Safe Staffing for Nursing in Accident and Emergency Departments

Evidence Review

Jonathan Drennan, Alejandra Recio-Saucedo, Catherine Pope, Rob Crouch, Jeremy Jones, Chiara Dall'Ora and Peter Griffiths

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Contents

Introduction

The National Institute for Health and Care Excellence (NICE) has been asked by the Department of Health and NHS England to develop an evidence-based guideline on safe staffing for nursing in accident and emergency departments (A&Es) – also known as emergency departments (EDs).

Identifying approaches to safe nurse staffing in A&E departments is a key challenge for health service providers. Recent enquiries (Francis 2010, Berwick 2013, Francis 2013, Keogh 2013) have highlighted the role of poor staffing levels in clinical areas in deficits in care leading to excess mortality rates and poor patient experiences. Safe nurse staffing requires that there are sufficient nurses available to meet patient needs, that nurses have the required skills and are organised, managed and led in order to enable them to deliver the highest care possible. Thus, this review is intended to identify the evidence base which would help determine the nursing staff requirements in accident and emergency departments that achieves patient safety outcomes and how organisational culture, structure and policies can support safe nurse staffing in A&E.

Aims and questions of the review

The *Safe Staffing for Nursing in Accident and Emergency Departments* review aims to identify the evidence base for safe nurse staffing in A&E departments by examining the impact of variation in staffing and approaches to determining staffing on patient and nurse outcomes, and the impact of variation in relevant factors on measured staffing requirements. The review explores evidence to inform the questions set out in the scope published in August 2014[1].

At A&E departmental level

- What patient outcomes are associated with safe staffing of the nursing team?
    - Is there evidence that demonstrates a relationship between nursing staff numbers and increased risk of harm?
    - Which outcomes should be used as indicators of safe staffing?

- What patient factors affect nursing staff requirements as patients progress through an A&E department (attendance and initial assessment, on-going assessment and care delivery, discharge)? These include:

1 http://www.nice.org.uk/guidance/gid-accidentandemergencysettings/documents/accident-and-emergency-departments3

- Patient case mix and volume, determined by, for example, local demographics and seasonal variation, or trends in attendance rates (such as bank holidays, local/national events and the out-of-hours period).
- Patient acuity, such as how ill the patient is, their increased risk of clinical deterioration and how complex and time consuming the care they need is.
- Patient dependency.
- Patient risk factors, including psychosocial complexity and safeguarding.
- Patient support (that is, family, relatives, carers).
- Patient triage score.
- Patient turnover.

- What environmental factors affect nursing staff requirements as patients progress through A&E (attendance and initial assessment, on-going assessment and care delivery, discharge)? These include:
  - Availability and physical proximity of other separate units (such as triage) or clinical specialties, such as the 'seven key specialties' (that is, critical care, acute medicine, imaging, laboratory services, paediatrics, orthopaedics and general surgery), and other services such as social care.
  - Department size and physical layout.
  - Department type (for example, whether it is a major trauma centre).

- What staffing factors affect nursing staff requirements as patients progress through an A&E department (attendance and initial assessment, on-going assessment and care delivery, discharge)? These include:
  - Availability of, and care and services provided by other multidisciplinary team members such as emergency medicine consultants, anaesthetists, psychiatrists, pharmacists, social workers, paramedics and advanced nurse practitioners and emergency nurse practitioners who are not part of the core A&E nursing establishment.
  - Division of activities and balance of tasks between registered nurses, healthcare assistants, specialist nurses and other healthcare staff who are part of the A&E team.
  - Models of nursing care (for example, triage, rapid assessment and treatment).
  - Nursing experience, skill mix and specialisms.
  - Nursing staff transfer duties within the hospital and to external specialist units.
  - Nursing team management and administration approaches (for example, shift patterns) and non-clinical arrangements.
  - Proportion of temporary nursing staff (for example, bank and agency).
  - Staff and student supervision and teaching.

- What approaches for identifying nursing staff requirements and/or skill mix, including toolkits, are effective and how frequently should they be used?
  - What evidence is available on the reliability and/or validity of any identified toolkits?

At organisational level

- What organisational factors influence nursing staff requirements at a departmental level? These include:

- Availability of other units or assessment models such as short-term medical assessment or clinical decision units, ambulatory care facilities or a general practitioner working within the hospital.
- Crowding (for example, local factors influencing bed occupancy levels and attendance rates such as changes in usual climate temperatures which results over-full A&E or wards).
- Organisational management structures and approaches.
- Organisational culture.
- Organisational policies and procedures, including staff training.
- Physical availability of inpatient wards or specialist units to transfer patients out of A&E to other parts of the hospital.

Operational Definitions

Nurse staffing: the size and skill mix of the nursing team in the A&E department, relative to the number of patients cared for expressed as nursing hours per patient day, nurse patient ratios or an equivalent measure (nurse time required per number of beds available in a unit)

Nursing team: the group of workers delivering 'hands on' nursing care in A&E (including 'basic' care to meet patients fundamental needs and technical care, including aspects of care generally undertaken only by registered staff, such as medication administration). This would include all necessary administrative assessment and planning work (e.g. documentation, discharge planning).

Accident and Emergency Departments: defined as type 1 A&E departments in hospitals. This includes all departments that are consultant-led 24-hour services with full resuscitation facilities and designated accommodation for the reception of A&E patients.

Box 1 shows a list of the outcomes considered in the review; however, as will be seen in the results, many of the outcomes were not present in the literature.

Box 1: Outcomes Considered
Serious preventable events • Deaths attributable to problems with care received in A&E • Serious, largely preventable safety incidents (also known as 'Never events'), including maladministration of potassium-containing solutions, wrong route administration of oral/enteral treatment, maladministration of insulin, opioid overdose of an opioid-naïve patient, inpatient suicide using non-collapsible rails, falls from unrestricted windows, entrapment in bedrails, transfusion of incompatible blood components, misplaced naso- or oro-gastric tubes, wrong gas administered, air embolism, misidentification of patients, severe scalding of

patients • Serious untoward incidents
Delivery of nursing care • Appropriate levels of family liaison • Appropriate levels of patient chaperoning • Appropriate drug delivery or drug omissions and other nursing staff-associated drug errors • Patient falls • Patients receiving assistance with activities, including missed care events such as help with eating, drinking, washing and other personal needs • Addressing the needs of patients with disabilities • Assessment of care needs, monitoring and record keeping • Time to analgesia • Time to fluids • Time to IV antibiotics • Time to pain assessment • Timeliness of scheduled observations and other clinical paperwork • Timeliness of required investigations • Timely completion of care bundles (for example, Sepsis 6 bundle and TIA and Stroke bundle) • Cared for by a nurse with appropriate competence • Assigned appropriate triage category • Completion of safeguarding duties
Reported feedback • Patients and carers experience and satisfaction ratings related to the A&E, such as: – Complaints related to nursing care – Friends and family test (CQI 5) – Staff experience and satisfaction ratings
Other • Ambulance wait • Ambulatory care rate (CQI[2] 1) • Closure to admissions or ambulance diversions caused by staffing capacity • Costs, including care, staff and litigation costs • Currency of relevant staff training • Nursing vacancy rates • Proportion of patients admitted from A&E • Proportion of patients in the department for more than 4 hours • Rate of patients leaving the department without being seen (CQI 4) • Staff clinical appraisal and statutory review rates • Staff retention and sickness rates

[2] Clinical Quality Indicators (CQI)

- Time to initial assessment (CQI 6)
- Total time in A&E (CQI 3)
- Other staffing-related outcomes

Summary of the Scope

Areas covered

- Registered nurse and healthcare assistant staffing requirements. Additionally, the guideline will cover registered nurses with specialist skills (such as registered mental health and registered children's nurses) who are members of A&E nursing staff establishment.

- All nursing care provided to adults and children in all secondary care type 1 A&E departments in hospitals. This includes all departments that are consultant-led 24-hour services with full resuscitation facilities and designated accommodation for the reception of A&E patients.

- Approaches, including toolkits, for identifying nursing staff requirements and/or skill mix at a department level.

- A range of patient, environmental, staffing and organisational factors that may impact on safe nursing staff requirements at the A&E department level (see figure 1).

Areas not covered

- A&E related service design or reconfiguration, or different service delivery models or components of these models such as hospital-level bed management.

- How to alter factors influencing A&E attendance, transfer out and discharge.

- Assessment of safe staffing requirements for other members of the multidisciplinary team in A&E departments. This includes emergency nurse practitioners (ENP) or advanced nurse practitioners (ANP).

- Type 2 and 3 A&E departments which comprise single specialty A&E services (for example: ophthalmology, dental) or other types of urgent care units such as walk-in centres and minor injury units, which may treat minor injuries and illnesses but are not consultant-led.

- Other hospital departments, such as intensive care units, surgery departments, clinical decision units and acute medical assessment/admission units.

- Nursing workforce planning or recruitment at network, regional or national levels.

Methods

In order to answer the research questions a systematic review of relevant primary material was conducted. The protocol produced and methods adopted to conduct the review were in accordance with *Developing NICE Guidelines: the manual* (NICE 2014).

Literature Search

The literature search consisted of studies from 1994 to present. This date range was chosen as A&E departments and the work practices within them have changed substantially since the early 1990s. The review aimed to identify relevant review papers, primary research and economic analyses.

The search strategy developed by an information scientist (KW) and quality assured by the NICE Information Scientist team (see Appendix C for full search terms/strategies) included the following databases.

- Embase
- CINAHL
- CENTRAL
- HTA database
- CDSR
- DARE
- NHS EED
- NHS Evidence
- Econlit
- Medline including In-process

Websites (search of websites was conducted using key terms taken from the search strategy)

- American Nurses Association
- Royal College of Nursing
- Joanna Briggs Institute
- Royal College of Emergency Medicine
- Society for Acute Medicine
- Faculty of Emergency Nursing
- Trauma Audit & Research Network

Other Resources

To identify additional potentially relevant primary studies the following were also considered:

- Potentially relevant references provided by stakeholders during scope consultation and supplied by the NICE team.
- As an additional check, volumes of specialist journals (*i.e.* Emergency Nursing, Journal of Emergency Nursing, Emergency Medicine Journal, European Journal of Emergency Medicine) were searched to avoid missing relevant papers published after the search results were available and the screening and review of papers conducted.
- Backwards and forwards citation searching on included studies was undertaken as required.

Screening Criteria

Criteria for screening of items retrieved using search strategy was agreed with the NICE team. The first screening consisted in rapid exclusion based on title/abstract completed by one reviewer with a random 10% check by a second researcher. Any disagreements were resolved by recourse to a third independent reviewer (first screening inter-rater reliability 90%). The criteria used for title/abstract screening excluded:

- Studies not reporting type 1 A&E departments
- Studies not reported in English
- Studies dating before 1994
- Studies from non-OECD member countries
- Studies reporting nurse practitioners only
- Studies not reporting staff levels or workload measures

Items were then subjected to a detailed second stage screening using a checklist covering inclusion/exclusion criteria that looked at study designs, variable associations and outcomes[3].

Inclusion criteria:

- Includes a direct measure of nurse staffing (including registered general, children's, learning disability or mental health nurses and non-registered staff delivering nursing care) in the emergency department (e.g. numbers of nurses on a shift, nursing hours per day) relative to a denominator based on activity (e.g. attendances, patient throughput) as an independent variable or an estimate of nurse staffing requirements as a dependent variable.
- Economic studies including: cost, cost-outcome, cost-consequences, cost effectiveness, cost utility or cost-benefit.
- Randomized or non-randomized trials.
- Prospective or retrospective observational studies.
- Cross-sectional or correlational studies.
- Interrupted time-series.
- Controlled before and after studies.
- From 1994 onwards (after casualty departments generally became A&E departments)
- OECD countries – (UK, Europe, USA, Canada, Australia, New Zealand, other developed countries).
- Studies published in English.

[3] None of the reviews identified through the searches, which were assessed as full papers, met the inclusion criteria. The team determined that reviews made inferences about nurse staffing but did not cite evidence clearly related to nurse staffing levels being related to any of the outcomes of the A&E review. An example of items assessed *PINES, J. M., GARSON, C., BAXT, W. G., RHODES, K. V., SHOFER, F. S. & HOLLANDER, J. E. 2007. ED crowding is associated with variable perceptions of care compromise. Academic Emergency Medicine, 14, 1176-1181* was excluded based on lack of evidence of overcrowding affecting nurse workload or overcrowding being associated with nurse staffing.

- Published and unpublished literature which is publicly available including papers in press ('academic in confidence').

Exclusion criteria:

- Nurse Practitioners.
- Type 2 and 3 A&E units.
- Specialist units (ophthalmologic, dental, GP walk in centres).
- Outpatients and long-term care.
- Before and after studies without control groups.

Search results

The database searches resulted in 16,132 items to screen; of these 15,948 were rapidly excluded. In addition, manual, pre-scoping searches and expert recommendations identified 2193 items; of which 2105 were rapidly excluded. A total of 55 studies remained for full paper assessment. Of these, 18 studies met the criteria and were included in the review (see Figure 1). Reasons for the exclusion of the thirty-five studies at full-paper assessment stage are detailed in Appendix D.

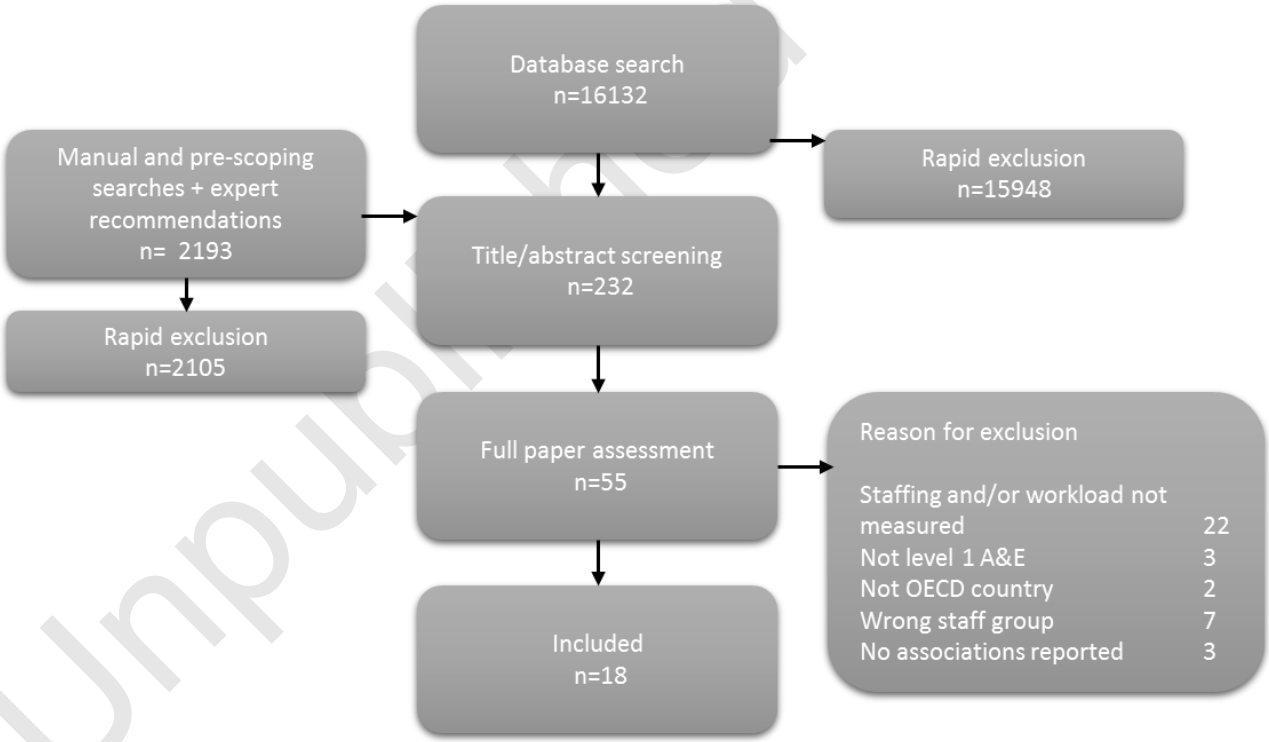

Figure 1 Study selection flowchart[4]

[4] See Appendix B for evidence tables of included studies where studies were grouped per variables of interest and/or outcomes

Quality assessment

A quality appraisal checklist was used to assess the internal and external validity of the studies reviewed, as outlined in *'Developing NICE guidelines: the manual'* (NICE 2014). Due to the majority of the studies reviewed being cross-sectional/observational in design, the appraisal checklist was designed to match the specifics of these studies (see Appendix A). The summary bias assessment was completed from a detailed assessment that considered risk adjustment and data completion/sampling across multiple data sources, outcome types and levels. For each criteria a rating of ++ (indicating that the method was likely to minimise bias) + (indicating a lack of clarity or a method that may not address all potential bias) or – (where significant sources of bias may arise) was given. Ratings were summarised to give an overall rating of ++ (most criteria fulfilled / conclusions very unlikely to alter) + (some criteria fulfilled, conclusions unlikely to alter) – (few criteria fulfilled, conclusions likely to alter). Studies were rated for internal / external validity[5] separately.

Methods of Data extraction

Data were extracted into Excel forms that included the inclusion/exclusion screening criteria that were applied to papers assessed in the second stage (full paper assessment). The form was designed to gather data relevant to bias assessment and evidence tables.

Data synthesis

The synthesis of the evidence is presented in a narrative format with summary tables used, where appropriate, to display patterns, direction and significance of relationships. Evidence statements (brief summary statements which outline key findings from the review) are produced for each review question, and will include the number of studies identified, the overall quality of the evidence and the direction and certainty of the results.

[5] Items to assess internal validity relate primarily to the design of the study, this is, a study is internally valid if the results and statistical conclusions accurately reflect associations between variables of interest in the observed groups. Items to assess external validity relate primarily to the study setting and sample and the extent to which there can be confidence that results will generalise to A&E departments in settings other than the study hospital.

Evidence Review

What patient outcomes are associated with safe staffing of the nursing team?

Introduction

This section of the review explores the relationship between nurse staff levels in A&E and patient outcomes. It addresses the question: 'what patient outcomes are associated with safe staffing of the nursing team?' Nine studies explored the relationship between outcomes and nurse staffing in A&E (Schull, Lazier et al. 2003, Hoxhaj, Moseley et al. 2004, Chan, Vilke et al. 2009, Chan, Killeen et al. 2010, Greci, Parshalle et al. 2011, Weichenthal and Hendey 2011, Brown, Arthur et al. 2012, Daniel 2012, Rathlev, Obendorfer et al. 2012). Details of these studies are provided in the evidence tables (see Appendix B) and quality ratings and design characteristics are outlined in Table 1.1.

The majority of the studies were either retrospective or prospective observational and as such, no direct causal inference can be made from the observed associations. One study used a time series design and one used a before and after design; however, both these studies were assessed as having some risk of bias. The number of A&E departments included in each of the studies varied (1 to 107); however, the majority of studies reviewed were undertaken in single A&E departments (six out of nine studies). All studies were undertaken in Type 1 A&E units with annual censuses of patients attending the A&Es ranging from approximately 30,000 to over 180,000. The majority of the studies were completed in the USA (seven out of nine) with no study reviewed in this section undertaken in the UK. Most studies had significant limitations in internal (five out of nine studies) or external validity (eight out of nine studies) that make it likely that results might change (rated as – for risk of bias). The remaining studies also had moderate limitations in internal validity (rated +) (four out of nine studies) with only one study being rated highly for external validity (Table 1.1). A particular risk of bias associated with some studies was that the relationships reported may be endogenous, arising from the fact that both outcomes and staffing levels are influenced by patient need. This would tend to attenuate observed staffing outcome associations or to produce apparently counter intuitive results whereby worse outcomes are associated with higher staffing. No studies were identified that measured the association between A&E nurse staffing and patient clinical outcomes such as mortality, failure to rescue, never events, time to pain assessment or falls.

Summary of the Evidence

Table 1.1 provides an overview of the studies that were used to address the question: 'what patient outcomes are associated with safe staffing of the nursing team?'

Table 1.1 Nurse Staffing and Patient Outcomes

	Country	Design	Number of A&Es	Comparisons	Outcome	Patients Seen in the A&E (Census)	Internal Validity	External Validity
Brown *et al.* (2012)	USA	RO	1	Actual Compared to Scheduled RN Staffing Hours	Left Without Being Seen	50,000	-	-
Chan *et al.* (2009)	USA	PO	2	Mandated Nurse-Patient ratios compared to Out of ratio care	Time to antibiotic administration	61,000	+	-
Chan *et al.* (2010)	USA	PO	2	Mandated Nurse-Patient ratios compared to Out of ratio care	Waiting Time Emergency Department Care Time	59,733	+	-
Daniel (2012)	Can	RO	107	Nurse-Patient Ratios	Patient Satisfaction	182,022	+	+
Greci *et al.* (2011)	USA	CS	1	Staff workload when the ED was crowded and not crowded	Left Without Being Seen Ambulance Diversion	30,000	-	-
Hoxhaj *et al.* (2004)	USA	RO	1	Nurse staffing levels	Left Without Being Treated	92,000	-	-
Rathlev *et al.* (2012)	USA	TS	1	Number of ED nurses on duty Hospital occupancy Number of patients admitted to the hospital Number of patients admitted from ED to ICU Number of ED resuscitation	Length of Stay	91,643	+	-

				cases				
Schull *et al.* (2003)	Can	RO	1	Number of patients boarded in the ED. Number of ED nurse hours worked per shift. Number of emergency physicians per shift	Ambulance Diversion	37,999	-	-
Weichenthal *et al.* (2011)	USA	BA	1	Nurse-patient ratios	Waiting times, Left without being seen, Medication errors Time to Aspirin Administration Time to Antibiotic Administration	59,163 (Before) 55,976 (After)	-	-

RO = Retrospective Observational; PO = Prospective Observational; CS = Cross=sectional; TS = Time Series; BA = Before and After study.

In total nine studies reported associations between nurse staffing levels and patient outcomes. Outcomes reported included patient waiting times, length of time patients were cared for in the A&E or ED (generally known as Emergency Department Care Times - EDCT), patients who left without being seen (LWBS), medication errors, time to aspirin or antibiotic administration, ambulance diversion and patient satisfaction. Two studies considered the association of mandated nurse patient ratios in California with outcomes (Chan, Killeen et al. 2010, Weichenthal and Hendey 2011).

Waiting Times

Two studies reported on the association between A&E nurse staffing levels and **waiting times** (Chan, Killeen et al. (2010) (-/-), Weichenthal and Hendey (2011) (-/-)). Both of these studies explored the association following the introduction of mandated nurse-patient ratios in California. Mandated registered nurse-patient ratios in EDs in California are set at 1:1 for trauma/resuscitation patients, 1:2 for critical patients and 1:4 for all other ED patients. Weak evidence from a before and after observational study (outcomes were measured one year before and one year after the introduction of mandated nurse-patient ratios) (Weichenthal and Hendey (2011), found a negative association between waiting times and staffing. That is, following the introduction of mandated nurse-patient ratios, waiting times increased significantly (room time increased from 79 to 123 minutes ($p = 0.0001$), throughput time increased from 365 to 397 minutes ($p = 0.001$), admission time increased from 447 to 552 minutes ($p = 0.0001$). In contrast a prospective observational study with moderate internal validity (Chan, Killeen et al. (2010), reported that waiting times[6] were shorter when patients were cared for in an ED where staffing levels were within Californian state mandated ratios[7]. In the analysis, waiting times were 16% longer (95% CI = 10% to 22%, $p < 0.001$) when the ED overall was out-of-ratio (median wait time = 63 minutes) compared to in-ratio (median wait time = 42 minutes)[8]. The inconsistency in the results between the two studies may be due to the different designs when comparing outcomes following the introduction of mandated nurse-patient ratios (NPRs). Weichenthal and

[6] Waiting time was defined as time from triage to placement in an ED bed.

[7] Mandated nurse-patient ratios in EDs in California are set at 1:1 for trauma/resuscitation patients, 1:2 for critical patients and 1:4 for all other ED patients.

[8] Out of ratio nurse-patient ratios were defined as 'a patient whose ED nurse had patient responsibilities greater than the current State-mandated NPRs for more than 20 minutes of care time'.

Hendey (2011) compared mandated NPRs and waiting times prior to and following the introduction of mandated NPRs (before and after observational study) whereas Chan, Vilke et al. (2009) explored patient outcomes when staffing was in-ratio compared to staffing out-of-ratio (prospective observational study).

Patients Leaving Without being Seen

Four studies (Weichenthal and Hendey (2011), Brown, Arthur et al. (2012), Hoxhaj, Moseley et al. (2004), Greci, Parshalle et al. (2011) reported significant association between A&E nurse staffing and patients who **left without being seen (LWBS).** All studies were weak for both internal and external validity. Weichenthal and Hendey (2011) in a before and after study showed a statistically significant decrease in the number of patients who left without being seen following the introduction of mandated NPRs when compared with the time prior to the implementation of mandated ratios. Although the before and after difference in this study was statistically significant ($p < 0.001$), the practical significance in the numbers who left without being seen prior to the introduction of mandated NPRs (11.9%) compared to after the introduction of NPRs (11.2%) was small. Similarly, Brown, Arthur et al. (2012) reported that higher levels of patients leaving without being seen (defined as more than 3 patients leaving without being seen)[9] was more likely during periods of short-staffing of Registered Nurses (OR 2.4, 95% CI 1.3-4.5, $p \leq 0.006$). RN shortages were defined as 'being present on any day where the total numbers of RN hours worked, were less than 90% of the scheduled hours' (p. S97). Hoxhaj, Moseley et al. (2004), in a retrospective observational study, also identified that nurse staffing levels were associated with patients leaving ED without being treated (no definition of leaving without being treated was provided). Higher levels of staff vacancies were associated with higher rates of patients leaving the department ($r = 0.89$, $p = 0.002$). Greci, Parshalle et al. (2011) used a self-report measure of staff workload as a predictor of patients leaving without being seen[10]. Staff workload was operationalised as an average of physicians' and nurses' perceptions of workload. High staff workload was reported as being a predictor of decreased nurse to patient ratios. Higher workload was found to be significantly associated with the odds of

[9] The median number of patients who left without being seen (LWBS) over a 9 month period was 3; "high LWBS" was defined as any day when the number of patients who LWBS was greater than the median.

[10] Number of patients who checked into the ED, left without being seen by a physician within the previous 2 hours.

patients leaving without being seen (OR 6, 95% CI 2.3-15.4, p = 0.02). That is, as perceived workload increased for ED staff, including the worsening of nurse to patient ratios, patients were more likely to leave the ED without being seen by a physician.

Emergency Department Care Time

One prospective observational study with moderate internal validity (Chan, Killeen et al. 2010) explored the association between nurse-patient ratios and **ED care time (EDCT)**. EDCT[11] was found to be longer for patients during times when nurse staffing levels were out-of-ratio[12] compared with times when nurse staffing was in-ratio. Median EDCT for patients treated when staffing was out of ratio was longer (225 minutes, IQR = 117–367 minutes) compared to those patients whose ED nursing remained in-ratio (within mandated nurse-patient ratios) (149 minutes, IQR = 79–261 minutes). In a log-linear regression analysis, the ED care time for patients whose nurse staffing was out-of-ratio was 37% longer (95% CI = 34% to 41%, p < 0.001) than those patients seen in an ED when nurse staffing was in-ratio.

Medication Errors and Aspirin Administration

Weak evidence from a before and after study (Weichenthal and Hendey 2011) examined **medication errors** prior to and following the introduction of mandated NPRs in the ED but no significant relationships were found (p = 0.16). The same study also found no significant change in the rate of **aspirin administration** (p = 0.15) after the institution of nursing ratios for patients admitted to the ED with chest pain, acute coronary syndrome, or acute myocardial infarction.

Time to Antibiotics for Patients Diagnosed with Pneumonia

Two studies with (moderate/weak for internal validity) examined the association between mandated NPRs and **time to antibiotics for patients diagnosed with pneumonia** in the ED (Chan, Vilke et al. 2009, Weichenthal and Hendey 2011). Chan, Vilke et al. (2009) using linear regression models to measure the impact of mandated NPRs on time to antibiotics after controlling for ED census found no significant association between in-ratio (median = 27.5 minutes) and out-of-ratio care (median =

[11] EDCT 'defined as the time between being seen by a doctor and being admitted to hospital'.

[12] Out of ratio nurse-patient ratios were defined as 'a patient whose ED nurse had patient responsibilities greater than the current State-mandated NPRs for more than 20 minutes of care time'.

30.0 minutes) on time to antibiotics for patients with pneumonia (p = 0.53) whereas Weichenthal and Hendey (2011), in weak evidence from a before and after study, reported a significant decrease in time to antibiotic administration following the introduction of mandated NPRs. The time from order to administration of antibiotics decreased from 103 minutes prior to the introduction of mandated NPRs to 62 minutes following the introduction; the difference was found to be statistically significant ($p<0.002$). It should be noted that the methods used to compare the impact of mandated NPRs differed in each of the studies reviewed: Weichenthal and Hendey (2011) compared mandated NPRs and time to antibiotics prior to and following the introduction of mandated NPRs (before and after observational study) whereas Chan, Vilke et al. (2009) explored patient outcomes when staffing was in-ratio compared to staffing out-of-ratio[13] (prospective observational study).

Patient Satisfaction with Nursing Care in A&E

One study, an unpublished PhD thesis, with moderate internal validity and strong external validity, using a retrospective observational design explored the relationship between nurse staffing in ED and **patient satisfaction with nursing care** (Daniel (2012). Each ED in Ontario's acute care hospitals was sampled and the study included all patients who had completed the patient satisfaction survey for the five-year period between 2005 and 2010. It was found that for each one per cent increment in RN staff skill mix[14] (RN skill mix was calculated by dividing the total RN worked hours by the total nursing care worked hours for the same time period), there was an associated increase in overall patient satisfaction with care received in the ED. RN proportion was found to have a weak statistical association with patient satisfaction with nursing care, patient satisfaction with overall care in the ED, and the likelihood to recommend the ED to friends and family. For each one per cent increment in RN staff skill mix, there was an associated increase in overall patient satisfaction with care received in the ED of .05 on a scale of 0 to 100. The per cent of full-time nursing worked hours was negatively associated with overall patient satisfaction with care with an estimate of -0.02 ($p<0.05$).

Length of stay in A&E

[13] Out of ratio nurse-patient ratios were defined as 'a patient whose ED nurse had patient responsibilities greater than the current State-mandated NPRs for more than 20 minutes of care time'.

[14] A higher proportion of RNs

Rathlev, Obendorfer et al. (2012) in a study of moderate internal validity, using a retrospective time series analysis measured the factors associated with patients' **length of stay**[15] in an ED over three eight hour nursing shifts. For each eight hour shift, associations were measured between length of stay and number of ED nurses on duty, ED discharges, ED discharges on the previous shift, number of patients resuscitated, admissions to an inpatient unit and admissions from ED to ICU. Staffing numbers (mean number of nurses on any particular shift) were found not to be associated with patients' length of stay in the regression model. Rathlev, Obendorfer et al. (2012) did report that longer lengths of stay for patients in the ED were associated with an increase in hospital (bed) occupancy, additional patients admitted to the wards from the ED and the number of patients admitted to ICU from the ED (the association was identified for one shift only). For every additional 1% increase in hospital occupancy, length of stay in minutes increased by 1.08 (0.68, 1.50, P = 0.001). For every additional admission from the ED, length of stay in minutes increased by 3.88 (2.81, 4.95) on shift 1, 2.88 (0.47, 5.28) on shift 2, and 4.91(2.29, 7.53) on shift 3. Three or more ICU cases (compared to 0) admitted from the ED per shift prolonged LOS by 14.27 minutes (2.01, 26.52) on one shift.

Ambulance Diversion

Two studies, one in the USA (Greci, Parshalle et al. 2011) (weak internal validity) and one in Canada (Schull, Lazier et al. 2003) (moderate internal validity) explored the association between **ambulance diversion** and nurse staffing. Weak evidence from a cross-sectional study (Greci, Parshalle et al. (2011) found no association between staff workload and the requirement to divert ambulances[16] to other departments (OR = 1.5, 95% CI = 0.7 – 3.5, p = 0.33). Similarly Schull, Lazier et al. (2003) in a retrospective observational study found no association between nursing hours (number of nurses working multiplied by the number of hours worked by each nurse in an eight hour interval) and ambulance diversion[17]. Schull, Lazier et al. (2003) concluded that ambulance delivered patient volume, total number of admitted patients, boarding time[18], and day, evening and weekend shifts determined ambulance diversion, not nursing hours. This study adjusted for total patient volume; nursing workload; volume

[15] Length of stay was measured in minutes from the time of registration to the time of departure from ED for all patients (discharged, transferred or admitted).

[16] Ambulances either "on diversion" (if diversion started any time in the previous 2 hours) or "off diversion" (no ambulance diversion during the previous 2 hours).

[17] The total duration (in minutes) of ambulance diversion during each 8- hour shift.

[18] Number of patients waiting for inpatient beds.

of trauma patients; number of patients admitted through the ED; time of day and day of week; mean assessment time; mean boarding time and; number of inpatient acute care beds occupied by patients awaiting placement in facilities in the community.

Summary Evidence Statements

There is inconsistent evidence from relatively small-scale observational studies, the majority with poor internal and external validity that associates ED staffing levels with patient outcomes. The evidence regarding patient waiting times and time to antibiotics for patients diagnosed with pneumonia is inconsistent. The inconsistency may be explained by differences in study designs and how nurse-patient ratios were operationalized; however, there is evidence that higher rates of ED staffing are associated with decreased levels of patients leaving an ED without being seen, and reduced emergency department care time. No association was found between ED nurse staffing medication errors, time to antibiotics or patients' length of stay. None of the studies were undertaken in the UK and only one was rated highly for external validity (Daniel 2012).

- There is mixed evidence on the association between ED nurse staffing levels and patient waiting times. Weak evidence from on prospective observational study reported a statistically significant association between higher nurse staff levels and shorter waiting times (Chan, Killeen et al. 2010); however, another weak before and after study showed the association in the opposite direction (Weichenthal and Hendey 2011). It should be noted that the designs in these studies differed considerably.

- There is evidence from four studies (weak for both internal and external validity) (Weichenthal and Hendey 2011, Brown, Arthur et al. (2012), Hoxhaj, Moseley et al. (2004), Greci, Parshalle et al. (2011)) that lower ED staffing levels are associated with higher rates of patients leaving an ED without being seen.

- There is evidence from one weak prospective observational study that emergency department care time is longer for patients when staffing levels are lower (Chan, Killeen et al. 2010).

- Evidence from one weak before and after study (Weichenthal and Hendey 2011) found no association between ED staffing levels and medication errors or the rate of aspirin administration to patients following admission to the ED with a cardiac event.

- Evidence is mixed for an association between ED staffing levels and time to administration of antibiotics to patients in the ED with pneumonia. One before and after study (Weichenthal and Hendey 2011) reported a significant decrease in time to antibiotics following the introduction of mandated nurse patient ratios; but weak evidence from a prospective observational study found no association (Chan, Vilke et al. (2009).

- One relatively strong retrospective observational study (Daniel 2012) (++) found a weak positive relationship between staffing proportions in the ED and patient satisfaction with nursing care.

- No association was found between staffing levels and patients' length of stay over three eight hour shifts in a time series study (Rathlev, Obendorfer et al. 2012). Rathlev, Obendorfer et al. (2012) did report that longer lengths of stay for patients in ED were associated with an increase in hospital occupancy rates, additional patients admitted to the wards and the number patients admitted to ICU from the ED.

- Evidence from two studies, one cross-sectional (Greci, Parshalle et al. (2011) and one retrospective observational (Schull, Lazier et al. (2003) found no association between ED staffing levels and ambulance diversion from the ED.

Staffing, patient, organisational and environmental factors that affect nursing staff requirements as patients progress through the A&E department?

Introduction

This section of the review explores the evidence related to staffing, patient, organizational and environment factors that affect nurse staffing requirements as patients progress through the A&E department (see table 1.2). Two studies (Sinclair, Hunter et al. (2006) and (Green, Savin et al. 2013) explored staffing factors (the introduction of a specialist psychiatric nursing service and staff absenteeism), one study explored patient factors (Hobgood, Villani et al. (2005) (relationship between workload and patient acuity), one study explored organisational factors (Harris and Sharma 2010) association between hospital-wide bed capacity, nursing and physician numbers at organisational level and the length of time that patients waited in the ED; no studies were identified that explored environmental factors that influence nursing staff requirements at a departmental level. The majority of the studies (three out of four) were either prospective or retrospective observational with one using a before and after design. The number of A&E departments included in each of the studies ranged from 1 to 38. All studies were undertaken in type 1 A&E departments. Patient census data was only available for two studies and these ranged from 55,000 to 70,000. Only one study was undertaken in the UK with two in the US and one in Australia. All studies had significant limitations in internal validity, with three out of four studies having limitations in external validity; this makes it likely that results might change (rated as – for risk of bias). One study had moderate limitations in external validity (rated +).

Table 1.2 Staffing, Patient and Organisational Factors and Outcomes

	Country	Design	Number of EDs	Comparisons	Outcome	Patients seen in the A&E (Census)	Internal Validity	External Validity
Green *et al.* (2013)	USA	PO	1	Workload as defined by nurse-patient ratios	Staff Absenteeism	Not stated	-	-
Harris *et al.* (2010)	Aus	RO	38	Annual average of nurses, physicians and beds at hospital level	Patient care time in the ED	Not stated	-	+
Hobgood *et al.* (2005)	USA	PO	1	Workload (Nurse-patient ratio ED Acuity Index)	Task Allocation	60,000	-	-
Sinclair *et al.*, (2006)	UK	BA Cross-over	2	Prior to and following the introduction of a specialist psychiatric nursing service	Waiting times Onward referral Repeat attendance Patient satisfaction Staff views	Dept: 1 = 55,000 Dept: 2 = 70,000	-	-

RO = Retrospective Observational; PO = Prospective Observational; CS = Cross=sectional; TS = Time Series; BA = Before and After study

What staffing factors affect nursing staff requirements as patients progress through an A&E department (attendance and initial assessment, on-going assessment and care delivery, discharge)?

This section explores staffing factors, such as the availability of other multidisciplinary team members and staff absenteeism (See Table 1.2).

Only one study (weak for both internal and external validity), carried out in the UK, was identified that explored the association between the introduction of specialist **multidisciplinary team members** and patient outcomes in the A&E. Sinclair, Hunter et al. (2006), using a before and after crossover design, assessed the impact of a dedicated specialist psychiatric nurse service on outcomes relevant to patients with mental health problems attending the A&E. In addition to assessing patients attending the A&Es with mental health problems, the specialist psychiatric nurses provided basic care to other patients in the department. Outcomes measured included waiting times[19], onward referrals, repeat attendances, patient satisfaction, and staff views. The dedicated psychiatric nurse intervention was found to have had no association with waiting times (hospital 1 $p = 0.76$ and hospital 2 $p = 0.76$), repeat attendances or satisfaction levels for mental health patients; however, there was evidence of an association between onward referral patterns post the introduction of the dedicated psychiatric nurse when compared to the pre-introduction time period (hospital 1 $p < 0.01$, hospital 2 $p < 0.001$). Patients with mental health problems seen by the specialist psychiatric nurse in the department were more likely to be transferred to a mental health unit than discharged against medical advice or referred to an outpatients department or general ward when compared to before the intervention.

A prospective observational study (Green, Savin et al. 2013) undertook an empirical investigation of the association between anticipated workload, as defined by the nurse-patient ratios and absenteeism[20] of RNs by means of a mathematical model. Nurse absenteeism was defined as any event where a nurse does not show up for work

[19] Defined as from time of arrival for patients assessed with a mental health problem to commencement of treatment.

[20] Absenteeism is defined as any event where a nurse does not show up for work without giving sufficiently advanced notice for the schedule to be revised.

without sufficiently advance notice[21] to allow reprogramming of the schedule. Anticipated workload was identified as nurses were informed in advance of their schedule and were aware of how many nurses were scheduled to work on the same shift. In addition, it was claimed, nurses, from previous experience, were aware of the number of patients to expect on a particular shift. It was found that the more nurses scheduled for a shift, the less likely that nurses will be absent (absenteeism rate would decrease from the average value of 7.34% to 6.78% when an extra nurse is added to a shift). In addition, nurse absenteeism in the ED was exacerbated when fewer nurses were scheduled for a particular shift.

Summary Evidence Statements

- Weak evidence from a before and after study undertaken in the UK (Sinclair, Hunter et al. 2006) found no association between the introduction of a specialist psychiatric nurse intervention service to the A&E and waiting times, repeat attendances or satisfaction levels for patients with mental health problems; however, there was evidence that patients with mental health problems seen by the specialist psychiatric nurse in the department were more likely to be transferred to a mental health unit than discharged against medical advice or referred to an outpatients department or general ward when compared with discharge patterns before the intervention.
- In a weak prospective observational study, nurse absenteeism in the ED (Green, Savin et al. 2013) was exacerbated when fewer nurses were scheduled for a particular shift. In addition, there was an association between the number of nurses scheduled for a shift and absenteeism.

What patient factors affect nursing staff requirements as patients progress through an A&E department (attendance and initial assessment, ongoing assessment and care delivery, discharge)?

One study was identified that explored patient requirements as patients progress through an A&E department and the association with patient volume and acuity (See Table 1.2).

Hobgood, Villani et al. (2005), in a prospective observational study (weak for internal validity), explored the association between workload, operationalized through nurse-patient ratios and an acuity index and how registered nurses in ED allocate their time between various tasks. Measures included percentage of time on direct patient care, percentage of time on indirect patient care, non-RN Time and personal time. Two

[21] Sufficient advance notice generally refers to short notice which does not allow for the roster to be changed in time.

measures of nurse workload were used: the patient-to-nurse ratio and the ED acuity index. For the 63 nursing shifts studied, on average RNs spent 25.6% of their time performing direct patient care, 48.4% on indirect patient care, 6.8% on non-RN care, and 19.1% on personal time. Regardless of the number of patients per RN, approximately twice as much time was spent on indirect patient care as direct patient care. In addition, regardless of workload, RNs spend the majority of their time performing indirect patient care. As overall ED workload rises, when measured by nurse-patient ratios and acuity index, task allocation was found to vary with direct patient care increasing, indirect patient care also increasing, non-RN care remaining relatively constant, and personal time decreasing. The majority of the time was spent on indirect patient care.

Summary Evidence Statement

- One study, (Hobgood, Villani et al. 2005), found that as overall ED workload rises, when measured by nurse-patient ratios and patient acuity, task allocation was found to vary with direct patient care increasing, indirect patient care also increasing, non-RN care remaining relatively constant, and personal time decreasing. In effect, as nursing workload increases, nurses spend the longest amount of time providing in-direct patient care.

What organisational factors influence nursing staff requirements at a departmental level?

This section of the review explores the limited evidence available on organisational factors that influence nursing staff requirements at a departmental level (See Table 1.2).

One study was identified that reported on organisational factors that influence nursing staff requirements at a departmental level. (Harris and Sharma 2010) explored the association between hospital-wide **bed capacity, nursing and physician numbers at organisational level** and the length of time that patients waited in the ED.

Harris and Sharma (2010), using a retrospective observational design, modelled the impact of changing organisational variables on patient care time[22] in the ED. Variables explored included the annual average of nurses, physicians and beds reported by the hospital and the length of time patients spent in the ED while controlling for variation in

[22] Defined as the time between being seen by a doctor and being admitted to hospital.

the demand for hospital care. This study did not specifically explore the association with length of stay and the number of nurses employed in the ED. It was reported that a 1% change in the mean number of nurses (from 998 to 1008) at hospital level was associated with a 2.38% fall in waiting time assuming all other variables were held constant (variables were held constant in the model). In addition, it was reported that an increase of 1% in the bed capacity was associated with a 2.99% fall in waiting time. The statistical model predicted that a combined 1% increase in the number of nurses in the hospital as a whole, physical bed capacity and the number of doctors was associated with a reduction in the average waiting time of 22 minutes from the average of 396 minutes. This study identified an association between hospital resources and time spent in ED waiting for admission. It should be noted that that the outcomes were statistically modelled rather than observed.

Summary Evidence Statement

- One prospective observational study, (Harris and Sharma 2010) (weak for internal and moderate for external validity), using statistical modelling, predicted that a combined increase in the number of nurses, physical bed capacity and the number of doctors at organizational level, was associated with a reduction in the average waiting time of patients in ED.

What environmental factors influence nursing staff requirements at a departmental level?

We found no evidence regarding the influence of environmental factors on nurse staffing requirements.

What approaches for identifying nursing staff requirements and/or skill mix, including toolkits are effective and how frequently should they be used?

Summary of the Evidence

Two studies were identified that used toolkits to determine staffing levels in the ED (Crouch and Williams 2006, Korn and Mansfield 2008). In one of the studies (Korn and Mansfield 2008), there was a lack of information on the reliability or validity of the tools to ascertain their utility or quality in practice. (See Table 1.3)

Table 1.3 Toolkits to identify nursing staff requirements and/or skill mix

	Country	Design	Number of EDs	Outcome	Patients (n)	Internal Validity	External Validity
Crouch and Williams (2006)	UK	PO	6	Dependency score	840	+	-
Korn and Mansfield (2008)	USA	PO	1	N/A	N/A	-	-

Crouch and Williams (2006), in the UK, tested the validity, reliability and generalizability of the Jones Dependency Tool (JDT). The aim of the study was to identify a toolkit that could be used to ascertain staffing numbers and skill-mix in the ED. The testing of the tool identified a significant correlation between the Jones Dependency Tool scores and the nurses' subjective ratings of patient dependency ($R = 0.786$, $p < 0.001$). There was also a positive relationship between the amount of time spent by nurses in direct care of patients and the patient's level of dependency ($R = 0.72$, $p < 0.001$). It was also identified that there was a relationship between JDT scores measured over time [23] ($k = 0.68$) as well as acceptable levels of inter-rater reliability between the JDT and nurses' subjective rating ($k = 0.75$).

A second toolkit was identified (Korn and Mansfield 2008). The aim was to identify a measure that could be used to identify ED nursing staff ratios for different types of patents taking into consideration boarders (occupancy rates)[24] in the department and how that impacts on the work of ED nurses. The model was based on the premise that

[23] *K* = Cohen's Kappa a measure of inter-rater reliability.

[24] A boarder was defined as a patient who was to be admitted but who remained in the emergency department longer than 30 minutes

patients that receive care while 'boarding' in the department require staffing ratios that are reflective of the care needed. The model is based on an algebraic category that ascertains if nursing work in the ED is overloaded. The algebraic formula for determining workload is based on calculating the following: actual work minutes per hour for new arriving patients, with acuity and volume converted to nursing work minutes; number of nurses who actually reported to work on the days studied; minutes of nursing work available to care for boarders; ICU boarder work; telemetry boarder work; regular boarder work. The outcome from the calculation is used to determine whether nursing workload for each hour of the day is overloaded or not. It allows a determination to be made on whether there are enough nurses to provide care for newly arrived ED patients as well as boarders. The basis of the model is that it mandates that boarders receive care in the emergency department that is similar to inpatient care: 1:2 for ICU patients, 1:4 for other monitored patients, and 1:10 for unmonitored patients. No tests of the reliability or validity of the model are provided in the study.

Summary Evidence Statements

- A study (Crouch and Williams 2006) identified a toolkit with the purpose of ascertaining staffing numbers and skill-mix in the ED. It did not consider the effects of the toolkit on patient or staff outcomes; however, it was identified as a patient classification system that could be used to determine nursing workload in an A&E department.
- A study (Korn and Mansfield 2008) aimed at identifying a measure for calculating ED nurse to patient ratios according to the ED occupancy rate. It did not take into account the effects of the toolkit on patient or staff outcomes. It allows a determination to be made on whether there were enough nurses to provide care for newly arrived ED patients as well as boarders.

Simulation Studies

In addition to the included studies we identified a number of simulation studies that were relevant to the questions at hand. Because the underlying data on which these simulations were based was often obscure we were unable to assess the risk of bias assessments. However, in all cases the results reported are those of the simulation and are not results that were observed in practice.

Table 1.4 Simulation Studies

	Country	Design	Number of EDs	Comparisons	Outcome	Patients seen in the A&E (Census)
Zeng *et al.* (2012)	USA	Simulation Study	1	Modelled number of nurses, physicians, CT scanners	Length of stay Waiting time Left without being seen	48,000
Sinreich & Jabali (2007)	USA	Simulation Study	5	Nurse Work Hours	Length of Stay	NA
Benner et al.	USA	Simulation study	1	Modelled number of nurses, physicians, CT scanners	Patient throughput waiting time	48,000

The study by Zeng, Ma et al. (2012) was a computer simulation study to improve the quality of care in terms of length of stay, waiting times and patients who LWBS. The model was compared with data collected in a single ED. Analyses on patient throughput, waiting times, length of stay, and staff and equipment utilizations were carried out in order to model the use of resources (physicians, nurses and equipment) and what the authors refer to as 'machines' (services provided by physicians and nurses, laboratory tests, waiting and discharge). Patient acuity was used to prioritise the availability of doctors, nurses, and testing procedures. Nurse staffing is measured as whole time equivalents and includes registered nurses. Additionally, the model introduced a team nursing policy whereby 2 nurses shared the workload of 6 rooms, instead of working only with the 3 rooms assigned to each individual nurse (the simulation model did not explore nurse-patient ratios). The purpose of the team nursing policy was to maximise nursing work time. The simulation model was compared with 1-month registration data collected in a community A&E department for validation. The model introduced variation in the number of nurses, physicians and CT scanners and observed the effects on length of stay, waiting time and patients who left without being seen. The simulation model showed sensitivity to the number of nurses required to ensure minimum waiting time for patients, to reduce length of stay (to in-hospital admission or home) and left without being seen. With regards to the sensitivity of the model for the introduction of team nursing results indicated a reduction in waiting times by 13% to 26% (patient acuity considered), in average length by more than 5%, and in patient who left without being seen by 25%. Average utilization of nurses was reduced by approximately 5%.

The study by Sinreich and Jabali (2007) aimed at determining the correct size of the workforce and its work shift scheduling by implementing staggered work shifts and determining how much the workforce in the ED (physicians and nurses) can be reduced whilst maintaining an acceptable level of efficiency in relation to length of stay. The simulation model was aimed at studying how length of stay and workload were affected by decreasing number of physicians, nurses and imaging technicians. The model focuses on a selective downsizing process where resources are treated individually (doctors, nurses and imaging technicians) and are increased or decreased in accordance with their contribution to the operation of the unit. Simulations ran using the Staggered Work Shift Scheduling Algorithm (SWSSA) (iterative simulation based algorithm to schedule resources' work shifts, one resource at a time) showed that a selective separate downsizing of resources, this is, reduction in staff hours for example, can maintain approximate ED operational measures with regards to LOS. The authors conclude that operation of the ED in terms of patients' LOS can be maintained despite an overall reduction in staff hours. Data from the level 1 trauma centre used to demonstrate operation of the model were not provided making validation and interpretation of results difficult.

The study by Brenner, Zeng et al. (2010), simulates patient throughput in an ED department in the USA with the purpose of creating a quantitative tool to use in the improvement of the operations in the department. The setting of the study describes nurses' categories (i.e. trauma, critical, acute and express nurses). The authors do not provide details regarding the sub specialism of these nurses and whether these may be referring to nurse practitioners. The model is aimed at determining optimal staffing levels and resources availability. There is no indication of multilevel analysis and therefore the variables included (number of doctors, number of equipment available) are not reported separately. It is not possible to see how confounding factors affected the results. Results of the simulation seem to indicate that to keep satisfactory operational levels in the ED, approximately 5 nurses (in any category) are appropriate.

Summary Evidence Statements

- A study (Zeng, Ma et al. 2012) is a computer simulation study to improve the quality of care in terms of LOS, waiting times and patients who LWBS. The model introduced a team nursing policy whereby 2 nurses shared the workload of 6 rooms, to maximise nursing work time. The simulation model showed sensitivity to the number of nurses required to ensure minimum waiting time for patients, to reduce LOS (to in hospital admission or home) and LWBS.

- The Sinreich and Jabali (2007) study aimed at determining the correct size of the workforce and its work shift scheduling by implementing staggered work shifts. Simulations ran using the SWSSA showed that a selective separate downsizing of resources can maintain approximate ED operational measures with regards to LOS.
- A study (Brenner, Zeng et al. 2010) simulated patient throughput in an A&E department with the purpose of creating a quantitative tool to use in the improvement of the operations in the department. Results of the simulation seem to indicate that to keep satisfactory operational levels in the ED, approximately 5 nurses (in any category) are appropriate.

Discussion and Conclusions

The evidence reviewed identified a number of outcomes that appear to be associated with nurse staffing levels in accident and emergency departments; however, the majority of the studies were carried out at single sites. The outcomes that were identified as being associated with nurse staffing included: patients leaving without being seen, emergency department care time, and patient satisfaction with nursing care. Although the evidence does not provide strong support for the validity of any single variable as an indicator of safe staffing in the A&E department, there was consistency in the results from the studies that explored the association between staffing levels and patients leaving the ED without being seen. We did not find strong evidence for waiting times, medication errors, and the rate of aspirin administration or ambulance diversion. There was conflicting evidence from two weak studies on the association between staffing levels and time to antibiotics for patients with pneumonia.

Only one included study found a relationship between the addition of a specialist member of nursing staff and patient outcomes. There was evidence that patients with mental health problems seen by the dedicated psychiatric nurse in an ED were more likely to be transferred to a mental health unit than discharged against medical advice or referred to an outpatients department or general ward.

At organisational level, two studies reported an association between increased length of stay in the ED and organisational factors. Rathlev, Obendorfer et al. (2012) reported that longer lengths of stay for patients in ED were associated with an increase in hospital occupancy, additional patients admitted to the wards and the number patients admitted to ICU from the ED. Similarly, in a modelling study, (Harris and Sharma 2010) predicted that a combined increase in the number of nurses, physical bed capacity and the number of doctors at organizational (hospital) level, was associated with a reduction in the average waiting time of patients in ED.

A relationship between workload and task allocation was also identified in one study (Hobgood, Villani et al. 2005); that is as workload increased, direct and indirect patient care (charting, dispensing medications, preparing I/V medications) also increased with non-RN care (ECGs, transporting patients) remaining relatively constant, and personal time (staff breaks, non-patient conversations) decreasing. Evidence on the effectiveness of toolkits in identifying staffing requirements was limited with only one, the Jones Dependency Tool (Crouch and Williams 2006), reporting on the reliability and validity of the toolkit. Two computer simulation studies (Brenner, Zeng et al. 2010, Zeng, Ma et al. 2012) modelled the relationship between staffing and a number of outcomes. In the first, it was found that the model that initiated team nursing, led to a reduction in waiting times, length of stay and patients who left without being seen. The model also predicted that the number of nurses needed could also be reduced. In a model to determine the size of the workforce, Sinreich and Jabali (2007), modelled staggered shifts. It was found through the simulation process that length of stay could be maintained with reduced nurse staffing hours in the ED.

In conclusion, there are a number of factors that were not studied that may influence nurse staff requirements in the ED including unit layout, patient acuity, overcrowding and time of day and day of week on which patients attend the ED. The primarily observational studies we found often had a high risk of bias from unmeasured confounding or endogeneity between staffing levels and the outcome. While the evidence is not strong, it appears to indicate that levels of nurse staffing in the ED are associated with patients leaving without being seen, emergency department care time and patient satisfaction. Lower staffing is associated with worse outcomes.

Evidence gaps / need for future research

This review has identified significant evidence gaps, most significantly the relative lack of research undertaken in the UK that could better identify relationships between nurse staffing configurations and patient safety outcomes in A&E. Although the review identified relationships between nurse staffing in the A&E and outcomes such as patients leaving without being seen and waiting times, there was a lack of evidence on the impact of safe staffing and direct patient outcomes such as mortality, failure to rescue, never events, time to pain assessment or falls. There was also a paucity of

economic evidence that could be used to inform decision making. The simulation studies included in the review, although not without limitations, demonstrated potential in using advanced modeling to simulate outcomes associated with nurse staffing in the A&E.

Appendix A. Risk of bias assessment/Quality appraisal

Scores	Internal	External
2	strong (++)	NA not applicable (rare)
1	moderate (+)	NR (not recorded)
0	weak (-)	

Design	
Study design & analysis cross sectional (-) or allows for cause / effect (exposure precedes outcome time series) (+) / RCT	
2.2 Is the setting applicable to the UK?	
· Did the setting differ significantly from the UK?	
· UK ++	
· Other developed countries with national health system +	
Other -	
1.1 Is the eligible population / area representative of the source population or area?	
· Single hospital (-)	
· Consider whether hospitals potentially included in the study are representative of acute general hospital emergency departments nationally or a large sub-national unit (e.g. USA state) (+1)	
· Were the staff / patients eligible to be included in the hospitals representative of all ED admissions (+1) or specific subgroup (-1) or limited time period (-1).	
1.2 Do the selected participants or areas represent the eligible population or area?	
· What % of selected hospitals agreed to participate (+1 for larger studies)	
· What % of eligible individuals (staff / patients) participated (60% + is acceptable)?(+1)	
· Was the data derived from administrative systems and complete (Give +1) or	
Were the inclusion or exclusion criteria explicit and appropriate?	
3.1 Were the main measures and procedures reliable?	
· Were main measures subjective (-1) or objective (give ++ for completely objective measures)	
· How reliable were measures (e.g. inter- or intra-rater reliability scores)? +1 for evidence of reliability	
Where relevant. was there any indication that measures had been validated (e.g. validated against a gold standard measure or assessed for content)	
3.2 Were the measurements complete?	
Were all or most of the study participants who met the defined study outcome definitions likely to have been identified? (++ for mortality, + for other PSIs collected using clearly defined methods, - if abstracted from discharge abstracts)	
4.1 Was the study sufficiently powered to detect an effect (if one exists)?	
· Were there sufficient units / hospitals / wards / patients to give variation and enough patients to detect effects	
· Large multi-hospital (20+) studies (state / national / international) with administrative data ++	
· Smaller studies / single hospital with large numbers of patients (000,000) +	
· Other - look at confidence intervals / sample size give (-) if unclear that results are	

sufficiently precise	
2.1 How well were likely confounding factors identified and controlled?	
· For main patient / staff outcomes, was there patient / staff level risk adjustment e.g. for AGE, (patient) DIAGNOSIS and COMORBIDITY (+ or ++) as appropriate. ITS / RCT consider +1	
4.2 Were the analytical methods appropriate?	
· Was there adjustment for clustering of data within hospitals? (+ 1), Where relevant was there control for ward / hospital characteristics (+1)	
4.3 Was the precision of association given or calculable? Is association meaningful?	
· Were confidence intervals or p values for effect estimates given or possible to calculate?	
Were CIs wide or were they sufficiently precise to aid decision-making? If precision is lacking, is this because the study is under-powered? If correlations between observations and workload how precise is the prediction?	
5.1 Are the study results internally valid (i.e. unbiased)?	
· How well did the study minimise sources of bias (i.e. adjusting for potential confounders)?	
Were there significant flaws in the study design?	
5.2 Are the findings generalisable to the source population (i.e. externally valid)?	
· Are there sufficient details given about the study to determine if the findings are generalisable to the source population?	
Consider: participants, interventions and comparisons, outcomes, resource and policy implications.	

Appendix B. Evidence tables

- **ABSENTEEISM**
  1. Green, L. V., et al. (2013). ""Nursevendor Problem": Personnel Staffing in the Presence of Endogenous Absenteeism." Management Science **59**(10): 2237-2256.

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	Failure to incorporate absenteeism as an endogenous effect results in understaffing. Nurse absenteeism is exacerbated when fewer nurses are scheduled for a particular shift. No quantitative results were reported.
Green, L. V., et al, 2013	USA	Patient factors: none reported. Environmental factors: none of interest to the review. Staffing: availability and/or numbers of external staff brought to the ED to cover absences (proportion of temporary nursing staff). Organisational: none reported	Nurse absenteeism as defined by any event where a nurse does not show up for work without sufficiently advance notice to allow reprogramming of the schedule.	
Study Aim	**Setting**			
Perform an empirical investigation of the factors affecting absenteeism of RNs by means of a mathematical model (newsvendor)	Type 1 A&E			
	Source population			
	Convenience sample based on patients attending the ED from July 1 2008 to May 30 2009	**If relevant, what was the comparison?**		
		No comparison	**Statistical Analysis**	
Study Design	**Selection procedure nurses**		The authors perform binomial multilevel models, for which the outcome is the nurses' absenteeism decision and predictors are parameters related to workload as well as fixed effects such as the day of the week or the shift. The authors use the nurse-to-patient ratio as a proxy for the workload nurses experience during a particular shift.	
Analytical treatment of observed data	Census: Unclear as to whether nurses reported in the study included RNs and HCAs	**How was staffing measured?**		
		Nurse to patient ratio		
	Selection procedure patients	**Patient/Nurse level adjustment**		
	Patient Census Values: all	NA		

	patients attending the A&E from July 1 2008 to May 2009.	**Which nursing groups were measured?**	To ensure the robustness of results, the authors estimated a number of alternative modelling specification (see article).	
		Registered nurses. Unclear if other staff		
Internal validity [i]	**Selection procedure A&E**	**Sample size (Hospitals)**		
-	Convenience	1		
External validity [ii]		**Sample size (Patients)**		
-		Day shift: average census 116; Night shift: average census 102; Evening shift: average census 125		
		Sample size (Nurses)		
		Day shift: mean 11.4; Night shift: mean 10.5; Evening shift: mean 3.63		

[i]: Internal validity rated as weak because the measurements were not complete; confounding factors were not identified/controlled for; no effect estimates were provided.

[ii]: External validity rated as weak because the sample was not representative of the source population or area; the study was not sufficiently powered to detect an effect.

- **AMBULANCE DIVERSION**

2. Greci, L. S., et al. (2011). "CrowdED: crowding metrics and data visualization in the emergency department." Journal of Public Health Management & Practice 17(2): E20-E28.

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	1. RN to patient ratio significantly associated with perception of crowding (OR 0.0018 95%CI 0.002-0.09, p<0.01) 2. RN to patient ratio significantly associated with patient reneging (number of patients who left before being seen by a physician) (OR 6, 95% CI 2.3-15.4) 3. Not associated with ambulance diversion (OR 1.4 95% CI 0.7-3.5)
Greci, et al, 2011	USA	RN to patient ratio	1. Staff perception of workload 2. Patients leaving without being seen 3. Ambulance diversions	
Study Aim	**Setting**			
To validate commonly used crowding metrics in the ED and then to incorporate these measures into a data visualization that may lead to an appropriate tool for the analysis of interventional studies	Type 1 A&E			
	Source population			
	Convenience sample. Adult, level-III, veterans' administration ED in urban southern California. It is open 24 hours per day, has 15 treatment beds with 4 cardiac monitors, and typically sees about 30 000 patients per year. Time periods sampled over 4 weeks - sampling unclear	**If relevant, what was the comparison?**		
		N/A		
Study Design	**Selection procedure nurses**			
Cross-sectional	Time periods sampled over 4 weeks - sampling unclear			
		How was staffing measured?		
		Nurse to patient ratio		
	Selection procedure patients	**Patient/Nurse level adjustment**		
	N/A	N/A		
		Which nursing groups were		

		measured?		
		Registered Nurses		
Internal validity [i]	**Selection procedure A&E**	**Sample size (Hospitals)**		
-	Convenience sample. adult, level-III, veterans administration ED in urban southern California. It is open 24 hours per day, has 15 treatment beds with 4 cardiac monitors, and typically sees about 30 000 patients per year. Time periods sampled over 4 weeks - sampling unclear	1	**Statistical Analysis**	
External validity [ii]		**Sample size (Patients)**	Pearson correlations were calculated to identify patterns of relationships among the variables. Exploratory analysis also utilized analysis of variance for continuous data, and χ2 analysis for ordinal data. Variables with a P<.10 were entered into a logistic regression to compare predictive values for the outcome variables: patient reneging and ambulance diversion status. Univariate odds ratio and confidence intervals were calculated. Multivariate logistic models were developed for the individual outcomes.	
-		n/a		
		Sample size (Nurses)		
		277 (time sampling periods)		

[i] : **Internal validity rated as weak because of study design; no indication that measures had been validated; likely confounding factors were not identified and controlled.**

[ii] **: External validity rated as weak because the sample was not representative of the source population or area; the study was not sufficiently powered to detect an effect**

3. **Schull, M. J., et al. (2003). "Emergency department contributors to ambulance diversion: a quantitative analysis." Ann Emerg Med 41(4): 467-476.**

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	1. Number of admitted patients boarded in the ED was a predictor of increased ambulance diversion. For every admitted patient boarded in the ED, there were an additional 6 minutes (95% CI 3 to 10 minutes) of diversion per interval (3% increase over the mean). 2. ED nurse hours were not associated with crowding. 3. 13 out of 15 emergency physicians were not associated with ambulance diversion. 2 who were (1 with a decrease of 36 minutes per interval [95% CI –65 to – 7 minutes] and the other with an increase of 48 minutes per interval [95% CI 5 to 91 minutes]).
Schull, et al, 2003	Canada	Organisational factors: physical availability of inpatient wards to transfer patients out of A&E; Patient factors: turnover	The association between ambulance diversion and: **1.** boarded patients **2.** Nurse hours **3.** physician on duty	
Study Aim	**Setting**			
To determine the relationship between physician, nursing, and patient factors on emergency department use of ambulance diversion.	**Type 1 A&E**			
	Source population			
	Convenience sample of patients attending the Sunnybrook site of a 1,200-bed tertiary-care hospital in Toronto, Ontario, Canada (Sunnybrook and Women's College Health Sciences Centre) from 1 Jan 1999 to 31 Dec 1999	**If relevant, what was the comparison?**		
		Not relevant		
Study Design	**Selection procedure nurses**			
Retrospective observational	Convenience			
		How was staffing measured?		
		Nurse hours were the number of nurses working multiplied by the number of hours worked by each nurse, in each 8-hour interval		
		Patient/Nurse level adjustment		
		Nursing workload measure was calculated by assigning individual ED patients a score based on presenting problem and intensity and duration of nursing care. The workload in each 8-hour interval was calculated by prorating the total		

		daily score by the number of patients seen in the ED during the interval.		
	Selection procedure patients	**Which nursing groups were measured?**		
	Convenience: total patient volume was the sum of walk-in and ambulance-delivered patients	Registered nurses		
		Sample size (Hospitals)		
		1		
Internal validity	**Selection procedure A&E**	**Sample size (Patients)**		
- [i]	Convenience	37 999 patients treated from Jan 1999 to Dec 1999	**Statistical Analysis**	
External validity		**Sample size (Nurses)**	The authors used an autoregressive integrated moving average model and evaluated its assumptions through standard tests (data stationarity and seasonality). A coefficient (and 95% confidence interval [CI]) was estimated for each predictor variable in univariate and multivariate models, representing the change in minutes of ambulance diversion per unit change in the variable. Model fit was assessed by using the Q statistic to test for residual autocorrelation, the Akaike information criterion, the Schwarz Bayesian information criterion, and adjusted R2 values.	
+ [ii]		Not reported		

[i] : Internal validity rated as weak due to study design; moderate indication that measures had been validated; analytical methods not appropriate.
[ii] : External validity rated as moderate due to sample strongly representative of the eligible population; the study was sufficiently powered to detect an effect.

- **ED VOLUMES / PATIENT FLOW**

4. Chan, T. C., et al. (2010). "Effect of mandated nurse-patient ratios on patient wait time and care time in the emergency department." Academic Emergency Medicine **17**(5): 545-552.

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	1. WTs were 17% (95% [CI] = 10% to 25%, p < 0.001) longer at Hospital A and 13% (95% CI = 3% to 24%, p = 0.008) longer at Hospital B (combined 16% [95% CI = 10% to 22%, p < 0.001] longer at both sites) when the ED overall was out-of-ratio compared to in-ratio. 2. The EDCT for patients whose nurse was out-of-ratio were 34% (95% CI = 30% to 38%, p < 0.001) longer at Hospital A and 42% (95% CI = 37% to 48%, p < 0.001) longer at Hospital B (combined 37% [95% CI = 34% to 41%, p < 0.001] longer at both sites) when compared to patients whose nurse was in-ratio.
Chan, et al, 2010	USA	Mandated Nurse-patient Ratios. 1:1 for trauma resuscitation patients, 1:2 for critical patients, 1:4 for all other ED patients). In-ratio or out-of-ratio status was then determined for each ED nurse, patient, and the ED overall.	1. Patient wait time (WT), defined as time from triage to placement in an ED bed, 2. ED care time (EDCT), defined as time from placement in an ED bed to either discharge from the ED or transfer to an inpatient bed.	
Study Aim	**Setting**			
To evaluate the effect of mandated nurse–patient ratios (NPRs) on emergency department (ED) patient flow.	Type 1 A&E			
	Source population			
	The study was conducted over a 1-year period (January 1, 2008, through December 31, 2008) after enactment of the state-mandated NPR levels. The study was conducted at two EDs (providing care for adult and paediatric patients) where state-mandated NPRs have been enacted for all acute care hospital settings, including the ED. One site (Hospital A) was an urban, academic teaching hospital (Level 1 trauma center) 24-bed ED (including a four-bed urgent care "fast-track" area) with an annual census of	**If relevant, what was the comparison?** Comparison of in-ratio and out-ratio care provided by nurses in the ED (Nurses were considered out-of-ratio if their patient load exceeded state regulations for more than 20 minutes of patient care time).	**Statistical Analysis** Data were analysed to determine if NPR status for each patient, nurse, or ED classified as in-ratio or out-of-ratio affected ED flow parameters of WT and patient EDCT after controlling for hospital, census, and patient triage acuity level. Log-linear regression models, using the natural log of WT and EDCT due to their skewed properties, were used to assess the effect of	

	approximately 37,000 visits. The other site (Hospital B) was a suburban community hospital, with a 15-bed ED (including a four-bed urgent care "fast-track" area), with an annual census of approximately 23,000 visits.		NPRs while controlling for census at time of waiting (for WT), ED bed placement (for EDCT), patient acuity level at triage, and hospital facility and were repeated stratifying by facility. For the models, the natural-log transformed WT or EDCT was used as the dependent variable, and the other factors were included as covariates.	
Study Design	**Selection procedure nurses**			
Prospective observational	Not reported			
		How was staffing measured?		
		Nurse to patient ratio		
		Patient/Nurse level adjustment		
		Patient triage acuity level (emergent, acute, urgent)		
	Selection procedure patients	**Which nursing groups were measured?**		
	Census	ED RNs		
		Sample size (Hospitals)		
		2		
Internal validity [i]	**Selection procedure A&E**	**Sample size (Patients)**		
+	Convenience	59733		
External validity [ii]		**Sample size (Nurses)**		
-		Not reported		

[i] : Internal validity rated as moderate due to moderate reliability of measures and procedures; moderately complete measurements; strong control of confounding factors; moderately appropriate analytical methods.

[ii] : External validity rated as weak due to sample moderately representative of the source population or area; the study was not sufficiently powered to detect an effect.

- **LEAVING WITHOUT BEEN SEEN / LEAVING WITHOUT TREATMENT**

5. Weichenthal, L. and G. W. Hendey (2011). "The effect of mandatory nurse ratios on patient care in an emergency department" Journal of Emergency Medicine 40(1): 76-81.

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	1. Measured wait times increased significantly after the introduction of nursing ratios, including: room time, 79 to 123 min (p<0.0001); throughput time, 365 to 397 min (p<0.001), and admission time, 447 to 552 min (p<0.0001). 2. The percentage of patients who LWBS decreased from 11.9% to 11.2% (p<0.0001). 3. Reported medication errors after the implementation of nursing ratios increased from 0.81 per 1000 visits to 1.17 per 1000 visits (p = 0.16) but not significant. 4. There was no significant change in the rate of aspirin administration after the institution of
Weichenthal, et al, 2011	USA	480 charts were reviewed from the study period; 240 charts were reviewed from the year before implementation of the nursing ratios, and an equal number were reviewed for the year after the implementation. Aspirin administration was counted if aspirin was given in the ED, aspirin was given by a pre-hospital provider, aspirin was taken at home that day by the patient, or aspirin was not given (e.g. due to drug allergy)	**1.** Waiting times **2.** Percentage of patients who LWBS **3.** reported medication errors **4.** Percentage of acute coronary syndrome (ACS) patients who received aspirin in the ED **5.** Time to antibiotics in pneumonia patients.	
Study Aim	**Setting**			
To look at the association between nursing ratios and quality of care in an urban teaching Emergency Department (ED)	Type 1 A&E			
	Source population			
	Patients attending the A&E 1 year before the introduction of mandatory nursing ratios (January 1-December 31 2003) and 1 year after (January 1 - December 31 2004). 59, 163 in 2003 and 55,976 in 2005).	**If relevant, what was the comparison?**		
		Comparison between each of the outcome variables before the intervention compared to after the intervention		
Study Design	**Selection procedure nurses**			
Before and after observational	Census: Unclear as to whether nurses reported in the study included RNs and HCAs	**How was staffing measured?**		
		Nurse to patient ratio		
		Patient/Nurse level adjustment		

		N/A		nursing ratios, decreasing from 87.7% to 80.4% (p=0.15). 5. For patients with pneumonia, the time from written order to administration of antibiotics decreased from 103 to 62 min, respectively (p=0.002).
	Selection procedure patients	**Which nursing groups were measured?**		
	Convenience	Registered nurses		
		Sample size (Hospitals)		
		1		
Internal validity[i]	**Selection procedure A&E**	**Sample size (Patients)**		
-	Convenience	57000	**Statistical Analysis**	
External validity[ii]		**Sample size (Nurses)**	Means and proportions of wait times; percentage of patients who left without being seen (LWBS); reported medication errors; percentage of acute coronary syndrome (ACS) patients who received aspirin in the ED; and time to antibiotics in pneumonia patients before and after the introduction of mandatory nursing ratios were compared using Student's t-tests or chi-squared tests.	
-		Not reported		

[i]: Internal validity rated as weak because the measurements were not complete; confounding factors were not identified/controlled for; no effect estimates were provided.

[ii]: External validity rated as weak because the sample was not representative of the source population or area; the study was not sufficiently powered to detect an effect.

6. Brown, L., et al. (2012). "Impact of nursing short-staffing and emergency department left without being seen." Annals of Emergency Medicine **Conference**(var.pagings): 4.

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	The dependent variable "high Left without been seen" had the following predictors: ED census on a continuous scale (OR 1.07, 95% CI 1.04-1.09, p ≤ 0.001) and short-staffing of RNs (OR 2.4, 95% CI 1.3-4.5, p ≤ 0.006).
Brown, et al, 2012	USA	Nursing shortages, defined a priori as being present on any day where the total numbers of RN hours worked were less than 90% of the scheduled hours.	Rate of patients leaving the department without been seen, creating a dichotomous variable. The dichotomous dependent variable "high LWBS" was defined as being met on any day in which there were more than 3 LWBS patients.	
Study Aim	**Setting**			
To assess the impact of day-to-day RN shortages on LWBS.	Type 1 A&E			
	Source population			
	Convenience sample based on patients attending the ED from July 2011 to March 2012.	**If relevant, what was the comparison?**		
		N/A		
Study Design	**Selection procedure nurses**			
Retrospective observational	Convenience			
		How was staffing measured?		
		RN staffing hours		
		Patient/Nurse level adjustment		
		N/A The study (analysis and/or methods) do not give indication of patient/nurse level adjustment having been performed		
	Selection procedure patients	**Which nursing groups were measured?**		
	Convenience	Registered nurses		
		Sample size (Hospitals)		

		1		
Internal validity[i]	**Selection procedure A&E**	**Sample size (Patients)**		
-	Convenience	During the 9-month study period, the median daily ED census was 132, and the median of patients who LWBS was 3	**Statistical Analysis**	
External validity[ii]		**Sample size (Nurses)**	Multivariate logistic regression, with reporting of covariates' Wald p values and odds ratios (ORs) with 95% confidence intervals (CIs).	
-		Not reported		

[i]: Internal validity rated as weak because the measurements were moderately complete; confounding factors were not identified/controlled for; the precision of association was moderately calculable.

[ii]: External validity rated as weak because the sample was not representative of the source population or area; the study was not sufficiently powered to detect an effect

7. Hoxhaj, S., et al. (2004). "Nurse staffing levels affect the number of emergency department patients who leave without treatment." Academic Emergency Medicine **11**(5): 459.

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	The number of nursing vacancies (FTE) strongly correlated with the percentage of patients who LWOT (r = 0.89, p = 0.007). The ratio of total monthly nursing hours to monthly ED census demonstrated strongly correlated with the percentage of patients who LWOT (r = -0.94, p = 0.002).
Hoxhaj, et al, 2004	USA	Nurse staffing levels, limited by the number of available nursing full-time equivalents (FTEs). Recorded by nursing work schedules monthly.	Rate of patients who left the department without treatment	
Study Aim	**Setting**			
To study the effect of the level of ED nurse staffing on the number of patients who leave without treatment (LWOT).	Type 1 A&E			
	Source population			
	Convenience sample based on patients attending the ED from July 2002 to June 2003	**If relevant, what was the comparison?**		
		N/A		
Study Design	**Selection procedure nurses**			
Retrospective observational	Convenience			
		How was staffing measured?		
		Ratio of total monthly nursing hours to monthly ED census.		
		Patient/Nurse level adjustment		
		N/A		
	Selection procedure patients	**Which nursing groups were measured?**		
	Convenience	Nurses, not further specified.		
		Sample size (Hospitals)		
		1		

Internal validity[i]	**Selection procedure A&E**	**Sample size (Patients)**		
-	Census	Not available	**Statistical analysis**	
External validity[ii]		**Sample size (Nurses)**	Regression analysis	
-		Not available		

[i]: Internal validity rated as weak because the measurements were moderately complete; confounding factors were not identified/controlled for; the precision of association was moderately calculable.

[ii]: External validity rated as weak because the sample was not representative of the source population or area; the study was not sufficiently powered to detect an effect

For other studies exploring "Leaving Without Being Seen (LWBS)" see table 2. Greci, et al.

- **LENGTH OF STAY / WAITING TIMES**

8. Harris, A. and A. Sharma (2010). "Access block and overcrowding in emergency departments: an empirical analysis." Emergency Medicine Journal **27**(7): 508-511.

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	Generalised y survival rates. Predicted percentage in patient care time associated with change in variables. For example, a 1% change in the mean number of nurses (from 998 to 1008) is associated with a 2.38% fall in waiting time (from 396 to 3871/49 min) assuming all other variables remain at their mean values.
Harris, et al, 2010	Australia	Patient factors - none Environmental - number of beds in hospital Staffing factors - number of nurses on the wards	- Length of time waiting in ED for a hospital bed	
Study Aim	**Setting**			
To quantify the determinants of the duration of time spent in an emergency department (ED) for patients who need admission to hospital.	Type 1 A&E			
	Source population			
	Retrospective analysis of all ED patients attending 38 EDs in Victoria state over years 2005-2006. Annual averages of nurses reported by the hospital	**If relevant, what was the comparison?**		
		Modelled the impact of changing variables on length of time patients waited in ED		
Study Design	**Selection procedure nurses**			
Retrospective observational	Annual averages per hospital			
		How was staffing measured?		
		Number of FTE nurses employed in the hospital.		
		Patient/Nurse level adjustment		
		Yes but modelled on a mean		
	Selection procedure patients	**Which nursing groups were measured?**		

	All patients presenting to the EDs during the study period	Registered Nurses - although nurses was used as a generic term		
		Sample size (Hospitals)		
		38		
Internal validity[i]	**Selection procedure A&E**	**Sample size (Patients)**		
-	All in state of Victoria	0	**Statistical Analysis**	
External validity[ii]		**Sample size (Nurses)**	Semi-parametric statistical Model: the Cox proportional hazard model.	
-		Mean 998 SD 714.81		

[i]: Internal validity rated as weak because the main measures were not reliable; confounding factors were not identified/controlled for; the analytical methods were not appropriate; the precision of association was moderately calculable.

[ii]: External validity rated as weak because the sample was moderately representative of the source population or area; the study was not sufficiently powered to detect an effect

9. Rathlev, N. K., et al. (2012). "Time series analysis of emergency department length of stay per 8-hour shift." The Western Journal of Emergency Medicine **13**(2): 163-168.

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	The numbers of nurses, ED discharges on the previous shift, resuscitation cases, and elective surgical admissions were not significantly associated with LOS on any shift. Length of stay was reduced by between .6 and 4.1 minutes on average per additional nurse (average staff level unclear)
Rathlev, N. K. et al, 2012	USA	Number of nurses in the department	Patient length of stay in the ED	
Study Aim	**Setting**			
To explore factors associated with length of stay in the ED across different shifts	Type 1 A&E			
	Source population			
	University, inner-city teaching hospital. All adult ED patients between October 12, 2005 and April 30, 2007.	**If relevant, what was the comparison?**		
		N/A		
Study Design	**Selection procedure nurses**			
Time series	1689 shifts			
		How was staffing measured?		
		ED nurses on duty per shift.		
		Patient/Nurse level adjustment		
		The study (analysis and/or methods) do not give indication of patient/nurse level adjustment having been performed		

	Selection procedure patients	**Which nursing groups were measured?**		
	Census	Registered nurses		
		Sample size (Hospitals)		
		1		
Internal validity[i]	**Selection procedure A&E**	**Sample size (Patients)**		
+	Convenience	91643	**Statistical Analysis**	
External validity[ii]		**Sample size (Nurses)**	Data was analysed using an autoregressive integrated moving average (ARIMA) time series model to account for the presumed serial correlation between successive 8-hour periods.	
-		N/A		

[i] : Internal validity rated as moderate due to strong reliability of measures and procedures; strongly complete measurements; weak control of confounding factors; moderately appropriate analytical methods.

[ii] : External validity rated as weak due to sample moderately representative of the source population or area; the study was not sufficiently powered to detect an effect.

10. Sinclair, L., et al. (2006). "How effective are mental health nurses in A&E departments?" Emergency Medicine Journal **23**(9): 687-692.

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	1. Despite average waiting times at each hospital being shortest during the intervention period, there were no significant differences between pre-intervention and intervention periods at either site (hospital 1, p=0.763; hospital 2, p=0.076) 2. There was a significant difference in onward referral patterns between intervention and non-intervention periods of the study at both sites (hospital 1, χ2=28.8, p,0.001; hospital 2, χ2=25.3, p,0.01). 3. Levels of satisfaction recorded were high for all patients with no significant differences between intervention and non-intervention periods for attendees with mental health problems or general A&E attendees. 4. The psychiatric nurse team was perceived to have had a positive impact on each
Sinclair, et al, 2006	UK	No discussion of staffing requirements - study provides no information on staffing in A&E other than the additional psychiatric nursing staff provided	1. Waiting times in A&E 2. Onward referral and repeat attendance 3. Patient satisfaction 4. Staff views	
Study Aim	**Setting**			
To assess the impact of a dedicated A&E psychiatric nurse service on several outcomes relevant to patients and clinicians	Type 1 A&E			
	Source population			
	A&E staff identified "mental health" attendees (identification/inclusion criteria not reported in paper but available from authors) before, during and after intervention period. During 3 month intervention period these patients were eligible for referral to psychiatric (if A&E staff thought patient would benefit from mental health assessment (criteria not reported). Around a third of "mental health" attendees were seen by psychiatric nurses. Study took place in Glasgow in 1999.	**If relevant, what was the comparison?** Not introducing the A&E psychiatric nurse service.		
Study Design	**Selection procedure nurses**			
Prospective observational	Only report activity/ staffing levels of psychiatric nurses	**How was staffing measured?**		

	based in A&E as intervention	Hours per week (approx 130 hrs /week provided by four G-grade psychiatric nurses [RMN qualified, two also RGN qualified]).		department.
		Patient/Nurse level adjustment		
		The study (analysis and/or methods) do not give indication of patient/nurse level adjustment having been performed		
	Selection procedure patients	**Which nursing groups were measured?**		
	Census of "Mental health" attendees at A&E	Registered mental health nurse		
		Sample size (Hospitals)		
		2		
Internal validity$_{i}$	**Selection procedure A&E**	**Sample size (Patients)**		
-	Convenience (two A&E in Glasgow)	4364	**Statistical Analysis**	
External validity$_{ii}$		**Sample size (Nurses)**	Differences in waiting times and onward referral patterns for all patients with mental health problems between intervention and non-intervention periods were tested initially using ANOVA and χ2 procedures. Linear and multinomial regression techniques were then applied to examine the effect of intervention period, seeing a psychiatric nurse, and	
-		4		

			other possible explanatory variables on waiting time and onward referral.	

[i]: Internal validity rated as weak because the main measures were moderately reliable; confounding factors were not identified/controlled for; the analytical methods were not appropriate; the precision of association was moderately calculable.

[ii]: External validity rated as weak because the sample was not representative of the source population or area; the study was not sufficiently powered to detect an effect.

<u>For other studies exploring "Length Of Stay/Waiting Times" see also 5. Weichental et al.</u>

- **OVERCROWDING**

11. Korn, R. and M. Mansfield (2008). "ED overcrowding: an assessment tool to monitor ED registered nurse workload that accounts for admitted patients residing in the emergency department." J Emerg Nurs 34(5): 441-446.

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	Factors influencing staff requirements were acuity-based norms (time for new admissions and nurse to staff ratios (from 1:2 for ICU to 1:10 for regular admissions) for boarders. Results were model tabulations stating whether ED was "OK" or "Overloaded" based on patient numbers/ acuity and model assumptions
Korn, et al, 2008	USA	Patient factors: acuity (new admissions and "boarders")	None	
Study Aim	**Setting**			
To properly size RN staff for an emergency department	Type 1 A&E			
	Source population			
	No detail on the samples or time when study was conducted. This work was part of a consulting project to evaluate ED operations. No details of dates provided except for indication is in Table 2 where a sample of model outputs are reported for dates between 2/1/2006 and 2/7/2006 (US date format)	**If relevant, what was the comparison?**		
Study Design	**Selection procedure nurses**			

Other/uncertain Prospective analysis of ED staffing (RN hours) versus a workload model based on observed patient characteristics for admissions (critical care/ ICU patients, monitored non-ICU patients, regular bed admissions/ discharges) combined with workload norms for admissions (CC/ICU patient = 90 minutes nurse time; monitored non-ICU patient = 60 minutes; regular bed admissions/ discharges = 30 minutes). Remaining staff time (if any) distributed across "ED Boarders" (categorised for acuity using same 3 levels as above)	Census - number of nurses available per hour x 60 (i.e. minutes of nurse time per one hour block)			
		How was staffing measured?		
		Nurse to patient ratio		
		Patient/Nurse level adjustment		
		N/A		
	Selection procedure patients	**Which nursing groups were measured?**		
	Census - categorised by acuity (hence workload)	Registered nurses		
		Sample size (Hospitals)		
		1		
Internal validity[i]	**Selection procedure A&E**	**Sample size (Patients)**		
-	1	Not reported	**Statistical Analysis**	
External validity[ii]		**Sample size (Nurses)**	Not reported.	
-		Not reported		

[i]: Internal validity rated as weak because the main measures were not reliable; confounding factors were not identified/controlled for; the analytical methods were not appropriate; the precision of association was not calculable.

[ii]: External validity rated as weak because the sample was not representative of the source population or area; the study was not sufficiently powered to detect an effect.

<u>For other studies exploring "Overcrowding" see also 2. Greci, et al.</u>

- **PATIENT COMPLEXITY – DEPENDENCE**

12. Hobgood, C., et al. (2005). "Impact of emergency department volume on registered nurse time at the bedside." Annals of Emergency Medicine **46**(6): 481-489.

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	1. RNs spent 25.6% of their time performing direct patient care 2. 48.4% on indirect patient care 3. 6.8% on non-RN care 4. 19.1% on personal time. 5. The correlation between the ED acuity index and the patient-to-nurse ratio was 0.98.
Hobgood, et al, 2005	USA	Patient factors - Acuity Environmental factors - Only measured care in Acute ED - one section of the department Staffing Factors - allocation of workload	1. Percentage of time on direct patient care 2. percentage of time on indirect patient care 3. Non RN Time 4. Personal Time 5. Correlation between ED acuity index and patient-to-nurse ratio	
Study Aim	**Setting**			
To determine how emergency department (ED) registered nurses (RNs) allocate their time between various tasks and describe how RN task distribution changes as a function of various measures of ED patient volume and patient acuity	Type 1 A&E			
	Source population			
	Convenience sample of 49 nurses. The study period was a convenience sample of 7 non-consecutive 24-hour periods during each of the 3 study years 2000, 2001, 2002. Data were collected at the nurse shift level	**If relevant, what was the comparison?**		
		N/A		
Study Design	**Selection procedure nurses**			
Prospective observational	Convenience			
		How was staffing measured?		
		Nurse to patient ratio		

		Patient/Nurse level adjustment		
		N/A		
	Selection procedure patients	**Which nursing groups were measured?**		
	Convenience	Registered Nurses		
		Sample size (Hospitals)		
		1		
Internal validity[i]	**Selection procedure A&E**	**Sample size (Patients)**		
-	Convenience	Not Known	**Statistical Analysis**	
External validity[ii]		**Sample size (Nurses)**	Regression analysis was used to further explore the value of adding ED acuity to simple ED volume in explaining RN time per task allocation. Significance was set at P less than .01, and 95% confidence levels were calculated.	
-		49		

[i]: Internal validity rated as weak because the main measures were moderately reliable; confounding factors were not identified/controlled for; the analytical methods were moderately appropriate; the precision of association was not calculable.

[ii]: External validity rated as weak because the sample was moderately representative of the source population or area; the study was not sufficiently powered to detect an effect.

13. Crouch, R. and S. Williams (2006). "Patient dependency in the emergency department (ED): Reliability and validity of the Jones Dependency Tool (JDT)." Accident and Emergency Nursing **14**(4): 219-229.

Study Details	**Population and setting**	**Intervention**	**Outcomes and control variables**	**Results**
Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	The higher the amount of time spent by nurses in direct care of patients the higher the patient's level of dependency (R = 0,72, P < 0.001). Dependency did not vary by time of day or day of week. Age was significantly associated with dependency - for a 10 year age difference the score increase by 0.51 (95% CI 0.43–0.59). There was a significant correlation between triage rating and Jones Dependency Tool scores (R = 0.58, P < 0.001). The higher the dependency, the higher the proportion of patients with abnormal pulse rates (chi square = 7.45, df = 1, P = 0.006), abnormal respiratory rates (chi square = 15.683, df = 1, P <0.001) and abnormal oxygen saturation (chi square= 15.583, df = 1, P < 0.001). The higher the amount of time spent by nurses in direct care of patients the higher the
Crouch, et al, 2006	UK	The tool assigns a dependecy level based on a range of factors determined by a consensus exercise and observation in the original development. These are: Communication , ABC, Eating drinking elimination and personal care, Environmental safety, health and social needs, Triage	Dependency score.	
Study Aim	**Setting**		**Statistical Analysis**	
To test the validity, reliability and generalisability of the Jones Dependency Tool.	Type 1 A&E		Construct validity was tested using Spearman correlation analysis and the chi-square statistic. Differences between the 'known groups' of the overall JDT scores was tested by methods of the non-parametric test of Kruskal Wallis. The construct validity element of the study was conducted using the same data collected to investigate the criterion-related validity. The sensitivity to change of the tool was explored using a test-re-test design. The	
	Source population			
	Convenience sample of hospitals selected to give a mix of urban and inner city departments from January 15th, 2001 and 7th June 2001. Patients sampled across late, early, night and weekend shifts with an average of 4 per shift. Unclear how patients were selected.	**If relevant, what was the comparison?**		
		N/A		
Study Design	**Selection procedure nurses**			
Prospective observational	N/A			
		How was staffing measured?		
		Measure of patient dependency on		

		nursing	stability of the tool was explored by measuring inter-rater reliability.	patient's level of dependency (R = 0,72, P < 0.001). Test retest reliability (k= 0.68), inter-rater reliability (jk= 0.75). There was a highly significant correlation between the Jones Dependency Tool scores and the nurses' subjective ratings of patient dependency (R = 0.786, P < 0.001).
		Patient/Nurse level adjustment		
		The study (analysis and/or methods) do not give indication of patient/nurse level adjustment having been performed		
	Selection procedure patients	**Which nursing groups were measured?**		
	Patients sampled across late, early, night and weekend shifts with an average of 4 per shift. Unclear how patients were selected.	Yes		
		Sample size (Hospitals)		
		6		
Internal validity[i]	**Selection procedure A&E**	**Sample size (Patients)**		
+	Convenience sample of hospitals selected to give a mix of urban and inner city departments.	840 / 40 for detailed observation		
External validity[ii]		**Sample size (Nurses)**		
-		N/A		

[i] : Internal validity rated as moderate due to strong reliability of measures and procedures; strongly complete measurements; weak control of confounding factors; moderately appropriate analytical methods.

[ii] : External validity rated as weak due to sample moderately representative of the source population or area; the study was not sufficiently powered to detect an effect.

- **PATIENT SATISFACTION**

14. Daniel, I. (2012). The Relationship between Nurse Staffing and Patient Satisfaction in Emergency Departments, University of Toronto (Canada). **Ph.D.:** 209.

Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	**Results**
Daniel, 2012	Canada	**Patient factors:** Patient case mix **Environmental factors:** Hospital size **Staffing factors:** Skill mix; Nurse experience; RN agency proportion **Organizational factors:** Organizational policies about maximum patient length of stay	Patient satisfaction expressed through the nursing care variables: Answer Explain Trust Respect Courtesy Availability Doctor/Nurse working relationship	For each one percent increment in RN staff skill mix, there was an associated increase in overall patient satisfaction with care received in the ED of .05 on a scale of 0 to 100. The percent of full-time nursing worked hours was negatively associated with overall patient satisfaction with care with an estimate of -0.02 ($p<0.05$).
Study Aim	**Setting**			
To explore the relationship of nurse staffing and patient satisfaction with nursing care in emergency departments.	Type 1 A&E			
	Source population			
	All EDs in Ontario's acute care hospitals. All patients who completed the patient satisfaction survey between 2005/06 to 2009/10. The Ontario Healthcare Reporting Standards (OHRS) (measurement of staffing hours).	**If relevant, what was the comparison?**		
		N/A		
Study Design	**Selection procedure nurses**			
Retrospective observational	Not available			
		How was staffing measured?		
		Nurse to patient ratio and FTE		
		Patient/Nurse level adjustment		
		Heterogeneity of ED patients by demographic characteristics		
	Selection procedure patients	**Which nursing groups were measured?**		

	Census	Registered nurses		
		Sample size (Hospitals)		
		107		
Internal validity[i]	**Selection procedure A&E**	**Sample size (Patients)**		
+	Census	182022	**Statistical Analysis**	
External validity[i]		**Sample size (Nurses)**	Multivariate linear mixed regression models to assess the relationship between nurse staffing and patient satisfaction with nursing care (i.e., Answer, Explain, Trust, Respect, Courtesy, Availability and Dr-Nurse working relationship).	
+		Not available		

[i] : Internal validity rated as moderate due to moderate reliability of measures and procedures; moderately complete measurements; moderate control of confounding factors; moderately appropriate analytical methods.

[ii] : External validity rated as moderate due to sample moderately representative of the source population or area; the study was strongly powered to detect an effect.

<u>For other studies exploring "Patient Satisfaction" see also 5. Weichental, et al.</u>

- **TIME TO ANTIBIOTIC ADMINISTRATION FOR PNEUMONIA PATIENTS**

15. Chan, T. C., et al. (2009). "Impact of mandated nurse-patient ratios on time to antibiotic administration in the emergency department." Annals of Emergency Medicine Conference(var.pagings): 3.

Author (Year)	**Country**	**What was the intervention, change or phenomenon of interest?**	**Outcomes**	**Results**
Chan, et al, 2009	USA	Patient factors - patients requiring antibiotics in the ED, Staffing factors - Mandated Nurse Patient Ratios	Time to antibiotic administration in the emergency department.	Time to antibiotic administration was 24 minutes (IQR 11, 49) when nurse staff was IR, and 29 minutes (IQR 15, 60) when OOR. For patients diagnosed with pneumonia, time to antibiotics was 28 minutes (IQR 14, 54) overall, 27.5 minutes (IQR 14, 53) when IR, and 30 minutes (IQR 15, 71) when OOR. Using log-linear regression, after controlling for patient acuity at time of triage, hospital, and census at time of ED admission, there was no significant difference in terms of time to antibiotics overall or for patients diagnosed with pneumonia (8.2%, [CI 4.9 to 21.3%], p 0.221 overall and 16.0%, [CI 66.2 to 34.2%], p 0.531).
Study Aim	**Setting**			
To assess the effect of mandated NPRs on ED patient care, specifically time to antibiotic administration for pneumonia patients.	Type 1 A&E			
	Source population			
	Patients who received antibiotics during their ED stay in two EDs, an academic urban centre and a community hospital.	**If relevant, what was the comparison?**		
		Comparison of patient outcomes when staffing was in ratio (IR) and compared with staffing out of ratio (OOR), defined as when ED nurse had patient responsibilities greater than current State-mandated NPRs for more than 20 minutes of care time.		
Study Design	**Selection procedure nurses**			
Prospective observational	Convenience			
		How was staffing measured?		
		Nurse to patient ratio		
		Patient/Nurse level adjustment		
		The study (analysis and/or methods) do not give indication of patient/nurse level adjustment having been performed		
	Selection procedure patients	**Which nursing groups were measured?**		

	Census	ED RNs		
		Sample size (Hospitals)		
		2		
Internal validity[i]	**Selection procedure A&E**	**Sample size (Patients)**		
+	Convenience	5318	**Statistical Analysis**	
External validity[ii]		**Sample size (Nurses)**	Log-linear regression models were used to assess the effect of NPR status on medication administration time after controlling for ED census, admission rate and acuity.	
-		Not reported		

[i] : Internal validity rated as moderate due to strong reliability of measures and procedures; strongly complete measurements; weak control of confounding factors; moderately appropriate analytical methods.

[ii] : External validity rated as weak due to sample moderately representative of the source population or area; the study was not sufficiently powered to detect an effect.

<u>For other studies exploring "Time To Antibiotic Administration For Pneumonia Patients" see also 11. Sinclair, et al.</u>

Evidence tables for the simulation studies included in the review (*i.e.* **Brenner, S., et al.,** Modeling and analysis of the emergency department at university of Kentucky Chandler Hospital using simulations. Journal of Emergency Nursing, 2010. 36(4): p. 303-310; **Sinreich, D. and O. Jabali,** Staggered work shifts: A way to downsize and restructure an emergency department workforce yet maintain current operational performance. Health Care Management Science, 2007. 10(3): p. 293-308 and **Zeng, Z., et al.**, A Simulation Study to Improve Quality of Care in the Emergency Department of a Community Hospital. JEN: Journal of Emergency Nursing, 2012. 38(4): p. 322-328). have not been added due to lack of extractable data.

Appendix C. Search strategy and results

Databases, Host Years Searched Keywords Added	Search Strategy	Results
Ovid MEDLINE(R) 1946 to August Week 1 2014 Limited to 1994-2014 Searched 16/08/2014 Keywords: MEDLINE EMERGENCY NURSING SAFE STAFFING SEARCH KW	1 Nursing Staff, Hospital/ (38435) 2 Nursing Service Hospital/ (11693) 3 1 or 2 (47816) 4 exp Nurses/ (71171) 5 (nurse or nurses or nursing).tw. (318872) 6 (RN or "RNs" or "RN's").tw. (9147) 7 Nurses' Aides/ (3599) 8 ("healthcare assistant*" or "health care assistant*").tw. (354) 9 Nursing Administration Research/ (2253) 10 Nursing Audit/ (2979) 11 Models Nursing/ (11078) 12 or/4-11 (360241) 13 exp Hospitals/ (206502) 14 exp Hospital Units/ (79507) 15 hospital*.tw. (789951) 16 or/13-15 (930678) 17 12 and 16 (66472) 18 3 or 17 (100045) 19 Emergency Service, Hospital/ (44243) 20 ("emergency department*" or "emergency room*" or "emergency unit*" or "emergency ward*" or "emergency service*").tw. (60074) 21 ("accident and emergency" or "A&E").tw. (14641) 22 or/19-21 (90505) 23 18 and 22 (4427) 24 Emergency Nursing/ (5713) 25 ((emergency or "A&E") adj5 nurs*).tw. (3369) 26 24 or 25 (7797) 27 23 or 26 (10832) 28 (skill* adj1 mix*).tw. (636) 29 skillmix*.tw. (6) 30 (staffmix* or "staff mix*").tw. (78) 31 (specialism* or specialist*).tw. (57030) 32 (experience* or inexperience*).tw. (661839) 33 (casemix or "case mix").tw. (4481) 34 staffing.tw. (8736) 35 understaff*.tw. (378) 36 "under staff*".tw. (38) 37 "Personnel Staffing and Scheduling"/ or "Personnel Staffing and Scheduling Information Systems"/ (14608) 38 ("teamwork*" or "team work*").tw. (6820) 39 ((staff* or team) adj3 (level* or ratio* or management or resourc* or model* or program* or policy or policies or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or	5277

	supervision or supervisory or administration or administrative or organization or organisation or turnover or "co-ordination")).tw. (16479) 40 ((staff* or team*) adj3 (experienced or inexperienced or competen* or sufficient* or sufficiency or adequate* or knowledge or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage or efficient* or efficienc* or inefficien*)).tw. (6516) 41 Health Manpower/ (11371) 42 manpower.tw,fs. (61142) 43 Personnel Turnover/ (3953) 44 (workload* or workforce* or workflow* or workplace or shift or shiftwork* or shifts or overtime or capacity).tw. (543526) 45 Workload/ (15816) 46 Workplace/og, st [Organization & Administration, Standards] (2276) 47 ("under pressure" or stress* or burnout or "burnt out").tw. (480255) 48 "care left undone".tw. (4) 49 ("missed care" or "missing care" or "deficit in care").tw. (36) 50 ("never event*" or "preventable event*" or "serious event*" or "serious adverse" or "preventable death*").tw. (15243) 51 maladministrat*.tw. (16) 52 ("medication error*" or "drug error*").tw. (3309) 53 ("risk of harm" or "risk factor*").tw. (332461) 54 (patient* adj1 safety).tw. (13691) 55 ("time to" or timeliness).tw. (1856115) 56 Time Factors/ (1017265) 57 ("safe care" or safeguard* or "unsafe care" or negligen*).tw. (9627) 58 safeguard*.tw. (5889) 59 ("length of stay" or "duration of stay").tw. (27598) 60 (bed* adj2 number*).tw. (1058) 61 ("bed block*" or "bed occupancy").tw. (536) 62 (patient* adj2 flow*).tw. (4988) 63 (complex* adj2 patient*).tw. (7996) 64 "patient* acuity".tw. (442) 65 "patient* dependency".tw. (179) 66 "patient outcome*".tw. (22802) 67 "number of attendances".tw. (75) 68 "attendance pattern*".tw. (193) 69 "waiting time*".tw. (5770) 70 (crowding or crowded or overcrowding or overcrowded).tw. (10571) 71 "seasonal variation".tw. (6338) 72 (environment* or layout).tw. (534175) 73 health facility environment/ or health facility administration/ or health facility size/ (7582)	

	74 ("organi?ational culture*" or "organi?ational structure*").tw. (3460) 75 organizational culture/ (13146) 76 (model* adj2 triage).tw. (87) 77 (triage adj (system* or scoring)).tw. (484) 78 Triage/ma, mt, og, st [Manpower, Methods, Organization & Administration, Standards] (3580) 79 (patient* adj1 death*).tw. (4249) 80 (patient* adj1 mortality).tw. (3285) 81 (cost* or economic*).tw. (440683) 82 Knowledge Management/ (173) 83 Clinical Competence/ (66286) 84 Professional Competence/ (20507) 85 Accreditation/ (11536) 86 Safety Management/ (16668) 87 Management Audit/ (2390) 88 Quality Assurance, Health Care/ or Quality Improvement/ (54987) 89 Health Plan Implementation/ (3946) 90 Education, Continuing/ (7913) 91 Mentors/ (7613) 92 mentor*.tw. (7506) 93 Inservice Training/ (17395) 94 Problem Solving/ (21408) 95 Workflow/ (983) 96 Efficiency, Organizational/ or Efficiency/ (29526) 97 Program Evaluation/ or Program Development/ (62939) 98 Patient Outcome Assessment/ or "Outcome Assessment (Health Care)"/ or "Outcome and Process Assessment (Health Care)"/ (72633) 99 Practice Guidelines as Topic/ (81751) 100 Documentation/ (14150) 101 Interprofessional Relations/ (44021) 102 (nursing and hours and patient and day).tw. (358) 103 NHPPD.tw. (7) 104 (nurs* and hours and care).tw. (3630) 105 (nurs* and work* and hours).tw. (1976) 106 (nurs* adj3 "patient* ratio*").tw. (272) 107 "nurse-patient-ratio".tw. (56) 108 (nurs* adj3 "patient* number*").tw. (3) 109 (nurs* and "whole time equivalent*").tw. (27) 110 (nurs* adj5 (temporary or bank or agency)).tw. (722) 111 (nurs* and adequate* and staff*).tw. (1327) 112 (nurs* and inadequate* and staff*).tw. (721) 113 ("nurs* unit*" and (organi?ation or characteristic* or outcome* or level*)).tw. (451) 114 (nurs* and deployment).tw. (325) 115 (nurs* and staff* and burnout).tw. (382) 116 (nurs* and staff* and stress).tw. (1152) 117 (nurs* and staff* and experience*).tw. (5619)	

	118 (nurs* and staff* and inexperience*).tw. (86) 119 (nurs* and staff* and fatigue).tw. (143) 120 (nurs* and staff* and practice).tw. (6483) 121 (nurs* and staff* and policy).tw. (1431) 122 (nurs* and staff* and policies).tw. (877) 123 (nurs* and staff* and speciali?ation).tw. (59) 124 (nurs* and staff* and audit*).tw. (828) 125 (nurs* and (toolkit* or "tool kit*")).tw. (125) 126 (nurs* and (tool or tools)).tw. (10395) 127 (nurs* and magnet and staff*).tw. (141) 128 "magnet hospital*".tw. (241) 129 or/28-101 (5244134) 130 27 and 129 (6097) 131 or/102-128 (28804) 132 22 and 131 (1367) 133 130 or 132 (6512) 134 (comment or editorial or letter).pt. (1274658) 135 133 not 134 (6242) 136 limit 135 to (english language and yr="1994 - Current") (5277)	
Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations August 15, 2014 MEIP EMERGENCY NURSING SAFE STAFFING SEARCH KW Searched 16/08/2014	As per Medline	348
Embase Ovid 1974 to 2014 August 18 Searched 19/08/14 Keywords Added: EMBASE EMERGENCY NURSING SAFE STAFFING SEARCH KW	1 emergency nursing/ (5158) 2 (emergency adj5 nurs*).tw. (4037) 3 1 or 2 (8082) 4 (skill* adj1 mix*).tw. (799) 5 skillmix*.tw. (7) 6 (staffmix* or "staff mix*").tw. (88) 7 (specialism* or specialist*).tw. (87618) 8 inexperience*.tw. (5466) 9 (casemix or "case mix").tw. (5764) 10 staffing.tw. (11656) 11 understaff*.tw. (485) 12 "under staff*".tw. (48) 13 teamwork/ (11713) 14 ("teamwork*" or "team work*").tw. (9969) 15 ((staff* or team) adj3 (level* or ratio* or management or resourc* or model* or program* or policy or policies or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or administration or administrative or organization or organisation or	5313

	turnover or "co-ordination")).tw. (23811) 16 ((staff* or team*) adj3 (experienced or inexperienced or competen* or sufficient* or sufficiency or adequate* or knowledge or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage or efficient* or efficienc* or inefficien*)).tw. (10014) 17 manpower.tw. (7699) 18 health care manpower/ or manpower planning/ (10674) 19 (workload* or workforce* or workflow* or workplace or shift or shiftwork* or shifts or overtime or capacity).tw. (692852) 20 Workload/ (28485) 21 time management/ or turnaround time/ or time to treatment/ or turnover time/ or working time/ (21097) 22 organization/ or organizational efficiency/ (109840) 23 job satisfaction/ (22030) 24 work environment/ (16670) 25 ("under pressure" or stress* or burnout or "burnt out").tw. (639039) 26 "care left undone".tw. (6) 27 ("missed care" or "missing care" or "deficit in care").tw. (42) 28 ("never event*" or "preventable event*" or "serious event*" or "serious adverse" or "preventable death*").tw. (24296) 29 maladministrat*.tw. (22) 30 ("medication error*" or "drug error*").tw. (5434) 31 medication error/ (12563) 32 ("risk of harm" or "risk factor*").tw. (477548) 33 (patient* adj1 safety).tw. (21038) 34 timeliness.tw. (3114) 35 ("safe care" or safeguard* or "unsafe care" or negligen*).tw. (12822) 36 "length of stay".tw. (45496) 37 "duration of stay".tw. (2022) 38 (bed* adj2 number*).tw. (1705) 39 ("bed block*" or "bed occupancy").tw. (796) 40 (patient* adj2 flow*).tw. (7217) 41 (complex* adj2 patient*).tw. (12121) 42 "patient* acuity".tw. (609) 43 patient acuity/ (174) 44 "patient* dependency".tw. (205) 45 "patient outcome*".tw. (34932) 46 patient safety/ (54544) 47 outcome assessment/ (249514) 48 "number of attendances".tw. (110) 49 "attendance pattern*".tw. (227) 50 "waiting time*".tw. (8772) 51 (crowding or crowded or overcrowding or	

	overcrowded).tw. (13160) 52 "crowding (area)"/ (375) 53 "seasonal variation".tw. (8653) 54 (environment* or layout).tw. (715129) 55 ("organi?ational culture*" or "organi?ational structure*").tw. (4485) 56 (model* adj2 triage).tw. (113) 57 (triage adj (system* or scoring)).tw. (722) 58 (patient* adj1 death*).tw. (6453) 59 (patient* adj1 mortality).tw. (5433) 60 (cost* or economic*).tw. (618066) 61 Knowledge Management/ (859) 62 Clinical Competence/ (42776) 63 Accreditation/ (27022) 64 continuing education/ (27228) 65 professional development/ or professional competence/ or professional knowledge/ or professional standard/ (61491) 66 total quality management/ or "quality of nursing care"/ or quality control procedures/ (25995) 67 practice guideline/ (238485) 68 medical documentation/ (20823) 69 decision support system/ (13247) 70 (mentor* or coaching).tw. (13298) 71 Inservice Training/ (13784) 72 Problem Solving/ (26431) 73 Workflow/ (4265) 74 patient scheduling/ (934) 75 Program Evaluation/ or Program Development/ (19069) 76 health care quality/ or personnel management/ or "organization and management"/ (534065) 77 "magnet hospital*".tw. (249) 78 magnet hospital/ (17) 79 standard/ (334056) 80 or/4-79 (4335729) 81 3 and 80 (4387) 82 (nursing and hours and patient and day).tw. (671) 83 NHPPD.tw. (6) 84 (nurs* and hours and care).tw. (5847) 85 (nurs* and work* and hours).tw. (3092) 86 (nurs* adj3 "patient* ratio*").tw. (350) 87 "nurse-patient-ratio".tw. (78) 88 (nurs* adj3 "patient* number*").tw. (5) 89 (nurs* and "whole time equivalent*").tw. (48) 90 (nurs* adj5 (temporary or bank or agency)).tw. (811) 91 (nurs* and adequate* and staff*).tw. (2020) 92 (nurs* and inadequate* and staff*).tw. (1077) 93 ("nurs* unit*" and (organi?ation or characteristic* or outcome* or level*)).tw. (619) 94 (nurs* and deployment).tw. (444)	

	95 (nurs* and staff* and burnout).tw. (525) 96 (nurs* and staff* and stress).tw. (1642) 97 (nurs* and staff* and experience*).tw. (8350) 98 (nurs* and staff* and inexperience*).tw. (123) 99 (nurs* and staff* and fatigue).tw. (240) 100 (nurs* and staff* and practice).tw. (8978) 101 (nurs* and staff* and policy).tw. (2076) 102 (nurs* and staff* and policies).tw. (1204) 103 (nurs* and staff* and speciali?ation).tw. (92) 104 (nurs* and staff* and audit*).tw. (1879) 105 (nurs* and (toolkit* or "tool kit*")).tw. (239) 106 (nurs* and (tool or tools)).tw. (15330) 107 (nurs* and magnet and staff*).tw. (161) 108 or/82-107 (41302) 109 *emergency health service/ or *emergency ward/ (51096) 110 ("emergency department*" or "emergency room*" or "emergency unit*" or "emergency ward*" or "emergency service*").tw. (91789) 111 "accident and emergency".tw. (4735) 112 or/109-111 (122630) 113 108 and 112 (2325) 114 (emergency and nurs* and staffing).tw. (326) 115 (emergency and RN* and staffing).tw. (22) 116 81 or 113 or 114 or 115 (6383) 117 limit 116 to (english language and yr="1994 - Current") (5539) 118 limit 117 to (editorial or letter) (226) 119 117 not 118 (5313)	
Cinahl (CINAHL Plus with Full Text (Cumulative Index of Nursing and Allied Health Literature) Searched 22/08/2014 Internal server errors 3 times running on first download – abandoned at record 3040. On re-entering database on 26/08/2014 I went through many screens to return to the	Limited to source type academic journal = 5070 S88 S5 AND S87 **Limiters** - Published Date: 19940101-20141231; Language: English; Publication Type: Academic Journal, Clinical Trial, Critical Path, Journal Article, Meta Analysis, Meta Synthesis, Nursing Interventions, Practice Guidelines, Protocol, Randomized Controlled Trial, Research, Research Instrument, Research Instrument Utilization, Research Instrument Validation, Standards, Systematic Review, Teaching Materials (5,822) View Details Edit Interface - EBSCOhost Research Databases Database - CINAHL Plus with Full Text S87 S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43 OR S44 OR S45 OR S46 OR S47 OR S48 OR S49 OR S50 OR S51 OR S52 OR S53 OR S54 OR S55 OR S56 OR S57 OR S58 OR S59 OR S60 OR S61 OR S62 OR S63 OR S64	5070

correct page for download and got an Ebsco system error again. Decided to limit the search to the whole year where the database had gone odd before and exported that set and de-duplicated it internally afterwards.	OR S65 OR S66 OR S67 OR S68 OR S69 OR S70 OR S71 OR S72 OR S73 OR S74 OR S75 OR S76 OR S77 OR S78 OR S79 OR S80 OR S81 OR S82 OR S83 OR S84 OR S85 OR S86S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43 OR S44 OR S45 OR S46 OR S47 OR S48 OR S49 OR S50 OR S51 OR S52 OR S53 OR S54 OR S55 OR S56 OR S57 OR S58 OR S59 OR S60 OR S61 OR S62 OR S63 OR S64 OR S65 OR S66 OR S67 OR S68 OR S69 OR S70 OR S71 OR S72 OR S73 OR S74 OR S75 OR S76 OR S77 OR ...Show Less Search modes - Boolean/Phrase View Results (1,314,699) S86 (MH "Magnet Hospitals") (1,978) S85 TX (staff* N5 (bank or agency or temporary (6,488) S84 TX "whole time equivalent" (611) S83 TX ("tool kit*" or toolkit*) (8,573) S82 (MH "Burnout, Professional") (4,976) S81 AB "patient ratio*" (297) S80 TX "nurse-patient-ratio" (2,787) S79 (MH "Nurse-Patient Ratio") (2,248) S78 AB (nurs* and hours and patient* and day (836) S77 TX NHPPD (82) S76 (MH "Documentation") (21,125) S75 (MH "Practice Guidelines") (45,551) S74 (MH "Program Development") OR (MH "Program Planning") OR (MH "Program Implementation") OR (MH "Program Evaluation") (48,697) S73 (MH "Organizational Efficiency") (6,624) S72 TX mentor* (41,644) S71 (MH "Mentorship") (9,159) S70 (MH "Education, Nursing, Continuing (11,193) S69 (MH "Nursing Audit") (849) S68 (MH "Quality of Care Research") (1,073) S67 (MH "Accreditation") OR (MH "Magnet Hospital Accreditation") (7,881) S66 (MH "Professional Competence") OR (MH "Clinical Competence") OR (MH "Competency Assessment") (36,651) S65 TX (cost* or economic*) (454,164) S64 (MH "Costs and Cost Analysis") OR (MH "Health Care Costs") OR (MH "Cost Benefit Analysis") OR (MH "Cost Savings") OR (MH "Nursing Costs") OR (MH "Health Facility Costs") OR (MH "Cost Control") Search modes - Boolean/Phrase	

	View Results (69,526) S63 patient* N1 mortality (4,608) S62 TX patient* N1 death* (11,453) S61 TX (triage W1 (system* or scoring) (1,016) S60 TX model* N2 triage (144) S59 TX "outcome* assessment*" (27,583) S58 (MH "Outcome Assessment") (23,146) S57 TX ("organi?ational culture*" or "organi?ational structure*") (25,083) S56 (MH "Organizational Culture") (12,073) S55 TX (room* N5 (environment* or design* or layout*)) (4,918) S54 TX (unit* N5 (environment* or design* or layout*)) View Results (14,391) S53 TX (ward* N5 (environment* or design* or layout*)) (3,798) S52 (MH "Health Facility Environment") OR (MH "Work Environment") (21,983) S51 (MH "Hospital Design and Construction") OR (MH "Facility Design and Construction") (5,833) S50 TX "seasonal variation" (1,241) S49 TX (crowding or crowded or overcrowding or overcrowded) (10,535) S48 (MH "Crowding") (829) S47 TX "waiting time*" (8,345) S46 TX "attendance pattern*" (174) S45 TX "number of attendances" (104) S44 TX "patient* acuity" OR TX "patient* dependency" OR TX "patient* outcome*" (38,190) S43 TX (patient* N2 flow*) (7,133) S42 TX ("bed block*" or "bed occupancy") (3,642) S41 TX (bed* N2 number*) (4,033) S40 ("length of stay" or "duration of stay") (25,526) S39 (MH "Negligence") (3,912) S38 TX ("safe care" or safeguard* or "unsafe care" or negligen*) (29,608) S37 (MH "Time Factors") OR (MH "Turnaround Time") (101,008 S36 TX timeliness (4,735) S35 (MH "Patient Safety") (31,139) S34 TX patient* N1 safety (77,022) S33 (MH "Medication Errors") OR (MH "Health Care Errors") OR (MH "Treatment Errors") (18,277) S32 (MH "Risk Assessment") (51,349) S31 TX "risk of harm*" Search modes - Boolean/Phrase View Results (3,088) S30 TX ("medication error*" or "drug error*") (16,536)	

	S29 TX maladministrat* (74) S28 TX ("never event*" or "preventable event*" or "serious event*" or "serious adverse" or "preventable death*") (11,241) S27 TX ("missed care" or "missing care" or "deficit in care") (117) S26 TX "care left undone" (21) S25 ("under pressure" or stress* or burnout or "burnt out") (114,567) S24 (MH "Work Environment") (17,975) S23 (MH "Workload") OR (MH "Workload Measurement") (10,145) S22 (workload* or workforce* or workflow* or workplace or shift or shiftwork* or shifts or overtime or capacity) (89,470) S21 (MH "Personnel Turnover") (3,022) S20 TX manpower (25,659) S19 (MH "Health Manpower") (1,908) S18 ((staff* or team*) N3 (experienced or inexperienced or competen* or sufficient* or sufficiency or adequate* or knowledge or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage or efficient* or efficienc* or inefficien*)) (4,888) S17 ((staff* or team) N3 (level* or ratio* or management or resourc* or model* or program* or policy or policies or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or administration or administrative or organization or organisation or turnover or "co-ordination")) (29,098) S16 TX teamwork* (24,400) S15 TX team W1 work* (10,845) S14 (MH "Teamwork") (9,924) S13 (MH "Personnel Staffing and Scheduling (22,280) S12 TX understaff* OR TX "under staff*" (4,393) S11 TX staffing (51,205) S10 TX casemix* OR TX "case mix*" (4,901) S9 TX experience* OR TX inexperience* (481,357) S8 TX staffmix* OR TX "staff mix*" (766) S7 TX skill* N1 mix* (6,964) S6 TX skillmix* (64) S5 S1 OR S2 OR S3 OR S4 (13,841) S4 emergency N5 nurs* (13,204) S3 (MH "Emergency Nurses Association") (389) S2 (MH "Emergency Nursing+") (11,617) S1 (MH "Emergency Nurse Practitioners") (246)	
ECONLIT Ebsco Host Searched 26/08/2014	S5 S1 OR S2 OR S3 (26) S4 TX (ER and nurs*) (3) S3 hospital and emergency and nurs* (23) S2 (TX emergency N5 nurs* AND TX ((ward* or	26

Keywords: ECONLIT EMERGENCY NURSING SAFE STAFFING SEARCH KW	room* or unit*)) (3) S1 TX nurs* and emergency (26)	
Cochrane Library CDSR DARE CENTRAL HTA NHSEED Searched 26/08/2014 Keywords: COCHRANE CDSR COCHRANE CENTRAL COCHRANE HTA COCHRANE NHSEED CRD NHSEED EMERGENCY NURSING SAFE STAFFING SEARCH KW	#1 MeSH descriptor: [Emergency Service, Hospital] explode all trees (1796) #2 (nurse or nurses or nursing):ti,ab (12778) #3 (RN or "RNs" or "RN's"):ti,ab (173) #4 MeSH descriptor: [Nurses' Aides] this term only (51) #5 ("healthcare assistant*" or "health care assistant*") (46) #6 MeSH descriptor: [Nursing Administration Research] this term only (35) #7 MeSH descriptor: [Nursing Audit] this term only (49) #8 MeSH descriptor: [Models, Nursing] this term only (159) #9 #2 or #3 or #4 or #5 or #6 or #7 or #8 (12982) #10 #1 and #9 (174) #11 MeSH descriptor: [Emergency Nursing] this term only (58) #12 #10 or #11 (210) #13 MeSH descriptor: [Personnel Staffing and Scheduling] this term only (108) #14 skill* near/3 mix* (69) #15 staff* near/3 mix* (31) #16 staffing (9551) (9551) #17 (understaff* or "under staff*") (13) #18 ((staff* or team) near/3 (experienced or inexperienced or competen* or sufficient* or sufficiency or adequate* or knowledge or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage or efficient* or efficienc* or inefficien*)) (585) #19 ((staff* or team) near/3 (level* or ratio* or management or resourc* or model* or program* or policy or policies or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory or administration or administrative or organization or organisation or turnover or "co-ordination")) (2164) #20 MeSH descriptor: [Health Manpower] this term only (12) #21 manpower (526) #22 (workload* or workforce* or shift or shiftwork* or shifts or overtime or capacity):ti,ab (19549) #23 MeSH descriptor: [Burnout, Professional] this term only (131) #24 burnout (255)	CDSR 7 DARE 7 CENTRAL 73 HTA 1 NHSEED 7 **(Plus 3 from CRD NHSEED unique items added. Total N-98)**

	#25 #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 (29971) #26 #12 and #25 (73) #27 NHPPD (0) #28 "nursing hours" (14) #29 nurse* near/3 "patient ratio*" (48) #30 "nurse-patient ratio*" (29) #31 nurs* near/2 staffing (1685) #32 ("nurs* unit*" and (organi?ation or characteristic* or outcome* or level*)) (80) #33 nurs* near/5 burnout (28) #34 nurs* near/5 stress (251) #35 nurs* near/5 fatigue (68) #36 nurs* and magnet and staffing (39) #37 (nurs* and (skillmix* or "skill mix*" or "staffmix*" or "staff mix*")) (55) #38 (nurs* and ("patient dependency" or "patient acuity")) (24) #39 #27 or #28 or #29 or #30 or #31 or #32 or #33 or #34 or #35 or #36 or #37 or #38 (2143) #40 #1 and #39 (35) #41 #26 or #40 Publication Year from 1994 to 2014, in Other Reviews, Trials, Technology Assessments and Economic Evaluations (79) #42 ("emergency nurs*" and staffing) Publication Year from 1994 to 2014 (42) #43 #41 or #42 (97) #44 #12 and #39 Publication Year from 1994 to 2014 (24) #45 #43 or #44 (95) (nhseed searched in CRD Yok database and 3 records added in)	

Appendix D. Excluded studies during full assessment

Fee, C., et al. (2011). "Effect of emergency department crowding on pneumonia admission care components." American Journal of Managed Care **17**(4): 269-278.
EXCLUDED: Not eligible staff group

Grouse, A. I., et al. (2014). "A stream for complex, ambulant patients reduces crowding in an emergency department." Emergency Medicine Australasia **26**(2): 164-169.
EXCLUDED: Not eligible staff group

Hwang, J. I. (2006). "The relationship between hospital capacity characteristics and emergency department volumes in Korea." Health Policy **79**(2-3): 274-283.
EXCLUDED: Context differences, not level 1 A&E comparable to the UK context

Hwang, J. I. and H. Chang (2007). "Impact of nurse staffing level on emergency department market share." Health Care Management Review **32**(3): 245-252.
EXCLUDED: Context differences, not level 1 A&E comparable to the UK context

Kuntz, L. and S. Suelz (2013). "Treatment Speed and High Load in the Emergency Department--Does Staff Quality Matter?" Health Care Management Science **16**(4): 366-376.
EXCLUDED: Not eligible staff group

Lyons, M., et al. (2007). "Factors that affect the flow of patients through triage." Emerg Med J **24**(2): 78-85.
EXCLUDED: Not eligible staff group

Mathison, D. and J. Chamberlain (2011). "Evaluating the impact of the electronic health record on patient flow in a pediatric emergency department." Applied Clinical Informatics **2**(1): 39-49.
EXCLUDED: Context differences, not level 1 A&E comparable to the UK context

McHugh, M., et al. (2012). "Time and expenses associated with the implementation of strategies to reduce emergency department crowding." J Emerg Nurs **38**(5): 420-428.
EXCLUDED: Not eligible staff group

Morris, J., et al. (2010). "NSW Emergency Department workforce research project and workforce analysis tool... 8th International Conference for Emergency Nurses, The National Convention Centre, Canberra, 14-16, October 2010." Australasian Emergency Nursing Journal **13**(4): 137-137.
EXCLUDED: Not eligible staff group

Nielsen, A. L., et al. (2008). "Discrete event simulation as a tool in optimization of a professional complex adaptive system." Studies in Health Technology & Informatics **136**: 247-252.
EXCLUDED: Not OECD member country

O'Brien, A. and J. Benger (2007). "Patient dependency in emergency care: Do we have the nurses we need?" Journal of Clinical Nursing **16**(11): 2081-2087.
EXCLUDED: Not eligible staff group

Ross, M.A., et al., Maximizing use of the emergency department observation unit: a novel hybrid design. Annals of Emergency Medicine, 2001. 37(3): p. 267-274.

EXCLUDED: Intervention requiring bed management of a unit outside A&E

Rossetti, A. C., et al. (2014). "Determining workload and size of nursing team in the pediatric emergency department." Einstein **12**(2): 217-222.
EXCLUDED: Not OECD member country

Steele, R. and A. Kiss (2008). "EMDOC (Emergency Department overcrowding) Internet-based safety net research." Journal of Emergency Medicine **35**(1): 101-107.
EXCLUDED: No associations reported

Taylor, C. J., F. Bull, C. Burdis and D. G. Ferguson (1997). "Workload management in A&E: counting the uncountable and predicting the unpredictable." Journal of Accident & Emergency Medicine 14(2): 88-91.
EXCLUDED: No associations reported; Outside the date restriction

The following twenty-two studies were excluded from the review becaue staff and/or workload were not measured

Eliasoph, H. and C. Ashdown (1995). "Development, testing and implementation of an emergency services methodology in Alberta." Healthcare Management Forum **8**(1): 31-37.

Fry, M. and A. Rhodes-Sutton (2005). "A retrospective chart review of adult mortality characteristics of patients presenting to a principal tertiary emergency department." Accident & Emergency Nursing **13**(2): 122-125.

Fullam, C. (2002). "Acuity-based ED nurse staffing: A successful 5-year experience." Journal of Emergency Nursing **28**(2): 138-140.

Guttman, A., et al. (2004). "An emergency department-based nurse discharge coordinator for elder patients: does it make a difference?.[Erratum appears in Acad Emerg Med.2005 Jan;12(1):12]." Academic Emergency Medicine **11**(12): 1318-1327.

Howard, A., et al. (2014). "Improving the Prompt Identification of the Emergency Severity Index Level 2 Patient in Triage: Rapid Triage and the Registered Nurse Greeter." J Emerg Nurs.

Kunkel, A. and L. A. McLay (2013). "Determining Minimum Staffing Levels during Snowstorms Using an Integrated Simulation, Regression, and Reliability Model." Health Care Management Science **16**(1): 14-26.

McCue, J. Y., et al. (2013). "Effects of emergency department expansion on emergency department crowding." Academic Emergency Medicine **Conference**(var.pagings): 305.

McDonough, K. S. and M. Pemberton (2013). "Evaluation and development of an ED management model: an effort to optimize patient-centered care." J Emerg Nurs **39**(5): 485-490.

Paulson, D. L. (2004). "A comparison of wait times and patients leaving without being seen when licensed nurses versus unlicensed assistive personnel perform triage." J Emerg Nurs **30**(4): 307-311.

Perhats, C., et al. (2012). "Non-violence-related Workplace Injuries Among Emergency Nurses in the United States: Implications for Improving Safe Practice, Safe Care." Journal of Emergency Nursing **38**(6): 541-548.

Pham, J. C., et al. (2011). "Are temporary staff associated with more severe emergency department medication errors?" Journal for Healthcare Quality **33**(4): 9-18.

Raup, G. H. (2008). "The impact of ED nurse manager leadership style on staff nurse turnover and patient satisfaction in academic health center hospitals." J Emerg Nurs **34**(5): 403-409.

Roberts, J. (1998). "The effects of technology on triage in A & E." Accident and Emergency Nursing **6**(2): 87-91.

Rosmulder, R. W. and J. S. K. Luitse (2011). "The role of operations management in improving emergency department outflow." International Journal of Healthcare Technology and Management **12**(3-4): 293-306.

Rowe, B., et al. (2014). "Frequency, determinants, and impact of overcrowding in emergency departments in Canada: a national survey of emergency department directors (Structured abstract)." Health Technology Assessment Database(2014 Issue 1).

Schneider, S., et al. (2001). "Rochester, New york: A decade of emergency department overcrowding." Academic Emergency Medicine **8**(11): 1044-1050.

Schwartz, D., et al. (2011). "Mitigating emergency department over-crowding utilizing focused operations management tools." Value in Health **Conference**(var.pagings): 7.

Turley, S. (1997). "Development of the 'Euro Rota' in A & E." Accident and Emergency Nursing **5**(4): 178-180.

Welling, A. (2006). "Registered children's nurses in emergency departments in England: an exploratory survey." Paediatric Nursing **18**(6): 14-17.

Worster, A., et al. (2006). "Identification of root causes for emergency diagnostic imaging delays at three Canadian hospitals." J Emerg Nurs **32**(4): 276-280.

Yen-Ju Lin, B., et al. (2012). "Relationships of hospital-based emergency department culture to work satisfaction and intent to leave of emergency physicians and nurses." Health Services Management Research **25**(2): 68-77.

Young-Ritchie, C., et al. (2009). "The effects of emotionally intelligent leadership behaviour on emergency staff nurses' workplace empowerment and organizational commitment." Nursing leadership (Toronto, Ont.) **22**(1): 70-85.

References

Berwick, D. (2013). A promise to learn—a commitment to act. Improving the safety of patients in England. National Advisory Group on the Safety of Patients in England, London: Stationery Office.

Brenner, S., Z. Zeng, Y. Liu, J. Wang, J. Li and P. K. Howard (2010). "Modeling and analysis of the emergency department at university of Kentucky Chandler Hospital using simulations." Journal of Emergency Nursing **36**(4): 303-310.

Brown, L., A. O. Arthur, B. Lynch, W. Gray, N. Zumwalt, J. M. Goodloe, J. Dixon and S. H. Thomas (2012). "Impact of nursing short-staffing and emergency department left without being seen." Annals of Emergency Medicine **Conference**(var.pagings): 4.

Chan, T. C., J. P. Killeen, G. M. Vilke, J. B. Marshall and E. M. Castillo (2010). "Effect of mandated nurse-patient ratios on patient wait time and care time in the emergency department." Academic Emergency Medicine **17**(5): 545-552.

Chan, T. C., G. M. Vilke, J. P. Killeen, D. A. Guss, J. Marshall and C. M. Edward (2009). "Impact of mandated nurse-patient ratios on time to antibiotic administration in the emergency department." Annals of Emergency Medicine **Conference**(var.pagings): 3.

Crouch, R. and S. Williams (2006). "Patient dependency in the emergency department (ED): Reliability and validity of the Jones Dependency Tool (JDT)." Accident and Emergency Nursing **14**(4): 219-229.

Daniel, I. (2012). The Relationship between Nurse Staffing and Patient Satisfaction in Emergency Departments. Ph.D., University of Toronto (Canada).

Francis, R. (2010). Independent inquiry into care provided by mid Staffordshire NHS Foundation Trust January 2005-March 2009, The Stationery Office.

Francis, R. (2013). "The Mid Staffordshire NHS Foundation Trust Public Inquiry—Chaired by Robert Francis QC." Report of the Mid Staffordshire NHS Foundation Trust Public Inquiry. Executive summary. TSO, London.

Greci, L. S., C. E. Parshalle, A. Calvitti and M. J. Renvall (2011). "CrowdED: crowding metrics and data visualization in the emergency department." Journal of Public Health Management & Practice **17**(2): E20-E28.

Green, L. V., S. Savin and N. Savva (2013). ""Nursevendor Problem": Personnel Staffing in the Presence of Endogenous Absenteeism." Management Science **59**(10): 2237-2256.

Harris, A. and A. Sharma (2010). "Access block and overcrowding in emergency departments: an empirical analysis." Emergency Medicine Journal **27**(7): 508-511.

Hobgood, C., J. Villani and R. Quattlebaum (2005). "Impact of emergency department volume on registered nurse time at the bedside." Annals of Emergency Medicine **46**(6): 481-489.

Hoxhaj, S., M. G. Moseley and C. L. Reese (2004). "Nurse staffing levels affect the number of emergency department patients who leave without treatment." Academic Emergency Medicine **11**(5): 459.

Keogh, B. (2013). Review into the quality of care and treatment provided by 14 hospital trusts in England: overview report, NHS.

Korn, R. and M. Mansfield (2008). "ED overcrowding: an assessment tool to monitor ED registered nurse workload that accounts for admitted patients residing in the emergency department." J Emerg Nurs **34**(5): 441-446.

Rathlev, N. K., D. Obendorfer, L. F. White, C. Rebholz, B. Magauran, W. Baker, A. Ulrich, L. Fisher and J. Olshaker (2012). "Time series analysis of emergency department length of stay per 8-hour shift." The Western Journal of Emergency Medicine **13**(2): 163-168.

Schull, M. J., K. Lazier, M. Vermeulen, S. Mawhinney and L. J. Morrison (2003). "Emergency department contributors to ambulance diversion: a quantitative analysis." Ann Emerg Med **41**(4): 467-476.

Sinclair, L., R. Hunter, S. Hagen, D. Nelson, J. Hunt and E. M. H. S. Group (2006). "How effective are mental health nurses in A&E departments?" Emergency Medicine Journal **23**(9): 687-692.

Sinreich, D. and O. Jabali (2007). "Staggered work shifts: A way to downsize and restructure an emergency department workforce yet maintain current operational performance." Health Care Management Science **10**(3): 293-308.

Weichenthal, L. and G. W. Hendey (2011). "The effect of mandatory nurse ratios on patient care in an emergency department." Journal of Emergency Medicine **40**(1): 76-81.

Zeng, Z., X. Ma, Y. Hu, J. Li and D. Bryant (2012). "A Simulation Study to Improve Quality of Care in the Emergency Department of a Community Hospital." JEN: Journal of Emergency Nursing **38**(4): 322-328.