours long.
Appendix P

Study leave does not include any travelling time to and from a venue

Study leave should be assigned in line with the Study Leave section of the Learning & Development Policy

Managers must ensure that mandatory training is balanced throughout the year as with annual leave and assigned per rota.

E-Rostering

All rosters should be developed and managed utilising the E-Rostering system

The E-Rostering system links via ESR to payroll which requires the manager to verify all rosters on a weekly basis to pay staff for their shift enhanced pay.

In addition to the verification of shifts worked, managers should ensure that the following are included in the roster verification

- Correct annual leave hours for each member of staff
- Short term sickness recorded against the rostered shifts
- Long term sickness recorded as the member of staffs normal weekly hours
- Maternity leave recorded as the member of staffs normal weekly hours
- Correct record of return to work shifts following sickness
- Correct record of Open University student hours
- Correct record of any overtime or excess shifts

Oceans Blue – Barnacles

Any accumulation of un-worked hours will be allocated as a working shift as soon as they reach the hours required for a shift. i.e. if a member of staff is contracted to work 32.5 hours per week but is rostered to work 31, the 1.5 hours owed will be accumulated until there are enough hours to allocate a full shift. The extra 1.5 hours should not be added on to a shift during that week. The E-Rostering system will automatically keep a tally and allocate shifts. The Barnacles system allows managers to have access to an accurate record of hours owing and utilise this information for roster planning.

Accumulation of unworked contracted hours

Due to the nature of different shift patterns and part time hours, it is likely that staff will at times accumulate unworked contracted hours. These hours must be assessed each roster
and planned into the individuals roster as soon as the hours reach the hours required for a full shift.

Temporary Staff

NHSP & Approved Framework Agencies

All temporary staff requests should be booked on the NHSP web browser.

Once the roster has been approved by the Matron, the Ward Manager and Matron should identify any staff shortages.

Temporary staff cannot be used to cover any annual leave allocation that exceeds the calculated acceptable level for the ward.

Temporary staff cannot be used to take charge of the wards unless they are known to the ward and have been assessed as competent to do so, and are willing to take charge. This must be approved by the ward manager.

Permanent staff who have informed their line manager that they are unable to work specific dates or times in their permanent place of work should not be working these shifts on NHSP.

Substantive staff cannot work within the Trust for any agency.

Requests for temporary staff can only be requested by staff authorised to do so. These are Matrons, Heads of Nursing, Corporate Nursing Team and Hospital at Night Team.

Some administrators can enter shifts onto the NHSP web browser that have been previously authorised by the Matron or Head of Nursing.

Permanent staff who have had a period of sickness should not be allowed to work NHSP, excess hours of overtime in 2 weeks following the end date of sick period.

Overtime

Overtime will only be offered in exceptional circumstances when safe staffing levels cannot be achieved through use of excess hours, NHSP or approved agency staff or due to an increase in service needs.

The use of overtime must be approved by the relevant Head of Nursing.

Overtime should not be utilised on Public Holiday periods and only in exceptional circumstances at weekends.

Overtime should not be used routinely or planned on rosters.
Appendix P

7. TRAINING REQUIREMENTS

Training will be available via the E-Rostering team.

Interim training for roster management and development will be available via Lead Nurse for Workforce
List of References


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