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The association between patient safety outcomes and nurse / healthcare assistant skill mix and staffing levels & factors that may influence staffing requirements

Authors: Peter Griffiths, Jane Ball, Jonathan Drennan, Liz James, Jeremy Jones, Alejandra Recio-Saucedo, Michael Simon.

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Executive Summary

Introduction

Identifying safe approaches to nurse staffing in hospital wards is a key challenge for health service providers. 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 and efficient staffing in acute adult inpatient wards.

This review is the first of two reviews to inform the safe staffing guideline. It aims to explore evidence to inform guidance related to the following three sets of questions, set out in the scope.

1. What patient safety outcomes are associated with nurse and healthcare assistant staffing levels and skill mix?
    a. What outcomes are associated with tasks undertaken by registered nurses, healthcare assistants (HCA), and other staff?
    b. Which outcomes should be used as indicators of safe staffing?
2. What patient factors affect nurse and healthcare assistant staffing requirements at different times during the day? These include:
    a. Patient dependency and acuity assessment and grading
    b. Patient turnover.
3. How does the ward environment, including physical layout and diversity of clinical disciplines, affect safe staffing requirements?

Methods

The review considered studies from 1993 and onwards. We aimed to identify relevant review papers, primary research and economic analyses. For question 1 we considered primary research exploring associations between ward based hospital staffing levels, skill mix and outcomes. For questions 2&3 we considered reviews and additional primary studies reporting factors influencing staffing requirements and studies showing the effects of relevant factors on outcomes. We conducted an extensive search of a wide range of

databases identifying 12146 items to screen. To this we added relevant material from existing reviews and personal libraries. In total 46 primary studies, reviews and economic studies were identified. Studies were critically appraised using an adapted version of the NICE quality appraisal checklist for quantitative studies reporting correlations. We undertook a narrative synthesis of evidence.

Results

What patient safety outcomes are associated with nurse and healthcare assistant staffing levels and skill mix?

Thirty-five eligible studies explored the relationship between outcomes and nurse staffing levels or skill mix. All the studies were observational and most analysed data in a cross sectional fashion and therefore no direct causal inference can be made from the observed associations. Only one included study was undertaken in the UK. Only 4 studies were assessed as strong for both external and internal validity and of these studies only one gave a temporal association and the possibility of assessing causation.

Registered / all nurse staffing levels and patient outcomes.

- There is evidence from large observational studies, of good quality (internal validity ++) that hospitals / units with higher nurse staffing have lower rates of **mortality** (Blegen et al., 2011, Needleman et al., 2011, Sales et al., 2008, Sochalski et al., 2008) and **failure to rescue** (Park et al., 2012, Twigg et al., 2013) .
- There is mixed evidence on the association between nurse staffing levels and **hospital acquired infections**. No studies showed a significant association with catheter associated UTI. One weak study (-) showed a significant association between low staffing and higher rates of pneumonia (Duffield et al., 2011) but 1 strong study showed a significant association in the opposite direction (Twigg et al., 2013). One study (++ for internal validity) showed higher rates of surgical site infection to be associated with lower staffing (Twigg et al., 2013). Two studies, ++ & - for internal validity, showed significant negative associations between staffing and other infections (Blegen et al., 2008, Duffield et al., 2011).

- There is evidence of an association between staffing levels and **falls** from 3 (+ or ++) studies (Donaldson et al., 2005, Patrician et al., 2011, Potter et al., 2003). Evidence from non-significant studies supports this direction of association.
- Evidence is mixed for an association with **pressure ulcers**. Three studies (+, -,- for internal validity) found significant negative associations between staffing levels and ***pressure ulcers*** with lower staffing associated with lower rates of ulcers (Donaldson et al., 2005, Duffield et al., 2011, Hart and Davis, 2011) but 2/12 studies, both rated as strong for internal validity (++), found a significant association in the opposite direction (Cho et al., 2003, Twigg et al., 2013).
- Evidence from three studies (internal validity -,-,++) found no association between nurse staffing levels and **venous thromboembolism** (Duffield et al., 2011, Ibe et al., 2008, Spetz et al., 2013).
- Three small studies with low / moderate (-,+,-) internal validity gave no significant association with **satisfaction** (Potter et al., 2003, Seago et al., 2006, Ausserhofer et al., 2013).
- There is strong evidence showing lower hospital use in terms of **length of stay** (Blegen et al., 2008, Frith et al., 2010, O'Brien-Pallas et al., 2010b, Spetz et al., 2013) or **readmission** (Weiss et al., 2011) is associated with higher levels of nurse staffing**.** The evidence includes some studies with strong internal validity (++, ++, +, + and -).
- Limited evidence from two studies (Shever et al., 2008, Twigg et al., 2013) suggests that cost of care is increased with higher nurse staffing levels although the picture is mixed with the lowest staffing levels also associated with increased hospital costs**.**

None of the studies were undertaken in the UK and few were rated highly for external validity, however the evidence is derived from a diverse range of settings including from studies which draw on nationally representative samples of hospitals in developed countries.

Registered / all nurse staffing levels and care processes / nurse outcomes

- There is some strong evidence that a lower level of nurse staffing is associated with higher rates of **drug administration errors** (Frith et al., 2012, O'Brien-Pallas et al., 2010a, Patrician et al., 2011) (rated as ++,+,-) and **missed nursing care** (Ball et al.,

2013, Tschannen et al., 2010, Weiss et al., 2011) (rated as ++,++,-) including paperwork (Ball et al., 2013).

- There is also some contradictory evidence on drug administration errors with one study (Blegen and Vaughn, 1998) of moderate internal validity (+) finding that wards with more nursing staff had significantly higher error rates.
- No significant relationships were found from five studies that reported nurse outcomes (Ausserhofer et al., 2013, O'Brien-Pallas et al., 2010a, O'Brien-Pallas et al., 2010b, Staggs and Dunton, 2012, Tschannen et al., 2010) but the overall quality of this evidence was moderate to low internal validity (three studies rated +, 2 rated -)

Health care assistant staffing and outcomes.

- Studies of moderate and low internal validity (+,-) found no association with mortality (Unruh et al., 2007), failure to rescue (Park et al., 2012), length of stay (Unruh et al., 2007), VTE (Ibe et al., 2008) or missed care (Ball et al., 2013).
- Studies with moderate to low internal validity (+,-) found that higher HCA staffing was associated with higher rates of falls (Hart and Davis, 2011, Lake et al., 2010) pressure ulcers (Seago et al., 2006), readmission rates (Weiss et al., 2011), medication errors (Seago et al., 2006), physical restraints (Hart and Davis, 2011) and lower patient satisfaction (Seago et al., 2006).
- One weak study (-) found that higher HCA staffing levels were associated with lower rates of pressure ulcers (Ibe et al., 2008).
- There were no studies looking at associations with costs, infections or nurse outcomes.

Skill mix and patient outcomes.

- Studies with high internal validity (++) found that a higher proportion of registered nurses on wards is associated with a significantly lower rate of death (Estabrooks et al., 2005, Shekelle, 2013) or failure to rescue (Blegen et al., 2011).
- Studies of mixed quality (++,++,-) found a significant association between a higher proportion of RNs in the nursing workforce and lower rates of **pneumonia** (Cho et al., 2003) **surgical site infection** (McGillis Hall et al., 2004) lower post-operative sepsis

(Blegen et al., 2011) but one study with low internal validity (-) found that higher rates of pneumonia were associated with a richer skill mix.

- Four studies (internal validity ++,+,+, -) found that a richer RN skill mix was associated with significantly fewer falls (Blegen and Vaughn, 1998, Donaldson et al., 2005, Duffield et al., 2011, Patrician et al., 2011).
- Three weak studies (all -) found that a richer RN skill mix was associated with fewer pressure ulcers (Blegen et al., 2011, Duffield et al., 2011, Ibe et al., 2008).
- Two weak studies (internal validity -) provided no evidence of association between skill mix and **VTE** (Duffield et al., 2011, Ibe et al., 2008).
- A single moderate study (+) showed significantly fewer complaints with a richer RN skill mix (Potter et al., 2003).
- Two weak studies (-) indicated that a richer RN skill mix might be associated with lower resource use in terms of hospital stay (Frith et al., 2010) or total nursing hours and overall cost of nursing hours (McGillis Hall et al., 2004).

Skill mix and care processes or nurse outcomes.

- No study found significant associations between skill mix and missed care but one (Blegen, 1998) (moderate internal validity, +) found no significant interaction effect between staff groups, suggesting that the level of RN staffing is the important determinant of the missed care rate.
- A single study of moderate internal validity found that a richer RN skill mix was significantly associated with lower turnover (Staggs and Dunton, 2012).

Economic studies of nurse staffing and skill mix

- The costs of increased nurse staffing may not be offset by savings from better patient or system outcomes (such as reduced hospital stays) although some scenarios modelled did suggest additional costs of increased staffing might be more than offset by savings from improved patient outcomes and thus lead to a net saving (Needleman et al., 2006).
- Studies suggest that increasing nurse staffing has the potential to be cost-effective in terms of cost per life year saved (Twigg et al., 2013), that increasing Registered Nurse staffing (rather than licensed practical nurse staffing (Needleman et al., 2006))

on general (medical/surgical) wards (rather than ICU (Shamliyan et al., 2009)) may be more cost effective than the alternatives.

Because none of the economic studies was conducted in the UK, used an NHS perspective or adopted evidence of the impact of nurse staffing levels on outcomes from the NHS, the results of the studies are of limited value in informing decision-making in the NHS context.

Factors affecting staffing requirements

We found five reviews, seventeen primary studies reporting the relationship between relevant factors and outcomes and two studies directly measuring associations with measured staffing levels. We found no economic evidence relevant to this section of the review. One review of 58 studies found:

- There is little objective and validated information regarding the systems to determine staffing requirements.
- There is a lack of standardization of measures.
- Systems to determine staffing requirements do not adequately capture nursing work and provide insufficient accuracy for resource allocation or for decision making.

- Evidence from five primary studies, including studies with high internal validity (++, ++,++,+,-) show that turnover is associated with patient outcomes, indicating it has an impact on nurse workload and hence staffing requirements (Donaldson et al., 2005, Duffield et al., 2011, Needleman et al., 2011, Patrician et al., 2011, Park et al., 2012).
- Two reviews support this conclusion, indicating that turnover increases staffing requirements (Fasoli and Haddock, 2010, Myny et al., 2011).
- Limited evidence from 1 primary study (Blegen et al., 2008) (internal validity +) and two reviews (Fasoli and Haddock, 2010, Myny et al., 2011) indicate lower staffing levels on larger wards. However the apparent efficiencies are not supported by evidence of equivalent outcomes and may be associated with poorer staff perceptions.

- Multiple observational studies support a link between patient acuity and dependency and patient outcomes (Duffield et al., 2011, Frith et al., 2010, Frith et al., 2012, McGillis Hall et al., 2004, Shekelle, 2013, O'Brien-Pallas et al., 2010b, Park et al., 2012, Patrician et al., 2011, Potter et al., 2003, Sales et al., 2008, Unruh et al., 2007).
- Three reviews conclude that increased dependency and acuity is associated with staffing requirements (Edwardson and Giovannetti, 1994, Fasoli and Haddock, 2010, O'Brien-Pallas et al., 2005).
- Eight studies found differences in outcomes between wards with different case mix (Blegen and Vaughn, 1998, Duffield et al., 2011, Frith et al., 2012, Hart and Davis, 2011, Lake et al., 2010, Sales et al., 2008, Seago et al., 2006, Unruh et al., 2007) and four studies (Unruh et al., 2007, Sales et al., 2008, Frith et al., 2010, Duffield et al., 2011) identified case mix as a factor independent of acuity.
- Two reviews (Fasoli and Haddock, 2010, Myny et al., 2011) supported this by identifying case mix / ward type as a factor affecting staffing requirements but no studies give clear evidence of specific differences in staffing requirements between ward types (e.g. medical vs surgical or care of older people).
- Nurse sensitive adverse outcomes are shown to vary by time of day and day of the weeks in two studies (Ball et al., 2013, Patrician et al., 2011) suggesting a variation in nursing workload or that mismatches between staffing requirement and available staff may vary according to these factors.
- Only one study with high risk of bias (-,-) was found showing an association between staffing levels and **ward layout**. This found that 'racetrack' style wards had lower staffing but there was no assessment of staffing adequacy or control for dependency/acuity in this study.

Discussion

The evidence we found has identified a number of outcomes that appear to be associated with nurse staffing levels on general medical and surgical wards. These are consistent with evidence derived from studies using hospital level staffing and studies that do not control for care assistant staffing (e.g. Kane et al., 2007a, Shekelle, 2013). The evidence does not give strong support for the validity of any single outcome as an indicator of adequate nursing staff specifically. However, infections, falls, pressure ulcers, drug administration

errors and missed care all remain plausible outcomes although they are potentially difficult to interpret and implement.

We found no evidence to support a positive role of health care assistants in patient safety outcomes. Some evidence points to a negative effect. In relation to costs, evidence suggests that increases in nurse staffing and / or a richer skill mix have a potential to be cost-effective but the existing evidence is derived from observational studies in countries with very different contexts and cost bases to the UK and so cannot be used to directly estimate the consequences of change.

Methods for determining staffing adequacy are not well validated but we identified a number of variables that may affect staffing requirements. Patient turnover, dependency/ acuity and ward case mix are associated with outcomes that are in turn influenced by nurse staffing and there is some evidence that these are independent factors. While some weak evidence points to day of week, time of day and ward configuration (size and layout) as potentially influencing staffing requirements the evidence is not strong and its implications unclear.

The diverse evidence base in terms of contexts, outcomes, measures of staffing and methods of analysis renders any attempt to directly derive safe staffing levels that could apply to the NHS context from this research, premature.

Conclusions & recommendations

Currently the NHS safety thermometer collects data on a range of potentially nurse sensitive outcomes including pressure ulcers, falls, catheter-related and urinary tract infections, venous thromboembolism. While all are important, their ability to be used as indicators of safe staffing is unclear.

We conclude that nurse staffing is linked to a number of patient safety outcomes but these outcomes are all problematic as indicators of safe nursing care. The most promising indicators are:

- Falls

- Medication administration errors
- Missed nursing care

Pressure ulcers and infections may also have a role but direct comparison between units is unlikely to be valid.

While evidence is not always strong, it appears to indicate that registered nurses are the key group in achieving patient safety. Determination of the required levels of health care assistant staffing requires consideration of different factors than those considered in this review.

Determination of safe staffing levels needs to take into account ward case mix, acuity, dependency and patient turnover. Other factors may also influence staffing requirements including ward layout and size but the evidence is not strong.

Evidence gaps / need for future research

This review has identified significant evidence gaps, most significantly a small amount of research undertaken in the UK that could better identify relationships between different staffing configurations and patient safety outcomes.

- Few studies here have analysed data in a manner that allows the effect of actual staffing levels, as opposed to variation in staffing to be readily determined. This might be remedied through a more detailed review and contact with authors but also presents a challenge for how staffing is modelled in future research.
- The outcomes measured generally represent failures of care, not positive 'quality'.
- Current measures of quality relevant to nurse staffing do not reflect contributions of health care assistants.
- There is insufficient evidence derived from the UK
- There is no economic evidence of direct relevance to inform NHS decision making

Much could be achieved if existing data were more suited to the purpose of identifying safe staffing

- In particular, the safety thermometer could be a rich source of data if minor additions that could facilitate risk adjustment were made to data gathered. Age of patient (as opposed to a single age related category of over 65) could be easily added as could simple patient level description related to case mix.
- Research to develop standard approaches to risk adjustment or stratification to facilitate comparison should be undertaken.
- Measures of missed care that can be routinely derived (as opposed to collected intermittently) should be investigated and validated by exploring their associations with outcomes
- Economic analyses based on NHS data are required to inform decision making

Introduction

Context in which the review is set

Identifying safe approaches to nurse staffing in hospital wards is a key challenge for health service providers. Recent inquiries, including the Keogh review into the quality of care and treatment provided by 14 hospital trusts in England and the inquiries into the Mid Staffordshire NHS Trust have highlighted the role of poor staffing levels on wards in deficits in care leading to excess mortality rates and poor patient experience (Keogh, 2013, The Mid Staffordshire NHS Foundation Trust Inquiry and Chaired by Robert Francis QC, 2010, The Mid Staffordshire NHS Foundation Trust Public Inquiry Chaired by Robert Francis QC, 2013). Safe nurse staffing requires that there are sufficient nurses available to meet patient needs, that the nurses have the required skills and are organised, managed and led in order to enable them to deliver the highest quality care possible.

Nurse staffing has consistently been linked to patient outcomes in systematic reviews (e.g. Kane et al., 2007a, Shekelle, 2013, Kane et al., 2007b). Most research in this field has focused on the association between registered nurse-to-patient ratios (or equivalent staffing measures) and patient outcomes. There is a large volume of studies (nearly 100 were reviewed in 2007), the majority of which are cross-sectional with analyses undertaken at a hospital level. However, registered nurses are not the only group delivering nursing care.

Unregistered practitioners (referred to here collectively as support staff or healthcare assistants) also deliver nursing care under the supervision of registered nurses. The skill mix of the nursing team (the mix of registered nurses and support staff) is also likely to be a significant factor in determining the cost effective delivery of safe care. While there is understandable interest in the potential to substitute unregistered support staff for registered nurses, the extent to which it can be done safely is an important question. Studies directly investigating the skill mix of registered nurses and support staff and its association with outcomes are less common. The results of these studies may give a basis on which to assess the potential for substitution between staff groups in the delivery of safety outcomes by allowing the calculation of substitution ratios where staffing from both groups

is positively associated with the outcome or, alternatively, may suggest that staffing for safety requires the contributions of each group to be considered separately.

Finally, the determination of safe staffing levels requires that the factors that impact upon staffing requirements are considered. This evidence review focusses on nurse staffing in general medical and surgical settings in acute care hospitals. However, such settings are unlikely to have uniform demands for nursing care. Patients vary in the nature, extent and the urgency of their need for nursing care. In addition, non-patient factors may significantly impact upon the workload of nurses including the number of admissions and discharges and the physical layout of the ward.

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 and efficient staffing in acute adult inpatient wards. The Francis report on Mid Staffordshire and the Berwick report on improving the safety of patients in England both identified NICE as a lead organisation in developing advice on NHS staffing levels. The Berwick report stated:

- 'NICE should interrogate the available evidence for establishing what all types of NHS services require in terms of staff numbers and skill mix to ensure safe, high quality care for patients' (Berwick, 2013)

The need for guidelines on safe staffing was also highlighted in the recent policy documents and responses from the National Quality Board and Department of Health:

- 'How to ensure the right people, with the right skills, are in the right place. A guide to nursing midwifery and care staffing capacity and capability' National Quality Board (National Quality Board, 2013)
- 'Hard truths. The journey to putting patients first' Department of Health (Department of Health, 2013)

Overall, this review is intended to identify the evidence that will help determine the most effective and efficient balance of nursing and support staff to achieve patient safety outcomes.

Aims and objectives of the review

This review is the first of two reviews to inform the safe staffing guideline. It aims to explore evidence to inform guidance related to the following three groups of questions, set out in the scope.

1. What patient safety outcomes are associated with nurse and healthcare assistant staffing levels and skill mix?
    a. What outcomes are associated with tasks undertaken by registered nurses, healthcare assistants (HCA), and other staff?
    b. Which outcomes should be used as indicators of safe staffing?
2. How does the ward environment, including physical layout and diversity of clinical disciplines, affect safe staffing requirements?
3. What patient factors affect nurse and healthcare assistant staffing requirements at different times during the day? These include:
    a. Patient dependency and acuity assessment and grading
    b. Patient turnover

A second review (forthcoming) will focus on the following additional questions:

- What management approaches affect nurse and healthcare assistant staffing requirements?
    - What nursing staff supervisory and/or team management approaches are required?
    - What approaches for identifying required nurse staffing levels and skill mix are effective, and how frequently should they be used?
- What organisational factors influence safe staffing at a ward level? This includes:
    - Management structures and approaches
    - Organisational culture
    - Organisational policies and procedures, including staff training

Operational definitions

Below we outline our operational definitions of the terms 'nurse staffing', 'skill mix' and the 'nursing team'

Nurse staffing: the size and skill mix of the nursing team on hospital wards, relative to the number of patients cared for expressed as nursing hours per patient day, patients per nurse or an equivalent measure

Nursing team: the group of workers delivering 'hands on' nursing care on wards (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). Members of the nursing team may include both registered nurses and unregistered support workers or assistants, regardless of job titles.

Skill mix: the composition of the nursing team in terms of qualification and experience. This is typically expressed as a ratio of registered to unregistered staff but may encompass other measures of skill mix.

Identification of possible equality and equity issues

Underlying all questions about the delivery of health care are possible questions about equity and equality in terms of access to services, differential outcomes and representation within the research base. Once patients are admitted to hospital these issues are likely to manifest themselves on a micro level – in the interactions between staff or patients. It is clear that some patient groups, for example older people and those with cognitive impairment may be significantly more vulnerable than others and determination of safe staffing should be based upon objective assessment of need. The nature of the service being evaluated – ward based nursing care – which is universally accessed by patients admitted to hospital limits our ability to explore these issues. By focussing on care delivered to all patients in general care settings, including those delivering care to older people and identifying the factors influencing safe staffing, this review aims to provide an overview of all the available evidence but cannot compensate for omissions in that evidence.

Methodology

Because of the compressed time frame for this review and the large and diverse evidence base, we agreed a number of strategies with NICE. We undertook a single broad search for evidence relevant to all three sets of review questions. We drew on the comprehensive searching undertaken for Kane's (2007) systematic review of nurse staffing / outcomes associations to identify primary studies prior to 2006 and focussed our searches for primary research on the period afterwards (1993 onwards).

Because the associations between registered nurse staffing levels and patient outcomes, most particularly mortality, have already been established through several high quality reviews (e.g. Kane et al., 2007a, Shekelle, 2013) [1] we agreed with NICE that for question 1 we would include only those studies that properly controlled for the contribution of the entire nursing team (including HCA) and measured nurse staffing on wards in order to be able to address the core questions about skill mix by attributing outcomes to the relevant staff group. Thus cross sectional studies that do not include the whole nursing team are not considered[2]. This approach ensures that the evidence presented has the potential to give clarity about which staff groups and what combinations of staff can contribute to patient safety.

For questions about the wide range of factors influencing staffing requirements (2 & 3) we used primary studies eligible for question 1 that reported on associations between these

[1] 96 studies published up to mid 2006 were included in Kane's 2008 review

[2] This results in the exclusion of a number of well-known studies including one from the UK RAFFERTY, A. M., CLARKE, S. P., COLES, J., BALL, J., JAMES, P., MCKEE, M. & AIKEN, L. H. 2007. Outcomes of variation in hospital nurse staffing in English hospitals: Cross-sectional analysis of survey data and discharge records. *International Journal of Nursing Studies,* 44**,** 175-182. and a more recent European study AIKEN, L. H., SLOANE, D. M., BRUYNEEL, L., VAN DEN HEEDE, K., GRIFFITHS, P., BUSSE, R., DIOMIDOUS, M., KINNUNEN, J., KÓZKA, M., LESAFFRE, E., MCHUGH, M. D., MORENO-CASBAS, M. T., RAFFERTY, A. M., SCHWENDIMANN, R., SCOTT, P. A., TISHELMAN, C., VAN ACHTERBERG, T. & SERMEUS, W. 2014. Nurse staffing and education and hospital mortality in nine European countries: a retrospective observational study. *The Lancet*. showing cross-sectional associations between registered nursing staffing levels and mortality where the analysis does not control for non-registered staffing. Because of the paucity of economic studies we took a more inclusive approach and additionally considered studies that modelled the costs of staffing changes based on regression models where the measurement level of the original staffing data was at the hospital level. Full details are in the list of excluded studies in Appendix 3. See "Addendum" at the end of this report for a summary of Kane et al., 2007 & Shekelle, 2013

factors and outcomes and in addition undertook a review of reviews that reported studies that used a measure of staffing as an outcome.

Literature search and abstract appraisal

The review considered studies from 1993 and onwards. We aimed to identify relevant review papers, primary research and economic analyses. Two different search approaches were taken.

For the time period before 2006 we screened the 96 primary research studies included in the systematic review by Kane et al. (2007a), which conducted a comprehensive search of relevant primary studies until 2006 and applied broader inclusion criteria than ours.

For the period from 2006 to the end of January 2014 we searched all of the following databases to identify more recent primary research, reviews and economic studies.

- CEA registry
- CDSR
- CENTRAL
- CINAHL
- DARE
- Econlit
- Embase
- HTA database
- Medline including In-Process
- NHS EED
- HEED

In addition, we searched the Cochrane databases (CDSR, Central, DARE, HTA database) from 1993-2006 to identify other relevant reviews and additional primary research not considered by Kane et al. and undertook hand searching of volumes of Medical Care, Journal of Nursing Administration and the International Journal of Nursing Studies (2010-present). See appendix 1 for search strategies.

These searches resulted in a total of 12146 items to screen after removing duplicates, including 9268[3] from database searches from 2006 onwards, 966 from Cochrane database searches pre 2006 and 2162 references from journals to be hand searched. These were exported into an EndNote database for further processing.

Additional potentially relevant sources (primary studies, reviews and economic studies) were also identified from the following:

- Search of existing project databases held by team members
- Potentially relevant references supplied by the NICE team
- Backwards and forwards citation searching on key included studies (no unique material identified)
- Contact with topic experts from Belgium, England, USA, Australia and Canada studies (no unique material identified)

These yielded an additional 69 potential sources that were merged into the database after initial (title / abstract) screening along with the 96 primary studies from the Kane review.

Screening – title and abstracts

Initial screening of the project database was undertaken separately by 2 senior reviewers (Figure 1) who undertook a rapid screen of titles. Patently irrelevant material was excluded rapidly, leaving 454 items for more detailed consideration (Figure 1). These items were subjected to a more detailed second stage screen using a checklist covering the following major inclusion / exclusion criteria that could be readily verified against title / abstract:

- Studies of the association between hospital nurse staffing and eligible outcomes as defined by the scope

  OR

- Study of the eligible associations between factors influencing staffing requirements and a measure of nurse staffing levels / requirements

[3] Figure after removing duplicates across databases

AND

- General surgical, medical or mixed (medical-surgical) patient settings
- From 1993 onwards

AND (one or more of)

- Randomized or non-randomized controlled trials
- Prospective or retrospective observational study
- Cross-sectional or correlational study
- Interrupted time-series
- Economic analysis
- (Systematic) Review[4]

Exclusion criteria:

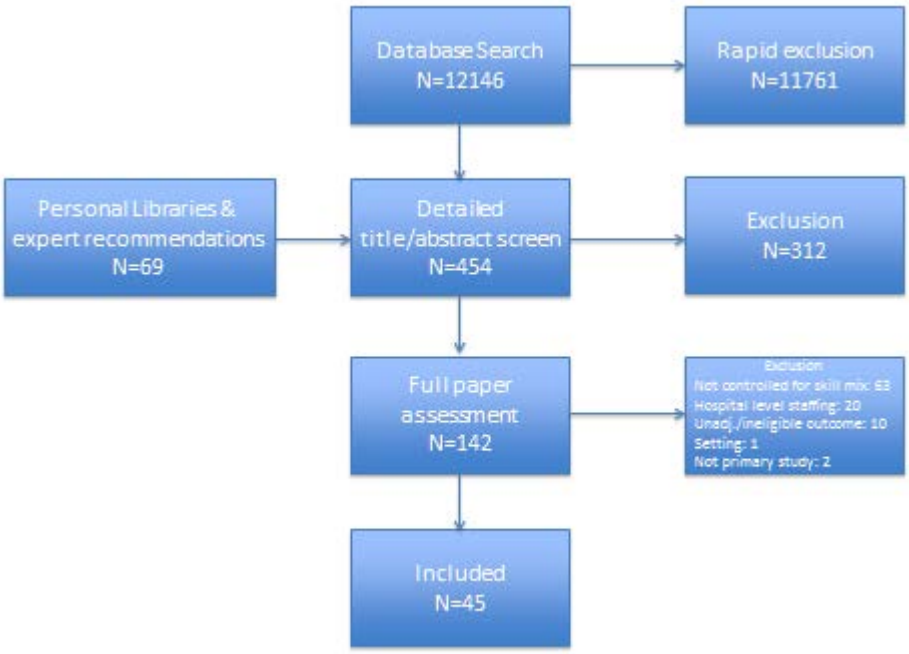
- Studies exclusively in intensive care, maternity, paediatric or mental health wards; out patients or long-term care
- General discussion / news articles with no empirical data or substantial literature review

At both stages of screening, samples of papers were screened by a second reviewer in order to check consistency. We identified no instances of disagreement over a paper that eventually moved forward to full appraisal (i.e. screened out by one reviewer but eventually identified as needing full appraisal).

For all questions both published and unpublished literature, which is publicly available including, papers in press ("academic in confidence") were considered. Only studies in English were considered. Potentially eligible papers went forward to full paper retrieval / appraisal.

[4] We checked the reference lists of relevant review articles for additional primary studies for question 1 but did not retain these for further detailed scrutiny. For questions 2&3, where we undertook a review of reviews, relevant review material was retained for further consideration.

Figure 1 selection of studies



Retrieval of data and full paper appraisal

142 papers were identified as requiring full paper appraisal (Figure 1). These were all retrieved and assessed using a checklist based on the detailed inclusion / exclusion criteria. Initially a single reviewer assessed against inclusion / exclusion criteria and abstracted data from included papers. A random sub-set of 10 papers were screened independently by a second reviewer with no disagreements identified. Subsequently, a second reviewer verified all decisions and checked data extractions. In the event of disagreement, where the first reviewer agreed that the decision was erroneous based on oversight of factual information the decision was changed. Where disagreement persisted or there was uncertainty a third reviewer was consulted and disagreements were resolved by consensus. In total 46 studies were included and 96 excluded. See Appendix 2 for included studies and 3 for excluded (with reasons).

Selection of studies for inclusion

We applied the following criteria to select studies for question 1.

Inclusion criteria:

- Studies of the association between hospital nurse staffing and eligible outcomes

- Randomized or non-randomized controlled trials
- Prospective or retrospective observational study
- Cross-sectional or correlational study
- Interrupted time-series
- Economic study based on data from any of the above
- General surgical, medical or mixed (medical-surgical) patient settings
- Nurse staffing measure is for staff delivering ward based nursing care measured as patient to nurse ratios, nurses per bed or nursing hours per patient day
- Nurse staffing by registered and unregistered nurses / nursing support staff included
- From 1993 onwards

Exclusion criteria:

- Studies exclusively in intensive care, maternity, paediatric or mental health wards; out patients or long-term care
- Nurse staffing *measured* at the hospital level[5]
- Studies which do not control for staffing by unregistered nursing / support staff
- Before and after studies without control groups
- Non-specific (global) nurse reports of care quality
- Mortality outcome (including failure to rescue) without adjustment for patient level risk factors
- Other clinical outcomes without risk adjustment or stratification

We considered a range of patient, process and nursing staff outcomes (Table 1)

[5] Because of the lack of economic evidence we did not apply this criterion when selecting potential economic studies. Economic studies had to report both costs of care delivery and costs associated with relevant outcomes

Table 1 Outcomes considered

• Serious preventable events • 'Never events' (serious, largely preventable safety incidents), 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 • 'Safety thermometer' including pressure ulcers, falls, catheter-related and urinary tract infections, venous thromboembolism – risk assessment and prophylaxis
• Delivery of nursing care • Patients receiving assistance with daily living activities, including missed care events such as help with eating, drinking, washing and other personal needs • Completion of vital signs observations and other clinical paperwork • Drug omissions and other nurse associated drug errors
• Reported feedback • Patient and/or carer experience and satisfaction ratings related to nursing care • Patient complaints related to nursing care • Staff experience and satisfaction ratings
• Other • Staff retention and sickness rates • Nurse and healthcare assistant vacancy rates • Costs, including both care, staff and litigation costs • Mortality • Hospital acquired infections • Length of admission • Hospital re-admission • Accident and emergency rates following discharge

For questions 2&3 we selected primary studies eligible for question 1 which report a measure of association between outcomes and the following potential effect modifiers:

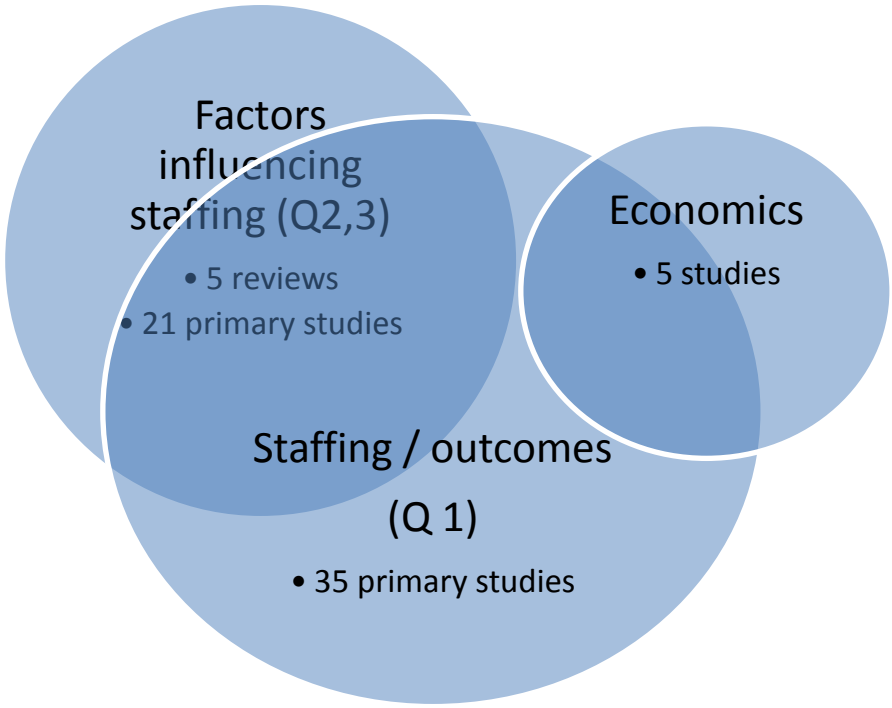
- Patient turnover
- Patient dependency / acuity
- Time of day
- Day of week
- Ward layout
- Ward size

- Seasonality
- Ward case mix (e.g. medical vs surgical wards)

In addition, to answer these questions we included reviews of studies that measured the effects of those factors identified above on direct measures of staffing or staffing requirements and primary studies published subsequent to the included reviews.

For question 1 we included 35 primary studies. For questions 2&3 we included 21 primary studies (19 in common with Q1) and five reviews. In addition we included 5 economic studies (2 in common with Q1). See Figure 2

Figure 2 Summary of studies included by review section



Quality assessment

Because most of the primary studies that were eligible for this review were cross sectional in nature, reporting associations between nurses staffing factors and outcomes, we adapted the NICE quality appraisal checklist for quantitative studies reporting correlations and

associations from the methods for development of NICE public health guidance (see Appendix 4 for an example of a completed checklist).

We adapted the prompts and major categories to fit the core quality issues relevant to the study questions at hand[6] . Questions about comparison groups were largely irrelevant and questions about control of confounding were explicitly addressed in terms of risk adjustment at individual and unit / hospital level. We added an item in order to identify studies which potentially assessed temporal associations, either because of longitudinal design and analysis based on *change* in staffing levels or because the temporal association between staffing and outcome was otherwise made clear.

The summary bias assessment was completed from a more detailed assessment that considered risk adjustment and data completion / sampling across multiple data sources outcome types and levels (see Appendix 4). 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[7] separately. We used the same checklist to summarise and appraise features of all studies that we included.

Quality assessments were undertaken by individual reviewers with checking by a second reviewer with disagreements resolved by consensus. A 10% sample of bias assessments were undertaken independently with no disagreements identified in overall ratings.

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[6] For example we combined questions 1.1. “is the source population well described?” & 1.2 “is the eligible population representative of the source population?” into a single item because of the restricted inclusion criteria.

[7] Items to assess internal validity related primarily to the design of the study. If a study is internally valid it is likely that the results and statistical conclusions accurately reflect associations between variables of interest in the observed groups. Items to assess external validity related primarily to the setting and sample and the extent to which there can be confidence that results will generalise to medical and surgical wards more widely.

Methods of data extraction

Data were extracted into Excel forms that included the initial screening criteria that were applied to all (full text) papers that were assessed. The content of the form was designed to gather data relevant to bias assessment and evidence tables (methods for development of NICE public health guidance). Evidence tables for each included study are presented in a separate document 'Evidence Tables'. For each staffing / outcome relationship reported we compiled a summary table (all staffing / RN staffing, HCA staffing. Skill mix) indicating the direction and significance of the relationships reported.

Synthesis and presentation

The results of the data extraction and quality assessment for each question are presented in a narrative summary. For staffing outcomes associations this is organised by the three major groups of outcomes

- patient outcomes & patient process outcomes such as length of stay
- process outcomes such as missed care and errors
- nurse outcomes such as satisfaction

Results are combined in a summary table showing the major relationships and overall quality assessments.

What patient safety outcomes are associated with nurse and healthcare assistant staffing levels and skill mix?

Introduction

This section of the review explores evidence of associations between nurse staffing levels and patient outcomes in order to answer the question "what patient safety outcomes are associated with nurse and healthcare assistant staffing levels and skill mix?" From this we aim to determine "what outcomes are associated with tasks undertaken by registered nurses, healthcare assistants, and other staff?" and "which outcomes should be used as indicators of safe staffing?"

Overview of studies

Thirty-five eligible studies explored the relationship between outcomes and nurse staffing levels or skill mix. Details of these studies are given in the accompanying evidence tables (see separate document 'Evidence Tables') and the quality ratings are summarised in Table 2 with design characteristics given in Table 3). All the studies were observational. While various descriptions were used for the designs, most analysed data in a cross sectional fashion and therefore no direct causal inference can be made from the observed associations.

Only six studies (Tschannen et al., 2010, Donaldson et al., 2005, Kutney-Lee et al., 2013, Needleman et al., 2011, Patrician et al., 2011, Ball et al., 2013) incorporated any kind of temporal analysis, where outcomes and staffing levels were directly linked either because one preceded the other or they were measured simultaneously. Typically these explored the association between changes in staffing levels (either at shift level or over time) and outcomes, while two studies (Ball et al., 2013, Tschannen et al., 2010) asked nurses to report on care left undone on their last shift due to lack of time, thus providing a subjective assessment of the link (see Table 3). This, while not providing any direct evidence of cause, does provide a temporal link between the staffing variable and the outcome which is absent from most studies where outcomes over a given period are associated with averaged staffing over the same period. Sample sizes varied from studies undertaken in hundreds of

hospitals (max 636) with millions of patients (max 26684752) to single centre studies and studies with less than 1000 patients (min patient sample 997).

Only one included study was undertaken in the UK (Ball et al., 2013). Seventeen studies were assessed as having significant weakness in either internal or external validity (or both). Only 4 studies (Shekelle, 2013, Patrician et al., 2011, Spetz et al., 2013, Sales et al., 2008) were assessed as strong for both external and internal validity and of these studies only one gave a temporal association and the possibility of assessing causation and none were undertaken in the UK (Table 3).

Table 2 Risk of bias summaries for studies relevant to question 1

Study	**Internal validity**	**External validity**	Temporal association
Ausserhofer 2013	-	++	**no**
Ball et al 2013	+	++	**subjective**
Blegen 2011	++	+	**no**
Blegen and Goode 1998	-	-	**no**
Blegen and Vaughn 1998	+	+	**no**
Chang 2011	-	++	**no**
Cho 2003	++	+	**no**
Donaldson 2005	+	++	**yes**
Duffield 2011	-	+	**no**
Estabrooks 2005	++	+	**no**
Frith 2010	-	-	**no**
Frith 2012	+	-	**no**
Hart 2011	-	-	**no**
He 2013	++	++	**no**
IBE 2008	-	+	**no**
Kutney lee 2013	++	+	**yes**
Lake 2010	+	+	**no**
Manojlvich 2011	-	-	**no**
McGillis Hall 2004	-	+	**no**
Needleman 2011	++	+	**yes**
O'Brien Pallas 2010	+	-	**no**
O'Brien Pallas 2010 b	-	-	**no**
Park 2012	++	+	**no**
Patrician 2011	++	++	**yes**
Potter 2003	+	-	**no**
Sales 2008	++	++	**no**
Seago 2006	-	-	**no**
Shever 2005	-	-	**no**
Sochalski 2008	++	+	**yes**
Spetz 2013	++	++	**no**
Staggs 2012	+	+	**no**
Tschannen 2010	+	++	**subjective**
Twigg 2013	++	+	**yes**
Unruh 2007	-	-	**no**
Weiss2011	+	-	**no**

Table 3 Summary of designs

Study	Country	Design[8]	n hospitals	N Units	N Patients[9]
Ausserhofer 2013	Swiss	CS	35	132	997
Ball et al 2013	UK	CS	46	401	-
Blegen 2011	US	CS	54	872	1100000
Blegen and Goode 1998	US	CS, RO	1	42	21783
Blegen and Vaughn 1998	US	RO	11	39	-
Chang 2011	US	CS	146	286	-
Cho 2003	US	RO	232	-	124 204
Donaldson 2005	US	PO	38	162	-
Duffield 2011	Australia	CS	19	80	2675428
Estabrooks 2005	Canada	CS	49	-	18 142
Frith 2010	US	CS	4	11	34838
Frith 2012	US	RO	1	11, 9	-
Hart 2011	US	CS, RO	5	26	-
He 2013	US	CS	128	446	236447
IBE 2008	Japan	CS, RO	42	87	317393 pat days
Kutney lee 2013	US	RO	134	0	467000
Lake 2010	US	CS	636	5388	-
Manojlvich 2011	US, Canada	RO	2	26	-
McGillis Hall 2004	Canada	CS	19	77	-
Needleman 2011	US	RO	1	43	197961
O'Brien Pallas 2010	Canada	PO	6	24	1198
O'Brien Pallas 2010 b	Canada	CS	41/39	182/163	8,138
Park 2012	US	CS, RO	42	759	1000000
Patrician 2011	US	RO	13	115 062 shifts	-
Potter 2003	US	PO	1	32	3 418
Sales 2008	US	RO, CS	123	453	129579
Seago 2006	US	RO	1	3	-
Shever 2005	US	RO	1	-	7851
Sochalski 2008	US	CS, RO	343	-	454 351
Spetz 2013	US	CS, RO	278	-	26684752
Staggs 2012	US	RO	306	1884	-
Tschannen 2010	US	CS	10	110	-
Twigg 2013	Australia	RO	3	-	214279
Unruh 2007	US	RO	1	6	15,192
Weiss2011	US	CS	4	16	1892

All studies were undertaken in what might be described as 'general' hospital settings although these ranged through studies with representative (census or random) samples of hospitals from large national or sub national regions (typically US states) to studies undertaken exclusively in teaching hospitals or US community hospitals (a term without specific meaning but that generally refers to smaller non-teaching hospitals offering general

[8] CS – cross-sectional, RO - retrospective observational, PO - prospective observational
[9] "-" indicates not reported

medical / surgical care but not high technology services, including intensive care). While for all included studies general medical / surgical care was the largest component of the care delivery or comprised the largest group of units, for some it was not possible to separate outcomes for patients cared for in other settings, most particularly patients cared for in ICU (see accompanying Evidence Tables).

Summary of the evidence

All nurse / registered nurse staffing; patient outcomes

In total, twenty eight studies reported associations between nurse staffing levels and the outcomes considered for the review (Table 4).

Table 4 Nurse staffing and patient outcomes[10]

Study	Country	Design	n hospitals	Internal validity	External validity	Staff groups	All deaths	Failure to rescue	CAUTI	pneumonia	surgical site	other / mixed infections	falls	pressure ulcer	vte	Length of stay	readmission	costs	any others
Ausserhofer 2013	Swiss	CS	35	-	++	All			▲ 1	▲ 1		▼ -1	▼ -1	▲ 1					▲ 1
Blegen 2011	US	CS	54	++	+	All	▲10	▲1				▲10		▲1		▲10			
Blegen and Goode 1998	US	CS, POI	1	-	-	All	▼-1					▼-1	▼-1	▼-1					▼-1
Blegen and Vaughn 1998	US	RO	11	+	+	All							▲1						▲1
Cho 2003	US	RO	232	++	+	All			▲1	▲1	▲1	▲1	▲1	▼10					
Donaldson 2005	US	PO	38	+	++	All							▲10	▲10					▲10
Duffield 2011	Australia	CS	19	-	+	RN			=0	▲10		▲10	=0	▲10	=0				
Frith 2010	US	CS	4	-	-	RN			=0					=0		▲10			
Hart 2011	US	CS, RO	5	-	-	All							▲1	▲10					▲1
He 2013	US	CS	128	++	++	All	▼-1												
IBE 2008	Japan	CS, RO	42	-	+	RN							=0	▼-1	=0				▼-1
Kutney lee 2013	US	RO	134	++	+	All	▼-1	▼-1											
Lake 2010	US	CS	636	+	+	RN							▲1						
Manojlvich 2011	US, Canada	RO	2	-	-	Composite score 'intensity' (FTE/rnptratio/RN-HPPD)						▲1	▲1						
Needleman 2011	US	RO	1	++	+	RN staffing (below target)	▲10												
O'Brien Pallas 2010	Canada	PO	6	+	-	All										▲10			▲10
O'Brien Pallas 2010 b	Canada	CS	41/39	-	-	All		=0								=0			=0
Park 2012	US	CS, RO	42	++	+	RN		▲10											
Patrician 2011	US	RO	13	++	++	ALL							▲10						
Potter 2003	US	PO	1	+	-	ALL							▲10						=0
Sales 2008	US	RO, CS	123	++	++	RN	▲10												
Seago 2006	US	RO	1	-	-	RN								▼-1					▲1
Shever 2005	US	RO	1	-	-	RN												=0	
Sochalski 2008	US	CS, RO	343	++	+	All	▲10	▼-1											
Spetz 2013	US	CS, RO	278	++	++	All		▲1						▼-1	▼-1	▲10			▼-1
Twigg 2013	Australia	RO	3	++	+	All	▲1	▲10	▲ 1	▼ -10	▲ 10	▼ -1		▼10				▲10	▲10
Unruh 2007	US	RO	1	-	-	RN	=0									=0			▲10
Weiss2011	US	CS	4	+	-	RN											▲10		

[10] In this and the following table numbers are used to indicate non-significant (1) or significant relationships (10). =/- indicates the direction - + indicates higher staffing is associated with better outcomes. Up and down arrows also indicate the direction of the outcome. Where a relationship was simply indicated as not significant this is indicated by a 0.

Nine studies studied reported ***mortality*** and seven ***failure to rescue*** (death among surgical patients with complications). See Table 4 for details. Four studies (all rated ++ for internal validity) showed significant associations between lower staffing (Registered Nurse [RN] or all nursing staff) and higher rates of death (Blegen et al., 2011, Needleman et al., 2011, Sales et al., 2008, Sochalski et al., 2008). Two studies (rated ++ for internal validity) showed significant associations between lower staffing (RN or all nursing staff) and higher rates of failure to rescue (Park et al., 2012, Twigg et al., 2013). No study showed a significant adverse relationship.

Eight studies reported infections as an outcome (see Table 4). No studies showed a significant association with catheter associated UTI although the direction of association was negative (fewer staff, more infections) in 3/5, with no study showing an association in the opposite direction (see Table 4). One study of four (rated – for internal validity) showed a significant association between low staffing and higher rates of pneumonia (Duffield et al., 2011). Two studies showed a similar direction of association that was not significant while one strong study (++) showed a significant association in the opposite direction (Twigg et al., 2013)[11] . Two studies, (both ++ for internal validity) showed higher rates of surgical site infection to be associated with lower staffing, although the relationship was significant in only one (Twigg et al., 2013). Two of seven studies, (++ & - for internal validity) showed significant negative associations between staffing and other infections (Blegen et al., 2008, Duffield et al., 2011).

Twelve studies reported ***falls*** (see Table 4). Three of the twelve (+ or ++) found significant negative associations with more staff associated with lower rates of falls (Donaldson et al., 2005, Patrician et al., 2011, Potter et al., 2003). Additionally 5 studies found the same direction of association but the results were not significant (see Table 4).

Twelve studies reported **pressure ulcers** (see Table 4). Three (1+, 2- for internal validity) found significant negative associations between staffing levels and ***pressure ulcers*** with

[11] This study is reported in several papers. For simplicity and consistency we give reference to the core source but all relevant papers are listed in the 'included studies' 2.

lower staffing associated with lower rates of ulcers (Donaldson et al., 2005, Duffield et al., 2011, Hart and Davis, 2011). However, 2/12 studies, both rated as strong for internal validity (++), found a significant association in the opposite direction, with units / hospitals that have more staff having higher rates of pressure ulcers (Cho et al., 2003, Twigg et al., 2013). While these studies are given an overall rating for high internal validity (++), the specific challenge of risk adjusting for pressure ulcers is not fully captured in this overall rating. Few studies have undertaken individual (patient level) adjustment for risk of falls or pressure ulcers and it is likely that apparently contradictory findings could be accounted for by risk factors (physical dependency, acute illness) being causally linked with staffing levels in the opposite direction – wards get more staff because they care for a lot of patients at risk of pressure ulcers (referred to as 'endogeneity'). A similar relationship might apply to some infections.

Three studies, including one rated as high internal validity (++), found no significant associations between nurse staffing and **venous thromboembolism** (see Table 4).

Six studies reported **length of stay** (see Table 4)**.** Four found that higher nurse staffing levels were associated with significantly shorter length of hospital stay (Blegen et al., 2008, Frith et al., 2010, O'Brien-Pallas et al., 2010b, Spetz et al., 2013). As with all studies showing an association, a cause and effect relationship should not be assumed. The intensity of demand for nursing care may be increased as hospital stays reduce and hence staffing is increased. However, irrespective of the direction of cause, the implication for nurse staffing levels appears to be the same.

One study showed a significant decrease in **readmission** to be associated with higher levels of nurse staffing (Weiss et al., 2011). Two studies reported on costs as a direct outcome (see below for more detail on economic analyses) with one showing hospital costs to be significantly increased at both the highest and lowest staffing levels (Shever et al., 2008) while another showed increased costs but a "favourable" cost per life year gained (AU$8907) associated with staffing increases (Twigg et al., 2013).

Three studies examined measures of patient **satisfaction** (Potter et al., 2003, Seago et al., 2006, Ausserhofer et al., 2013) but no significant relationships were found. All these studies were relatively small and two were single site studies. All had limitations in internal validity

(+,-,-). Other significant associations shown include lower staffing levels being associated with higher use of physical restraint (Donaldson et al., 2005) CNS complications and gastric bleeds (Twigg et al., 2013) quality of care (Clarke et al., 2002) and incident reports (Unruh et al., 2007).

Summary evidence statements

There is evidence from several studies including large observational studies that associates lower nurse staffing levels with increased rates of death and falls, shorter lengths of stay and lower readmission rates. There is similar but inconsistent evidence regarding infections and a contradictory evidence base regarding pressure ulcers. There is no evidence of an association with VTE and no strong evidence regarding satisfaction.

None of the studies in this section were undertaken in the UK and few were rated highly for external validity, however the evidence is derived from a diverse range of settings including from studies which draw on nationally representative samples of hospitals in developed countries.

- There is evidence from large observational studies, of good quality (internal validity ++) that hospitals / units with higher nurse staffing have lower rates of **mortality** (Blegen et al., 2011, Needleman et al., 2011, Sales et al., 2008, Sochalski et al., 2008) **and failure to rescue** (Park et al., 2012, Twigg et al., 2013) .
- There is mixed evidence on the association between nurse staffing levels and **hospital acquired infections**. No studies showed a significant association with catheter associated UTI. One weak study (-) showed a significant association between low staffing and higher rates of pneumonia (Duffield et al., 2011) but 1 strong study showed a significant association in the opposite direction (Twigg et al., 2013). One study(++ for internal validity) showed higher rates of surgical site infection to be associated with lower staffing (Twigg et al., 2013). Two studies, ++ & - for internal validity, showed significant negative associations between staffing and other infections (Blegen et al., 2008, Duffield et al., 2011).

- There is evidence of an association between staffing levels and **falls** from 3 (+ or ++) studies (Donaldson et al., 2005, Patrician et al., 2011, Potter et al., 2003). Evidence from non-significant studies supports this direction of association.
- Evidence is mixed for an association with **pressure ulcers**. Three studies (+, -, - for internal validity) found significant negative associations between staffing levels and ***pressure ulcers*** with lower staffing associated with lower rates of ulcers (Donaldson et al., 2005, Duffield et al., 2011, Hart and Davis, 2011) but 2/12 studies, both rated as strong for internal validity (++), found a significant association in the opposite direction (Cho et al., 2003, Twigg et al., 2013).
- Evidence from three studies (internal validity -,-,++) found no association between nurse staffing levels and **venous thromboembolism** (Duffield et al., 2011, Ibe et al., 2008, Spetz et al., 2013).
- Three small studies with low / moderate (-,+,-) internal validity gave no significant evidence on association with **satisfaction** (Potter et al., 2003, Seago et al., 2006, Ausserhofer et al., 2013).
- There is strong evidence showing lower hospital use in terms of **length of stay** (Blegen et al., 2008, Frith et al., 2010, O'Brien-Pallas et al., 2010b, Spetz et al., 2013) or **readmission** (Weiss et al., 2011) is associated with higher levels of nurse staffing**.** The evidence includes some studies with strong internal validity (two ++, two + and one -).
- Limited evidence from two studies (Shever et al., 2008, Twigg et al., 2013) suggests that cost of care is increased with higher nurse staffing levels although the picture is mixed with the lowest staffing levels also associated with increased hospital costs**.**

All nurse / registered nurse staffing: process outcomes & nurse outcomes

Thirteen studies reported associations between nurse staffing levels drug administration errors or missed care (Table 5).

Table 5 Nurse staffing and process outcomes

								Missed care		
Study	Country	Design	n hospitals	Internal validty	External validity	Staff groups	medication errors	general	paperwork	vital signs
Ausserhofer 2013	Swiss	CS	35	-	++	All	▲ 1			
Ball et al 2013	UK	CS	46	+	++	All		▲**10**	▲**10**	▲**1**
Blegen and Goode 1998	US	CS, RO	1	-	-	All	▲1			
Blegen and Vaughn 1998	US	RO	11	+	+	All	▼10			
Cho 2003	US	RO	232	++	+	All	▲1			
Frith 2012	US	RO	1	+	-	RN	▲10			
O'Brien Pallas 2010	Canada	PO	6	+	-	All		▲1	▲1	
O'Brien Pallas 2010 b	Canada	CS	41/39	-	-	All	▲10			
Patrician 2011	US	RO	13	++	++	ALL	▲**10**			
Potter 2003	US	PO	1	+	-	ALL	=0			
Seago 2006	US	RO	1	-	-	RN	▼-1			
Tschannen 2010	US	CS	10	+	++	All		▲**10**		
Weiss2011	US	CS	4	+	-	RN		▲10		

Nine studies examined associations between nurse staffing and **drug administration errors** with three showing low staffing to be significantly associated with higher rates of errors (Frith et al., 2012, O'Brien-Pallas et al., 2010a, Patrician et al., 2011) and a further three showing non-significant associations in the same direction. While most of these studies were rated low for internal validity (-) significant associations came from both strong (++) and less strong studies (+,-). One study (+ for internal validity) found that wards with more nursing staff had significantly higher error rates (Blegen and Vaughn, 1998). The issue of a possible endogenous relationship arises as units where more medication is administered may have more and more complex medication administration tasks and be provided with higher staffing levels.

Four studies explored associations between "missed care" (that is nursing care deemed necessary that was not performed in a given time period) and staffing (Table 5). These studies all had modest rating for internal validity (+) primarily because of the reliance on self-report measures of missed care. However, they also included two studies rated as

strong for external validity (++) which includes the only one undertaken in the UK. Three of the 4 showed significantly more missed care was associated with lower staffing levels (Ball et al., 2013, Tschannen et al., 2010, Weiss et al., 2011) while the fourth showed a non-significant relationship in the same direction. Two of these studies reported specifically on paperwork. One found that where there are fewer nurses necessary paperwork was more likely to be left undone (Ball et al., 2013) while the other found no significant association. A single UK study examined vital signs observations and found a non-significant relationship with lower RN staffing levels associated with more reports of missed observations (Ball et al., 2013).

We found five studies exploring nurse outcomes (Table 6). None of these studies showed a significant relationship with any outcome and there was no clear pattern for the direction of the relationship. The overall quality of the evidence was rated as low or moderate (two studies rated -, three rated +) although one study rated + for internal validity with high external validity (++) showed no significant relationship with intent to leave or turnover / retention (Tschannen et al., 2010).

Table 6 Nurse staffing and nurse outcomes

Study	Country	Design	n hospitals	Internal validty	External validity	Staff groups	burnout	satisfaction	other well-being	intent to leave	turnover / retention
Ausserhofer 2013	Swiss	CS	35	-	++	All		▼ -1			
O'Brien Pallas 2010	Canada	PO	6	+	-	All			▲1		
O'Brien Pallas 2010 b	Canada	CS	41/39	-	-	All		▲1	▲1		
Staggs 2012	US	RO	306	+	+	All					0
Tschannen 2010	US	CS	10	+	++	All				▼-1	▼-1

Summary evidence statements

Evidence from several studies, including some of high quality, suggests that lower nurse staffing is associated with higher rates of medication errors and missed care. There is no strong evidence concerning associations with nurse outcomes.

- There is some strong evidence that a lower level of nurse staffing is associated with higher rates of **drug administration errors** (Frith et al., 2012, O'Brien-Pallas et al., 2010a, Patrician et al., 2011) (rated as ++,+,-) and **missed nursing care** (Ball et al.,

2013, Tschannen et al., 2010, Weiss et al., 2011) (rated as ++,++,-) including paperwork (Ball et al., 2013).

- There is also some contradictory evidence on drug administration errors with one study (Blegen and Vaughn, 1998) of moderate internal validity (+) finding that wards with more nursing staff had significantly higher error rates.
- No significant relationships were found from five studies that reported nurse outcomes (Ausserhofer et al., 2013, O'Brien-Pallas et al., 2010a, O'Brien-Pallas et al., 2010b, Staggs and Dunton, 2012, Tschannen et al., 2010) but the overall quality of this evidence was moderate to low internal validity (three studies rated +, 2 rated -)

Health care assistant staffing

We found eight studies examining associations between health care assistant staffing and outcomes (Table 7).

						Death		Other			Patient / process			Process				
	Country	Design	n hospitals	Internal validty	External validity	All deaths	Failure to rescue	falls	pressure ulcer	vte	Length of stay	readmission	medication errors	general	paperwork	vital signs	any others	Other
Ball 2013	UK	CS	46	+	++									-1	-1	-1		
Hart2011	US	CS, PO	1	-	-			-10	-1								-10	RESTRAINTS
Ibe, 2008	Japan	CS,RO	42	-	+			0	10	0							-1	RESTRAINTS
Lake 2010	US	CS	636	+	+			-10										
Park2012	US	CS,RO	42	++	+		-1											
Seago 2006	US	RO	1	-	-				-10				-10				-10	SATISFACTION
Unruh 2007	US	RO	1	-	-	0					0						0	RESTRAINTS
Weiss 2011	US	CS	4	+	-							-10		-1				

Table 7 care assistant staffing and outcomes

One weak study (internal validity -) found no association with mortality (Unruh et al., 2007) while a stronger study (++) found no association with failure to rescue (Park et al., 2012). Three studies (one rated + and 2 rated -) looked at associations with falls. Two studies (Hart and Davis, 2011, Lake et al., 2010) found that units with more healthcare assistants had significantly higher rates of falls (+,-) while a weak study (-) found no association (Ibe et al., 2008).

Three studies reported on pressure ulcers (all – for internal validity). One found a significant positive association (Seago et al., 2006) and one found a significant negative association (Ibe et al., 2008). A third study found no association (Hart and Davis, 2011). A single study found no association with VTE (Ibe et al., 2008).

A single study (Unruh et al., 2007) found no association with length of stay while one study (+) found that higher numbers of health care assistants were associated with higher readmission rates (Weiss et al., 2011). One weak study (-) found significantly more medication administration errors in units with more healthcare assistants (Seago et al., 2006). A single study (+) explored the association between care assistant staffing and missed care in England (Ball et al., 2013). There was no significant association. One study (-) showed significantly less patient satisfaction in units with more health care assistants (Seago et al., 2006) and one (-) showed significantly higher use of physical restraints (Hart and Davis, 2011). There we no studies looking at associations with costs infections or nurse outcomes.

Summary evidence statement

Eight mostly weak studies give no strong evidence of beneficial associations between care assistant staffing and patient safety. There is mixed evidence on pressure ulcers with studies showing both positive and negative associations but otherwise the associations are absent or adverse.

- Studies of moderate and low internal validity (+,-) found no association with mortality (Unruh et al., 2007), failure to rescue (Park et al., 2012), length of stay (Unruh et al., 2007), VTE (Ibe et al., 2008) or missed care (Ball et al., 2013).
- Studies with moderate to low internal validity (+,-) found that higher HCA staffing was associated with higher rates of falls (Hart and Davis, 2011, Lake et al., 2010) pressure ulcers (Seago et al., 2006), readmission rates (Weiss et al., 2011), medication errors (Seago et al., 2006), physical restraints (Hart and Davis, 2011) and lower patient satisfaction (Seago et al., 2006).
- One weak study (-) found that higher HCA staffing levels were associated with lower rates of pressure ulcers (Ibe et al., 2008).

- There were no studies looking at associations with costs, infections or nurse outcomes.

Skill mix & patient outcomes

We found 22 studies reporting associations between skill mix and patient outcomes (Table 8). The variables used in these studies were diverse. While all gave an indication of a clear skill gradient, most US studies were based on a measure of RN staffing as a proportion of all nurse staffing including Licensed Practical Nurses and unlicensed assistants (more closely equivalent to a HCA).

Table 8 Skill mix & Patient outcomes

Study	Country	design	nhospitals	Internal validity	External validity	Staff groups	All deaths	Failure to rescue	CAUTI	pneumonia	surgical site	other / mixed infections	falls	pressure ulcer	vte	costs	Length of stay	readmission	any others	Others
Ausserhofer 2013	Swiss	cs	35	-	++	RN/RN+HCA			-1	-10		-1	-1	1					1	satisfaction
Blegen 2011	US	cs	54	++	+	RNs, LPNs, and NAs	-1	10				10		1			0			
Blegen & Goode 1998	US	cs, RO	1	-	-	RN / RN+HCA+LPN	1					1	-1	10					1	complaints
Blegen & Vaughn 1998	US	RO	11	+	+	RN / RN+HCA+LPN							10						1	cardiac arrests
Cho 2003	US	RO	232	++	+	RN/RN+:PN+HCA			1	10	1	1	1	1						
Donaldson 2005	US	PO	38	+	++	RN / RN+LPN+LVN							10							
Duffield 2011	Australia	cs	19	-	+	EN/EN+RN				0		0	10	10	0					
Estabrooks 2005	Canada	cs	49	++	+	RN/RN+LPN+HCA, %RN with degree	10													
Frith 2010	US	cs	4	-	-	RN / RN+HCA+LPN											10		10	combined complications
He 2013	US	cs	128	++	++	RN / RN+HCA+LPN	10													
IBE 2008	Japan	cs, RO	42	-	+	RN / RN+HCA							0	10	0				-1	restraints
Kutney lee 2013	US	RO	134	++	+	RN / RN+HCA+LPN	-1	-1												
Manojlvich 2011	US, Canada	RO	2	-	-	Composite education/experience/skill mix						1	1							
McGillis Hall 2004	Canada	cs	19	-	+	RN+RPN / RN+RPN+HCA					10					10				
O'Brien Pallas 2010	Canada	PO	6	+	-	RN / RN+HCA											-1			
Patrician 2011	US	RO	13	++	++	RN / RN+HCA+LPN							10							
Potter 2003	US	PO	1	+	-	RN/RN+LPN+HCA							0						10	satisfaction
Sales 2008	US	RO, cs	123	++	++	RN / RN+HCA+LPN	0													
Seago 2006	US	RO	1	-	-	RN / RN+HCA+LPN								1					1	satisfaction

Six studies explored associations between skill mix and **mortality and / or failure to rescue** (Table 8). Two studies (rated as high internal validity, ++) found that a higher proportion of registered nurses on wards is associated with a significantly lower rate of death (Estabrooks et al., 2005, Shekelle, 2013) and one (also rated as ++) found a similar association with failure to rescue (Blegen et al., 2011). Four studies including 2 with high internal validity (++) found no significant association between death rates (3 studies) or failure to rescue (1) and skill mix (Blegen et al., 2011, Blegen et al., 1998, Kutney-Lee et al., 2013, Sales et al., 2008). In most cases the ratio was RN to Licensed practical nurses and HCA and so the implications for RN/HCA skill mix are unclear.

One strong study (++) found a significant associations between a "richer" RN skill mix (defined as a higher proportion of RNs in the nursing workforce) and lower rates of **pneumonia** (Cho et al., 2003). One study with low internal validity (-) found that higher rates of pneumonia were associated with a richer skill mix (Ausserhofer et al., 2013),although this was based on subjective nurse reports and may indicate greater awareness among RNs, while a third (also -) found no association (Duffield et al., 2011). One study (-) showed significantly lower rates of **surgical site infection** with a richer RN skill mix (McGillis Hall et al., 2004) while a second (++) found no significant association (Cho et al., 2003). One strong study (++) found that a richer RN skill mix was associated with lower post-operative sepsis (Blegen et al., 2011) while 5 other studies of mixed / other types of infection showed no significant associations although 4/6 showed a non-significant difference in favour of richer skill mix and only 1/6 showed a non-significant difference in the opposite direction (see Table 8).

Ten studies explored the association between skill mix and **falls**. Four studies (internal validity ++,+,+, -) found that a richer RN skill mix was associated with significantly fewer falls (Blegen and Vaughn, 1998, Donaldson et al., 2005, Duffield et al., 2011, Patrician et al., 2011). Two other studies showed non-significant differences in the same direction while two gave non-significant differences in the opposite direction and a further two did not report the direction of association (see Table 8).

Seven studies explored associations between skill mix and **pressure ulcers**. Three studies (all -) found that a richer RN skill mix was associated with fewer pressure ulcers (Blegen et al., 2011, Duffield et al., 2011, Ibe et al., 2008). Four other studies found no significant association (including 2 rated ++) but in all cases the direction of the non-significant relationship was the same (see Table 8).

Two weak studies (internal validity -) explored relationships between skill mix and **VTE** (Duffield et al., 2011, Ibe et al., 2008). Neither showed a significant relationship. One study (-) found a significant association with a combined complications index (Frith et al., 2010).

Four studies explored **satisfaction or complaints**. One (+) showed significantly fewer complaints with a richer RN skill mix (Potter et al., 2003). Three other studies, all with low

internal validity (-), found no significant association but all findings were in the same direction (see Table 8).

One study (-) found a richer RN skill mix was significantly associated with a shorter length of stay (Frith et al., 2010), while one found that a richer RN skill mix was associated with lower total nursing hours and overall lower cost of nursing hours (McGillis Hall et al., 2004). No studies explored readmissions.

Summary evidence statement

There is evidence from a number of observational studies that support an association between a nursing skill mix that has a higher proportion of registered nurses and lower mortality, infections, falls, pressure ulcers and satisfaction. The overall pattern is largely consistent, with the only significant contradictory evidence coming from weaker studies.

- Studies with high internal validity (++) found that a higher proportion of registered nurses on wards is associated with a significantly lower rate of death (Estabrooks et al., 2005, Shekelle, 2013) or failure to rescue (Blegen et al., 2011).
- Studies of mixed quality (++,++,-) found a significant associations between a higher proportion of RNs in the nursing workforce) and lower rates of **pneumonia** (Cho et al., 2003) **surgical site infection** (McGillis Hall et al., 2004) lower post-operative sepsis (Blegen et al., 2011) but one study with low internal validity (-) found that higher rates of pneumonia were associated with a richer skill mix.
- Four studies (internal validity ++,+,+, -) found that a richer RN skill mix was associated with significantly fewer falls (Blegen and Vaughn, 1998, Donaldson et al., 2005, Duffield et al., 2011, Patrician et al., 2011).
- Three weak studies (all -) found that a richer RN skill mix was associated with fewer pressure ulcers (Blegen et al., 2011, Duffield et al., 2011, Ibe et al., 2008).
- Two weak studies (internal validity -) provided no evidence of association between skill mix and **VTE** (Duffield et al., 2011, Ibe et al., 2008).
- A single moderate study (+) showed significantly fewer complaints with a richer RN skill mix (Potter et al., 2003).

- Two weak studies (-) indicated that a richer RN skill mix might be associated with lower resource use in terms of hospital stay (Frith et al., 2010) or total nursing hours and overall cost of nursing hours (McGillis Hall et al., 2004).

Skill mix & process / nurse outcomes

Fifteen studies explored associations between care processes or nurse outcomes and skill mix (Table 9).

Table 9 Skill mix & process / nurse outcomes

Study	Country	design	nhospitals	Internal validity	External validity	Staff groups	medication errors	missed care	paperwork	vital signs	burnout	satisfaction	other well-being	intent to leave	turnover / retention
Ausserhofer 2013	Swiss	cs	35	-	++	RN/RN+HCA	▲ 1					▲ 1			
Ball 2013	UK	cs	46	+	++	RNXHCA interaction		0	0	0					
Blegen & Goode 1998	US	cs, RO	1	-	-	RN / RN+HCA+LPN	▲10								
Blegen & Vaughn 1998	US	RO	11	+	+	RN / RN+HCA+LPN	▲10								
Chang 2011	US	cs	146	-	++	RN / RN+HCA+LPN	▲10								
Cho 2003	US	RO	232	++	+	RN/RN+:PN+HCA	▲ 1								
Frith 2012	US	RO	1	+	-	RN / RN+HCA+LPN	▼-10								
McGillis Hall 2004	Canada	cs	19	-	+	RN / RN+HCA	▲10								
O'Brien Pallas 2010	Canada	PO	6	+	-	RN / RN+HCA		▲ 1	▲ 1				▼-1		
O'Brien Pallas 2010 b	Canada	cs	41/39	-	-	RN / RN+HCA	▲ 1					▲10	▲ 1		
Patrician 2011	US	RO	13	++	++	RN / RN+HCA+LPN	▲10								
Potter 2003	US	PO	1	+	-	RN/RN+LPN+HCA	0								
Seago 2006	US	RO	1	-	-	RN / RN+HCA+LPN	▲ 1								
Staggs 2012	US	RO	306	+	+	RN / RN+HCA+LPN									▲10
Tschannen 2010	US	cs	10	+	++	RN / RN+HCA+LPN		▲ 1						▼-1	▼-1

Eleven studies explored relationships between skill mix and **medication administration errors** (see Table 9). Of these, five (Blegen et al., 1998, Blegen and Vaughn, 1998, Chang and Mark, 2011, McGillis Hall et al., 2004, Patrician et al., 2011) found that a richer RN skill mix was associated with significantly fewer medication errors including one study rated as strong for internal validity (++ with one + and three -). One single site study (rated + for internal validity) found a significant relationship in the opposite direction (Frith et al., 2012). Of the other studies, four found non-significant associations which favoured a richer RN skill mix while one reported no direction of association (Table 9).

Three studies explored **missed care** (nursing care deemed necessary that was not performed in a given time period) (see Table 9). None found a significant relationship although one UK study (Ball et al., 2013) is of particular note because it was the only study to model an interaction effect. This study also found that higher levels of RN staffing were

associated with less missed care but found no association with HCA staffing. This clearly indicates that missed care as measured by the range of care items included in the instrument (representing core nursing duties including monitoring vital signs) is a function of low registered nurse staffing levels and the absence of a significant interaction suggests that HCAs cannot substitute for nor compliment (enhance the effectiveness of) work of registered nurses in achieving this outcome (Ball et al., 2013).

Two studies, both with weak internal validity (-), reported **nurse job satisfaction** (Table 9). One found that higher job satisfaction was significantly associated with a richer RN skill mix (O'Brien-Pallas et al., 2010b) while the other found a non-significant association in the same direction (Ausserhofer et al., 2013). Two studies showed no significant association between skill mix and nurse well-being (+,-) (O'Brien-Pallas et al., 2010a, O'Brien-Pallas et al., 2010b). Two studies with moderate validity (+) explored **retention / turnover** with one also exploring **intent to leave** (Staggs and Dunton, 2012). One (Tschannen et al., 2010) found no significant associations but the larger study (Staggs and Dunton, 2012) found that a richer RN skill mix was significantly associated with lower turnover.

Summary evidence statement

The evidence reviewed suggests an association between a skill mix that has a higher proportion of registered nurses and fewer medication errors. There is no evidence of an association between missed nursing care and skill mix although the absence of an interaction effect between RNs and HCAs suggests that it is the level of RN staffing that is important in determining missed care. There is little evidence about nurse outcomes although a richer RN skill mix has been associated with lower turnover.

- Five studies with mixed internal validity (one ++ one + and three -) found that a richer RN skill mix was associated with significantly fewer medication errors (Blegen et al., 1998, Blegen and Vaughn, 1998, Chang and Mark, 2011, McGillis Hall et al., 2004, Patrician et al., 2011). One single site study (rated + for internal validity) found a significant relationship in the opposite direction (Frith et al., 2012).
- While no study found significant associations between skill mix and missed care one (moderate internal validity) found no significant interaction effect between staff

groups, suggesting that the level of RN staffing is the important determinant of the missed care rate.

- A single study of moderate internal validity found that a richer RN skill mix was significantly associated with lower turnover (Staggs and Dunton, 2012).

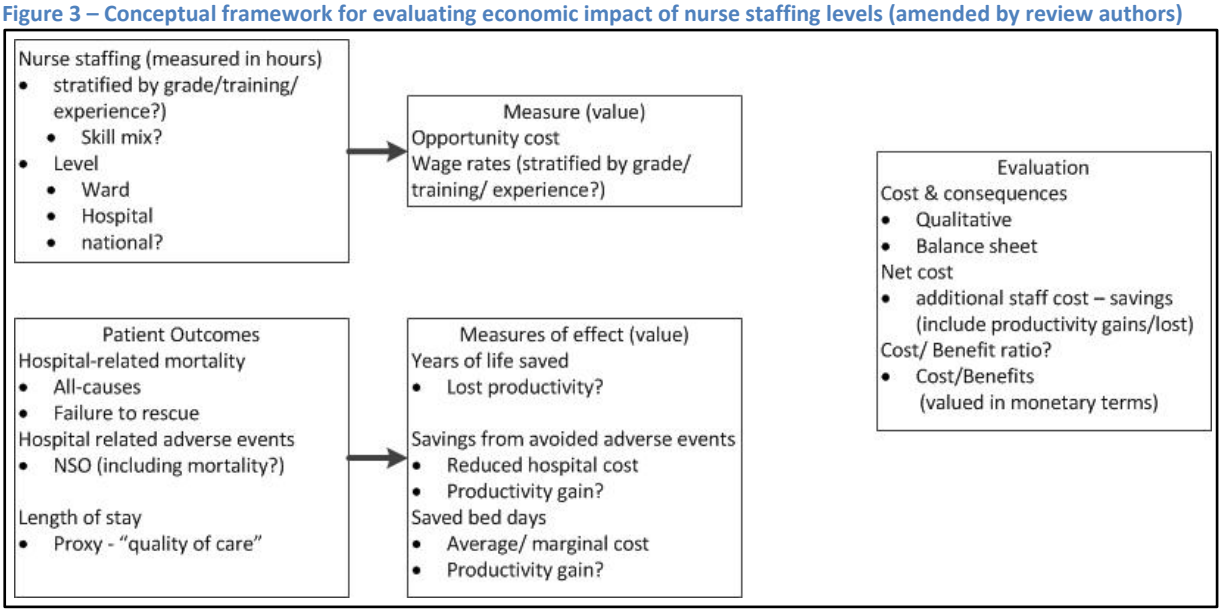
Economic implications of changes in nurse staffing levels – estimating net costs

Five studies were identified that reported costs associated with change in nurse staffing levels (or skill mix) and costs of nurse sensitive outcomes (Cho et al., 2003, Dall et al., 2009, Needleman et al., 2006, Shamliyan et al., 2009, Twigg et al., 2013). The studies were conducted using data from a range of base years, and were predominantly undertaken in the US. None of the studies was conducted in the UK or uses an NHS perspective.

Two studies (Cho et al 2003 and Twigg et al 2013) have been included in the review for question 1 (see Table 2 for risk of bias summary and Table 3 for details). Three additional studies (Dall et al., 2009, Needleman et al., 2006, Shamliyan et al., 2009) using hospital level staffing data or presenting secondary analyses met the broader inclusion criteria for this review. All three studies report US-based simulations, combining published evidence of the impact of increasing nurse staffing levels on a range of outcomes with estimates of incidence of these outcomes from regional or national data sources.

Shamliyan et al (2009) present a conceptual framework for assessing the costs (additional staff cost against potential savings due to avoided deaths and adverse events) of increased staffing levels – Figure 3 presents an amended version developed by the review authors.

Figure 3 – Conceptual framework for evaluating economic impact of nurse staffing levels (amended by review authors)



The framework indicates that nurse staffing levels may be measured and analysed at a range of levels and may be adjusted or stratified to take account of variation in skill mix, but will typically be measured in hours per patient bed day and valued using relevant wage rates (adjusted for employer on-costs). This approach may not fully indicate the opportunity cost of changes in staffing levels as wage rates reflect other factors than resource cost (benefit foregone from the second best alternative use of the resource). The challenges of identifying outcomes related to nurse staffing levels have been identified in the main review, above. Studies purporting to assess the economic impact of these outcomes face additional methodological difficulties regarding the appropriate perspective to adopt for the analyses (societal versus third-party payer) and the appropriate valuation to apply to avoided events or saved bed days (average versus marginal costing).

Table 10 shows that the identified studies have used a range of potential outcomes, with few included in all studies. Where similar outcomes have been included the definitions may vary – for example, mortality is defined as all in-hospital deaths identified by discharge, as failure to rescue or both depending on which study is being considered.

Table 10 – outcomes included in identified studies

Outcome	Study				
	Cho (2003)	Dall (2009)	Needleman (2006)	Shamliyan (2009)	Twigg (2013)
Mortality	✓[a]	✓[b]	✓[b]	✓[c]	✓[c]
Fall/ injury	✓	✓			
Pressure ulcer	✓	✓			
Adverse drug event	✓	✓			
Pneumonia	✓	✓	✓	✓	✓
Urinary tract infection	✓	✓	✓		✓
Wound infection	✓	✓		✓	✓
Sepsis	✓	✓			✓
Upper GI bleeding		✓	✓		✓
Pulmonary failure		✓		✓	✓
Shock/cardiac failure		✓	✓	✓	✓
CNS complications		✓			✓
Deep vein thrombosis		✓			✓
Bloodstream infection				✓	
Unplanned extubation				✓	
Physiol/ metabolic derangement					✓
Length of stay	✓	✓	✓	✓	
Cost	✓[d]	✓[d]			✓[e]

Notes:
[a] in-hospital mortality recorded in discharge abstract
[b] failure to rescue
[c] in-hospital mortality and failure to rescue
[d] based on charges and charge-to-cost-ratio
[e] uses average cost of any adverse event from a published source

The studies differ widely in the nurse staffing measures used in their analysis (Table 11). Cho et al (2003) and Twigg et al (2013) used administrative financial databases to derive hours of nursing time, by grade, in study hospitals during the study observation period. The other three studies did not collect information on nurse staffing levels, but used published data from previous studies to estimate the impact of increasing staffing beyond a given baseline. For Dall et al (2009) and Needleman (2006) this was based on increasing staffing levels to a given norm (75th percentile level) in those hospitals currently below that level. It is unclear from Shamliyan et al (2009) what baseline levels were used.

Table 11 – Measures of nurse staffing included in identified studies

Nurse staffing measure	Study				
	Cho (2003)	Dall (2009)	Needleman (2006)	Shamliyan (2009)	Twigg (2013)
All nurse hours	✓[a]		✓[c]		✓[e]
Registered nurse hours	✓[a]	✓[b]	✓[c]	✓[d]	✓[e]
Registered nurse hours (%)	✓		✓[c]		✓[e]

Notes:
[a] hours per patient day
[b] registered nurse hours per patient day: simulation study estimating benefits of increasing registered nurse staffing levels (based on values presented by Needleman et al (2001, 2002, 2006))
[c] nurse hours provided (exact measure not reported): simulation study estimating benefits of increasing proportion of registered nurses (option 1); number of licensed nurses without changing proportion of registered nurses (option 2); or increasing the proportion of registered nurses while also increasing the number of licensed nurses (option 3). Based on values presented by Needleman et al (2001, 2002)
[d] full-time equivalent registered nurse per patient day: simulation study estimating benefits of increasing registered nurse staffing levels (based on odds ratios reported by Kane et al (2007))
[e] total nursing hours (classified by RN vs EN) during 22 month pre- and 22 month post-implementation period.

Evidence on the effect of nurse staffing levels on outcomes used in the studies varies widely and in some cases in not well reported (Table 12). In particular, the methods for estimating baseline event rates and for combining these with effect estimates derived from the literature, are not clearly reported in the studies by Needleman et al (2006) and Shamliyan et al (2009). The approaches may be made more transparent by cross reference to the authors' earlier publications (which provide the effectiveness estimates adopted in the analysis). However, we were not always able to find the referenced sources because web links given in publications were outdated. The clearest reports, and therefore the sources most accessible for methodological review and possible re-analysis/ replication, are those presented by Cho et al (2003) and Twigg et al (2013). Given the methodological differences between the five studies, it is difficult to draw any firm conclusions from the results presented (Table 13).

Table 12 – Evidence of effect of nurse staffing level on outcome used in studies

Study	Source	Method	Control variables
Cho (2003)	Assessed within study (California 1997 State Inpatient Databases; 232 acute hospitals)	Multi-level regression (1 = patient; 2 = hospital)	*Patient*: age, sex, race, primary payer, DRG, number of diagnoses at admission, type of admission (scheduled or unscheduled) *Hospital* : ownership, size, teaching affiliation, rural/urban
Dall (2009)	Baseline: impact of adverse events on mortality, LOS, cost (Hospital discharge data from 2005 Nationwide Inpatient Sample; 610 hospitals) Effect of nurse staffing level on adverse events from published sources: Cho (2003), Needleman (2001)	Regression: logistic (mortality) poisson (LOS) OLS (cost) Derive "elasticities"[a]	*Patient*: age, sex, payer, DRG, type of admission *Hospital* : ownership, size, teaching status, rural/urban, region Separate regressions for surgical and medical patients
Needleman (2006)	Effect of nurse staffing level on adverse events from published sources: Needleman (2001), Needleman (2002)	Not clearly reported	
Shamliyan (2009)	Baseline: not clearly reported Effect of nurse staffing level on adverse events from published sources: Kane (2007a), Kane (2007b)	Not clearly reported	
Twigg (2013)	Assessed within study, using data from previously published studies – Twigg and Duffield (2009), Twigg et al (2011)) – drawn from 3 adult teaching hospitals	Logistic regression[b]	*Patient*: age, sex, (age/ sex interaction), indigenous status, country of birth, season of admission, referral source, Major Diagnostic Category, care type and DRG cost weight *Hospital* : none

[a] percentage change in patient risk for each nurse sensitive outcome for a 1% change in nurse hours per patient day (evaluated at median staffing level, 7.8 nurse hours per patient day)

[b] fitted to pre-intervention data in order to model "expected" events in post-intervention patient population. Change in events attributable to the intervention were derived as the difference between observed and expected (post-intervention). Statistical significance of the difference was tested using chi-square: significance level adjusted using Bonferroni correction for multiple comparisons. Only NSOs demonstrating statistical significant differences were included in the economic analysis

Table 13 – Summary outcome and cost results from identified studies

Study	Intervention	Avoided mortality	Avoided NSO	Hospital days avoided	Costs		
					Savings	Additional	Net
Dall (2009)	Increase RN hours to 75th percentile, where required	5,900[a]	NR	3,600,000[b]	6,100[c]	11,039[d]	4,939
Needleman (2006)	Option 1 – raise proportion of RN hours to 75th percentile	354	59,938	1,507,493	1,053[e]	811	-242
	Option 2 – raise licensed nurse hours to 75th percentile	597	10,813	2,598,315	1,719[e]	7,538	5,819
	Option 3 – combine option 1 and option 2	942	70,416	4,106,315	2,772[e]	8,488	5,716
Shamliyan (2009)	ICU – increase RN staffing in this setting	648,378	NR	NR	1,478,933[f]	589,680	889,253
	Surgical – increase RN staffing in this setting	592,958	NR	NR	1,646,190[f]	923,832	722,358
	Medical – increase RN staffing in this setting	425,568	NR	NR	1,244,061[f]	982,800	261,261
Twigg (2013)	Increased hours with Nurse Hours per Patient Day method	155	709	NR	7,142,466[g]	16,833,392	9,690,926

Notes:
[a] estimated from DRG risk-adjusted logistic regression, including dummy variables for presence/ absence of NSO (see Table 1 above)
[b] estimated from DRG risk-adjusted poisson regression, including dummy variables for presence/ absence of NSO
[c] valued in US dollars, 2005 and presented in million US $.. This represents the estimate of reduced medical costs associated with reduced NSO. They also estimated potential averted lost productivity at $1.3bn, from avoided mortality, and a further $231m averted lost productivity from earlier recovery.
[d] value estimated by this review authors, based on study reported increase of 133,000 FTE RNs at annual cost of $83,000 (salary $57,820 and 30.4% benefits), US $, 2005
[e] base year for US dollar costs not reported. Costs in million US $.
[f] Costs in million US dollars per 1,000 patients.
[g] base year for Australian dollar costs not reported Costs in AUD $.

Cho et al (2003), while titling the paper “The effects of nurse staffing on adverse events, morbidity, mortality and costs”, do not appear to present any results for the cost impact of variation in nurse staffing levels. Cost results are largely limited to a demonstration that costs are approximately doubled in patients experiencing in-hospital pneumonia (the adverse event demonstrating a statistically significant association with registered nurse staffing levels) compared to those who do not.

Across the remaining studies a limited number of general conclusions may be suggested. Increasing nurse staffing levels appear to be associated with reduced mortality (overall mortality, mortality associated with in-hospital adverse events and avoided failure to rescue events), avoided adverse events and reduced hospital bed days. Moreover these reductions can be quantified as potential savings accruing to the health system.

Differences in the scale of these savings are attributable to a range of factors, including the scale of the study reporting savings and the scope of costs included. For example, Twigg et al (2013) report results for three hospitals while Needleman et al (2006) report savings aggregated to the national level. Dall et al (2009) include a range of potential productivity gains from avoided mortality, earlier recovery and averted adverse events while other studies consider only costs and savings to hospitals. Some of the studies explicitly compared the costs of the intervention against the estimated financial savings – generally indicating that the financial savings are insufficient to offset fully the additional costs of increasing nurse staffing levels although the estimate of cost per life years gained (Au$ 8907) from Twigg et al (2013) would, if replicated in the current NHS, be within a range that may fall below accepted cost effectiveness thresholds (McCabe et al., 2008). The models presented by Needleman (2006) and Shamliyan (2009) suggest that the most cost effective approaches result from increasing RN hours as opposed to licensed practical nurses (Needleman et al., 2006) and from increasing (RN) staffing in general wards as opposed to ICU (Shamliyan et al., 2009). However, as none of the studies was conducted in the UK, used an NHS perspective or adopted evidence of the impact of nurse staffing levels on outcomes from the NHS, the results of the studies are of limited value in informing decision-making in the NHS context.

Summary evidence statement

Economic evidence from five studies (Twigg et al., 2013, Dall et al., 2009, Cho et al., 2003, Shamliyan et al., 2009, Needleman et al., 2006) undertaken in countries other than the UK suggests that the costs of increased nurse staffing may not be offset by savings from better patient or system outcomes (such as reduced hospital stays) although some scenarios modelled did suggest additional costs of increased staffing might be more than offset by savings from improved patient outcomes and thus lead to a net saving (Needleman et al., 2006).

- Studies suggest that increasing nurse staffing has the potential to be cost-effective in terms of cost per life year saved (Twigg et al., 2013), that increasing Registered Nurse staffing (rather than licensed practical nurse staffing (Needleman et al., 2006)) on general (medical/surgical) wards (rather than ICU (Shamliyan et al., 2009)) may be more cost effective than the alternatives.

Because none of the studies was conducted in the UK, used an NHS perspective or adopted evidence of the impact of nurse staffing levels on outcomes from the NHS, the results of the studies are of limited value in informing decision-making in the NHS context.

Section conclusions

This section of the review explored evidence on association between nurse staffing levels and patient outcomes in order to answer the question "what patient safety outcomes are associated with nurse and healthcare assistant staffing levels and skill mix?" From this we aim to determine "what outcomes are associated with tasks undertaken by registered nurses, healthcare assistants, and other staff?" and "which outcomes should be used as indicators of safe staffing?"

Previous reviews showing associations between nurse staffing levels and patient outcomes have included studies which use hospital level data and do not control for or otherwise incorporate staffing from unregistered nursing staff (healthcare assistants) (e.g. Kane et al., 2007a, Butler et al., 2011, Shekelle, 2013). Our review, which has included only studies which use nurse staffing data derived from wards and which control for other nursing staff groups shows similar associations. The clearest evidence is for associations with mortality.

The evidence of an association with falls is also relatively clear. However for both these outcomes several studies, including some of high quality and having large samples, have failed to find a significant association. In simple terms this reflects the fact that the signal provided by these outcome indicators is weak relative to the 'noise' of patient, and organisational level factors that also affect the outcome. It is also likely that outcomes, particularly mortality, are substantially influenced by other staff groups.

Thus while mortality rates may indicate a problem with nurse staffing; it is not a specific indicator. We also found evidence for associations between nurse staffing and length of stay and readmissions but use of these as indicators of nurse staffing adequacy share similar limitations as mortality. Falls are likely to be more directly affected by nursing staff inputs, although the evidence of the association here is less strong. This is no doubt influenced by multiple factors including the challenge of accurately determining falls rates from incident reports or routine data. Additionally, risk adjustment strategies deployed in studies do not appear to be strong and there is no clear 'standard' by which to judge its adequacy. Furthermore, evidence from systematic reviews of interventions makes it clear that falls prevention interventions are a multi-disciplinary endeavour and does not provide unambiguous evidence to support any specific interventions provided by ward based nursing staff (Cameron et al., 2012). Thus the extent to which it is a sensitive indicator of safe staffing remains questionable although it appears promising and it is used as an indicator in many nursing quality monitoring systems (Griffiths et al., 2008, Maben et al., 2012).

Similar issues arise for pressure ulcers. Although the significance of nursing care for this outcomes seems clear and like falls it is strongly supported as an indicator in quality monitoring systems (Griffiths et al., 2008, Maben et al., 2012) the associations between overall nurse staffing and pressure ulcers was not consistent in the studies we identified. Since it is unlikely that higher nurse staffing levels cause higher rates of pressure ulcers it seems likely that there is an endogenous relationship. However this makes it difficult to clearly advocate pressure ulcer rates as an indicator of safe nursing care. Certainly there would need to be clear stratification by unit type and patient case mix. The results of studies we found suggest that there is no clear standard for doing this. Using process measures as an alternative is likely be confounded by lack of a clear evidence base for most nursing

interventions, including the use of risk assessment tools (Moore and Cowman, 2008). Similar to pressure ulcers, we found mixed evidence on the association between infections and nurse staffing raising similar challenges in using infection rates as indicators of safe staffing.

Of the process outcomes that we assessed, both drug administration errors and rates of missed care appear promising as indicators of staffing adequacy. The direction of association appears to be largely consistent (although unit level stratification or other adjustment may be required for drug errors) and evidence comes from a number of studies with moderate validity. These therefore seem promising as indicators of safe staffing. However, neither is unproblematic. Missed care has been measured in studies using intermittent surveys and has not been objectively verified, although nurse reports of missed care are associated with mortality rates at a hospital level (Schubert et al., 2012). Drug administration errors have been studied in a variety of ways but methods that are not dependent on incident reporting or self-report require systems to gather data on (for example) delayed or missed doses.

In relation to the question "what outcomes are associated with tasks undertaken by registered nurses, healthcare assistants, and other staff?" the evidence reviewed, primarily from cross sectional studies of staffing outcome associations, is indirect. We found no experimental studies comparing care delivered by different staff groups.

None of the outcomes we studied appear to be positively associated with the availability of health care assistants (as measured by staff patient ratios or equivalent). The patient outcomes considered in this review were primarily selected to reflect patient safety. The evidence from the studies we found points toward negative outcomes associated with higher levels of care assistant staffing and/or a skill mix that is lower in registered nurses. While limitations in the evidence base, including the issues raised above, make it difficult to conclude that the adverse associations observed are directly caused by the work of care assistants, this review provides no basis on which to shift care related to any of these outcomes from registered nurses to health care assistants or that any such shift would reduce the registered nurse staffing required to maintain patient safety.

Because none of the studies was conducted in the UK, the results of the economic studies are of limited value in informing decision-making in the NHS context. They do raise the possibility that raising nurse staffing on general wards may be cost effective and that compared to other strategies, raising RN staffing may yield more benefit. However, without direct NHS evidence or models using NHS costs it is impossible to determine if these results generalise from the settings of the original studies (US and Australia).

Factors affecting staffing requirements

Introduction

The second section of this report addresses the following questions:

- What patient factors affect nurse and healthcare assistant staffing requirements at different times during the day?
- How does the ward environment, including physical layout and diversity of clinical disciplines, affect safe staffing requirements?

In order to determine staffing requirements it is important to unpick the underlying concepts that define the workload of nurses and healthcare assistant staff. In nursing the term nursing *intensity* is frequently used to describe the workload of nursing staff, which is ideally managed by a workload management system (WMS). A WMS *"is defined as a method for quantifying nursing activity for staffing purposes"* (Edwardson and Giovannetti, 1994) and therefore is a measure of staffing requirements. There is not a standard classification of WMS, but they can broadly be described as based on a) patient profiles b) critical indicators of care and of c) nursing task documents (Edwardson and Giovannetti, 1994).

Patient profile based approaches provide descriptions of patient types with which actual patients are matched. The Shelford Group Safer Nursing Care Tool (SNCT)[12] is an example for this type of WMS. *Critical indicators of care* approaches are based on a list of indicators which represent different levels of care needs and are used to classify patients. *Task based approaches* do not classify patients but employ lists of tasks that are partially unique to the setting and are backed up by an associated time value. All three approaches attempt to estimate the underlying construct *nursing intensity*. There is no universally accepted definition what constitutes nursing intensity. Prescott et al. (1991) provide a useful

[12] This tool was developed in the NHS and as it developed it has been known by a variety of names, most commonly the "AUKUH" tool or "AUKUH Patient Care Portfolio", referencing the early support given by Association of UK University Hospitals. http://shelfordgroup.org/resource/chief-nurses/safety-nursing-care-tool

framework, which describes four principal dimensions of nursing intensity: severity of illness, patients' needs, complexity of tasks and procedures; and time.

Severity of illness is often used synonymously with *acuity* and is "an assessment of a patient's illness, its chronicity, severity, and other qualitative aspects" (National Library of Medicine, 2013). *Patient needs* or dependency refers to the demand for assistance with activities of daily living, but also includes elements like psychosocial and teaching needs. *Complexity* reflects the required knowledge, skills, experience and decision-making necessary to carry out treatments and procedures. The fourth dimension refers to the actual *time* spent in providing the care.

Overview of studies

Table 14 gives an overview of the 21 primary studies and Table 15 the five reviews used in this section. Nineteen of the primary studies report the relationship between relevant factors and outcomes considered previously. Two directly measure associations with measured staffing requirements (Blegen et al., 2008, Hurst, 2008).

Table 14 Primary studies for factors affecting staffing requirements

	Unruh et al. (2007)	Seago et al. (2006)	Sales et al. (2008)	Potter et al. (2003)	Patrician et al. (2011)	Park et al. (2012)	O'Brien-Pallas et al. (2010b)	Needleman et al. (2011)	McGillis Hall et al. (2004)	Lake et al. (2010)	Shekelle (2013)	Hart and Davis (2011)	Frith et al. (2012)	Frith et al. (2010)	Duffield et al. (2011)	Donaldson et al. (2005)	Chang and Mark (2011)	Blegen and Vaughn (1984)	Ball et al. (2013)	Blegen et al. (2008)*	Hurst (2008)*
Patient turnover					+	+		+							+	+					
Patient dependency / acuity	+		+	+	+	+	+		+		+		+	+	+						+
Time of day					+														+		
Day of week					+																
Ward layout																					+
Ward size																				+	
Ward case mix	+	+	+							+		+	+		+			+		+	+
Risk of bias: Internal Validity	-	-	++	+	++	++	-	++	-	+	++	-	+	-	-	+	-	+	+	+	-
Risk of bias: External Validity	-	-	++	-	++	+	-	+	+	+	++	-	-	-	+	++	++	+	++	++	-

+ Significant association found, () association not significant

Table 15 Overview reviews of factors affecting staffing requirements

Study ID	Edwardson and Giovannetti (1994)	O'Brien-Pallas et al. (2005)	Myny et al. (2011)	Fasoli and Haddock (2010)	Huisman et al. (2012)
Key question (relevant to review)	1. Describes Approaches to workload measurement 2. Identifies measurement issues	1. Define concepts of nursing workload and productivity 2. Present theoretical underpinnings of nursing workload and productivity 3. Critically examine factors that influence nursing workload and productivity	1. Which non-direct patient care factors are related to the difference in nursing workload 2. The development of a conceptual model to describe the relation between non-direct patient care factors and nursing work- load	1. Identify the literature on patient classification/acuity systems 2. Identify validated staffing models 3. Identify classification variables to consider in staffing model	1. Is healthcare design related to Patient/family/staff outcomes?
Timeframe	1977-1992	-2005	1970-2009	1983-2010	1984-2011
Sources	Medline, CINAHL, Health Planning and Administration	unknown	PubMed, Embase, CINAHL, BNI, Elin, Engineering Village, snowballing	Medline, CINAHL, SSCI, Embase, CDSR, BIOSIS	PubMed, Jstor, Scopus
No screened	unknown	1000	1782	375	798
Included	unknown	93	30	63	61 studies, 4 reviews
Critical Appraisal	unclear	unclear	RAC	Own	Levels of evidence

Summary of the evidence

The findings of this section should be read in the context of the conclusions of the recent review we considered that explicitly addressed methods of determining staffing requirements (Fasoli and Haddock, 2010). In their review of 58 studies they found little objective and validated information regarding the systems to determine staffing requirements, lack of standardization of measures and concluded that systems to determine staffing requirements do not adequately capture nursing work and provide insufficient accuracy for resource allocation or for decision making.

They noted that "*the literature is replete with descriptive studies of single-hospital systems*" and "*there is no criterion standard of nursing workload measurement*". Thus, while studies may identify factors thought to inform staffing requirements, the methods used to validate these requirements are generally inadequate. Because of the extensive literature and our limited time frame, we were unable to replicate this review to give a detailed appraisal of the individual studies it considered. However, their overview gives a clear indication of the 'state of the art'.

Therefore we concentrated on using evidence of associations between factors that may influence staffing requirements and patient outcomes and describing the factors identified within the reviews, drawing on additional evidence published since the reviews. The relevance of associations with patient outcomes is two-fold. Adverse outcomes (or the risk thereof) generate nursing work to treat or prevent them. The presence of a significant relationship in a study adjusted for staffing levels identifies a factor that may moderate the effect of nurse staffing (although this requires a test of interaction to verify) or require different staffing levels to achieve equivalent outcomes to when it is not present.

Patient turnover

Patient turnover (also labelled in the literature as census variability or churn) describes the throughput of patients from admissions, discharges and transfers (Park et al., 2012). Five studies were identified showing a significant association between patient turnover and patient outcomes in staffing adjusted analyses (Donaldson et al., 2005, Duffield et al., 2011, Needleman et al., 2011, Patrician et al., 2011, Park et al., 2012) with ratings for internal

validity of ++, ++,++,+,- and external validity of ++,++,+,+,+. One study specifically analysed the interaction of patient turnover and RN hours per patient day on failure to rescue in 42 hospitals in the US finding a diminishing association of RN hours per patient day with failure to rescue with increasing levels of patient turnover (Park et al., 2012).

Two recent reviews (Fasoli and Haddock, 2010, Myny et al., 2011) identified turnover as a factor associated with increased nursing workload.

Summary evidence statement

Evidence from five primary studies, including studies with high internal validity (++, ++,++,+,-) show that turnover is associated with patient outcomes, indicating it has an impact on nurse workload and hence staffing requirements (Donaldson et al., 2005, Duffield et al., 2011, Needleman et al., 2011, Patrician et al., 2011, Park et al., 2012). One study specifically indicates that increased turnover decreases the marginal effectiveness of increased RN staffing (Park et al., 2012). Two reviews support this conclusion, indicating that turnover increases staffing requirements (Fasoli and Haddock, 2010, Myny et al., 2011).

Ward size

One primary study (internal validity +) found less total RN hours and lower proportion of RNs with increasing ward size (Blegen et al., 2008) although the absolute differences were small (1.6. minutes less care per patient per additional bed on the unit). The relationship between ward size and staffing requirements is not fully understood, but it is hypothesised that with increased ward size economies of scale may influence care hours and skill mix, with more opportunity for delegation in a larger team (Blegen et al., 2008). However, there was no control for quality of care and so no indication of equivalent outcomes. Two reviews (Fasoli and Haddock, 2010, Myny et al., 2011) also identified ward size as a relevant factor for staffing requirements, although the implications of their findings were unclear. In each case this conclusion was based on one primary study, different in each review. Myny (2011) presented results indicating that larger units were associated with “higher role overload” which appeared to be associated with lower staffing levels. While Fasoli and Haddock identified ‘volume’ as a key variable in the literature, its significance was unclear in the sense that it could be referring to efficiencies associated with specialism or the self-evident need to consider total patient load rather than ward size per-se.

Summary evidence statement

Limited evidence from 1 primary study (Blegen et al., 2008) (internal validity +) and two reviews (Fasoli and Haddock, 2010, Myny et al., 2011) indicate lower staffing levels on larger wards. However the apparent efficiencies are not supported by evidence of equivalent outcomes and may be associated with poorer staff perceptions.

Patient dependency / acuity

Eleven studies were identified supporting the association of dependency/acuity and patient outcomes in staffing adjusted analyses (Duffield et al., 2011, Frith et al., 2010, Frith et al., 2012, McGillis Hall et al., 2004, Shekelle, 2013, O'Brien-Pallas et al., 2010b, Park et al., 2012, Patrician et al., 2011, Potter et al., 2003, Sales et al., 2008, Unruh et al., 2007). The results were drawn from studies with mixed validity but included 4 studies rated as high for internal validity (4 rated as ++) and external validity (3 rated as ++).

Three reviews support this association (Edwardson and Giovannetti, 1994, Fasoli and Haddock, 2010, O'Brien-Pallas et al., 2005) although Fasoli and Haddock (2010) emphasise the lack of any clear validated measures that accurately link dependency and acuity to staffing requirements with the precision required for workforce planning.

Summary evidence statement

Multiple observational studies support a link between patient acuity and dependency and patient outcomes (Duffield et al., 2011, Frith et al., 2010, Frith et al., 2012, McGillis Hall et al., 2004, Shekelle, 2013, O'Brien-Pallas et al., 2010b, Park et al., 2012, Patrician et al., 2011, Potter et al., 2003, Sales et al., 2008, Unruh et al., 2007).

Three reviews conclude that increased dependency and acuity is associated with higher staffing requirements (Edwardson and Giovannetti, 1994, Fasoli and Haddock, 2010, O'Brien-Pallas et al., 2005).

Ward case mix

Case mix can be either defined by diagnostic related groups (or equivalents), by nursing diagnosis or more simply by broad clinical disciplines such as surgical or medical, and the ward types accordingly. Overall eight primary studies found differences in outcomes

between different ward types or with different case mix profiles (Blegen and Vaughn, 1998, Duffield et al., 2011, Frith et al., 2012, Hart and Davis, 2011, Lake et al., 2010, Sales et al., 2008, Seago et al., 2006, Unruh et al., 2007) with risk of bias ratings for internal validity ranging from ++ to – (see Table 14) and external validity ranging ++ to - (see Table 14). See evidence tables for details. Two reviews (Fasoli and Haddock, 2010, Myny et al., 2011) supported this by identifying case mix / ward type as a factor affecting staffing requirements.

The implications of these findings are difficult to fully judge. While the significance of case mix seems clearly established, the studies have used various approaches to classifications from simple stratification by ward type (medical surgical) to complex adjustment by diagnostic related group. The distinction between dependency/acuity and case mix is sometimes unclear (with some studies using acuity adjustment based on case mix) and only four studies (Unruh et al., 2007, Sales et al., 2008, Frith et al., 2010, Duffield et al., 2011) having identified case mix and acuity as significant independent factors in the same study. However this seems sufficient to determine that case mix is a factor that is independent of acuity. No studies give clear indication of specific differences in staffing requirements between ward types (e.g. medical vs surgical or care of older people) although it may be possible to infer this from regression coefficients.

Summary evidence statement

Eight studies found differences in outcomes between wards with different ward types (case mix) (Blegen and Vaughn, 1998, Duffield et al., 2011, Frith et al., 2012, Hart and Davis, 2011, Lake et al., 2010, Sales et al., 2008, Seago et al., 2006, Unruh et al., 2007) and four studies (Unruh et al., 2007, Sales et al., 2008, Frith et al., 2010, Duffield et al., 2011) identified case mix as a factor independent of acuity.

Two reviews (Fasoli and Haddock, 2010, Myny et al., 2011) supported this by identifying case mix / ward type as a factor affecting staffing requirements but no studies give clear evidence of specific differences in staffing requirements between ward types (e.g. medical vs surgical or care of older people).

Time of day / Day of week

Two primary studies reported an association between time of day and patient outcomes in staffing controlled models (Ball et al., 2013, Patrician et al., 2011). Ball et al. (2013) found an increased risk of missed care on day and afternoon shifts compared to the night shift (+/++). Patrician et al. (2011) found an increased risk for falls on night shifts in medical-surgical wards but a decreased risk for medication errors on night shifts in a sample of US military hospitals (++,++). The different directions of association between the two outcomes clearly reflects differences in activities and patient need across time of day and suggests that while some aspects of workload may reduce (drug administration) others may increase (managing risk of patient falls). The same study found fewer falls with injuries on Mondays in medical-surgical wards. The reasons for this are unclear and likely to be highly context specific. No studies directly reported on measured staffing requirements for different days of the weeks / times of day.

Summary evidence statement

Nurse sensitive adverse outcomes are shown to vary by time of day and day of the weeks in two studies (Ball et al., 2013, Patrician et al., 2011) suggesting a variation in nursing workload or that mismatches between staffing requirement and available staff may vary according to these factors. No studies directly reported on measured staffing requirements for different days of the weeks / times of day.

Ward layout

A single study of low internal validity (Hurst, 2008) explored the association of different ward layouts and whole time equivalent nurses per occupied bed. The study found lowest staffing levels on racetrack wards compared to other designs including nightingale wards, other bay designs and hub and spoke wards and other designs (including wards with all single room accommodation)[13]. Although the study reports acuity levels per ward layout, staffing variables are unadjusted for differences in patient acuity, ward specialty or

[13] Racetrack wards are a variation of 'Bay' wards. Bay wards have a central station and peripheral rooms housing small numbers of beds. In a racetrack ward offices and utility rooms occupy a central ward area while bays are situated off a corridor that skirts the ward's central block in a rectangular configuration. Hub and spoke wards have a central nursing station with large rooms (or corridors) radiating out.

clustering of wards in hospitals and therefore results are likely to be confounded. It is clear that there is confounding by ward speciality as some ward types (e.g. 'other') are identified as containing high numbers of high dependency beds and therefore have disproportionately high staffing requirements. Furthermore while quality of care was measured and reported as broadly equivalent it was not controlled for in analyses. We identified one review investigating the effects of physical environment factors of hospital wards (Huisman et al., 2012). This did not find evidence for the association of ward layout and staffing requirements, patient or staff outcomes.

Summary Evidence statement

Only one study with high risk of bias (-,-) was found showing an association between staffing levels and **ward layout**.

Economic evidence

We found no economic evidence relevant to this section of the review.

Further discussion, conclusions and recommendations

The evidence reviewed here has identified a number of outcomes that appear to be associated with nurse staffing levels on general medical and surgical wards. These seem to be consistent with evidence derived from studies using hospital level staffing and studies that do not control for care assistant staffing (e.g. Kane et al., 2007a, Butler et al., 2011, Shekelle, 2013). The evidence does not give strong support for the validity of any single outcome as an indicator of adequate nursing staff. However, infections, falls, pressure ulcers, drug administration errors and missed care all remain plausible outcomes although they are potentially difficult to interpret and implement as indicators of adequate staffing. We did not find strong evidence for patient satisfaction or experience although the potential importance of these measures seems self-evident in relation to psychosocial aspects of care.

While evidence of the association of nurse staffing for infections, pressure ulcers and (to a lesser extent) medication errors is inconsistent, this seems to be partly a product of difficulties in adjusting for case mix. For individual units this need not present a problem if case mix is relatively stable over time. Changes (or stability) over time can still be used as an indicator of adequate staffing, although the issue of signal to noise in relation to patient level risk factors remains. However, this presents a significant challenge for benchmarking across units and comparing performance against reference standards. Our own recent research has shown that nursing units which superficially had similar specialties (care of older people, general surgery, acute admissions) can have very substantial differences in case mix that are likely to reflect differences in risk for these outcomes (unpublished).

We found no evidence to support a positive role of health care assistants in patient safety outcomes. Some evidence points to a negative effect. Although they fall outside the scope of this review, directly relevant outcomes do not appear to have been widely studied[14]. While inadequate health care assistant staffing has the potential to adversely affect patient

[14] The limited evidence on patient experience points toward negative associations between HCA staffing and satisfaction. However outcomes related to aspects of care frequently delegated to HCAs such as food and drink and basic hygiene is required to shed further light on the contributions.

safety outcomes by diverting registered nurses from work that requires their unique skills, we found no evidence of interaction in the effect of the two groups.

In relation to costs of care, evidence suggests that increases in nurse staffing and / or a richer skill mix have a potential to be cost-effective but the existing evidence is derived from countries with very different contexts and cost bases to the UK and so cannot be used to directly estimate the consequences of change. Furthermore it must be remembered that all of the research considered here is observational. While Kane's review assesses the evidence using epidemiological principles and concludes that it is largely consistent with causation (Kane et al., 2007b) only the studies of Needleman and Patrician reviewed here (Needleman et al., 2011, Patrician et al., 2011) provide evidence of an association between variation in staffing at the level of a nursing shift and subsequent adverse outcomes. Both do provide stronger evidence that the association between low nurse staffing and adverse events – mortality (Needleman et al., 2011), falls and drug administration errors (Patrician et al., 2011) – are causal.

Methods for determining staffing adequacy are not well validated. While the evidence as a whole is not strong, we identified a number of variables that may affect staffing requirements. Patient turnover, dependency/ acuity and ward case mix are associated with outcomes that are in turn influenced by nurse staffing. Although there is conceptual overlap between case mix and dependency / acuity there is some evidence that these are independent factors. While some weak evidence points to day of week, time of day and ward configuration (size and layout) as potentially influencing staffing requirements, the evidence is not strong and its implications unclear.

The diverse evidence base in terms of contexts, outcomes, measures of staffing and methods of analysis renders any attempt to directly derive staffing levels that could apply to the NHS context from this research, premature. However it is worth noting that in the one NHS study reported here (Ball et al., 2013) levels of missed care only reduced substantially as average staffing fell below 7.33 patients per registered nurse and the improvement over the worst staffing category was only significant at the highest staffing level (6.13 patients per registered nurse or fewer).

Conclusions & recommendations

Currently the NHS safety thermometer collects data on a range of potentially nurse sensitive outcomes including pressure ulcers, falls, catheter-related and urinary tract infections, venous thromboembolism. While all are important, their ability to be used as indicators of safe staffing is unclear.

We conclude that nurse staffing is linked to a number of patient safety outcomes but these outcomes are all problematic as indicators of safe nursing care. The most promising indicators are:

- Falls
- Medication administration errors
- Missed nursing care

Pressure ulcers and infections may also have a role but direct comparison between units is unlikely to be valid. Methods for determining medication errors and missed care as routine indicators are underdeveloped. Advances in this area will require validation of nurse reports and better routine data collection. There are issues of ascertainment for both falls and pressure ulcers. While evidence of the association between nurse staffing and falls appears to be robust, methods used for reporting need to be validated and bias remains a possibility.

There is a possibility of an endogenous relationship between staffing and outcomes and appropriate methods for risk adjustment / stratification need to be used when comparing units. The same is particularly the case for pressure ulcers where endogeneity appears to be a likely explanation for contradictory results. Data gathered for the NHS safety thermometer, currently limited to single age group stratification are unlikely to be sufficient for risk adjustment.

The findings appear to primarily relate to overall nurse staffing levels, primarily registered nurses. While evidence is not always strong, it appears to indicate that registered nurses are the key group in achieving patient safety. In general, evidence on skill mix favours a higher proportion of registered nurses and most evidence of associations with higher health care assistant staffing was negative (ie favouring fewer care assistants). Determination of the

required levels of health care assistant staffing requires consideration of different factors than those considered in this review.

Determination of safe staffing levels needs to take into account ward case mix, acuity, dependency and patient turnover. These are associated with outcomes that may be sensitive to nursing care which are in turn likely to drive nursing work associated with prevention or treatment, but the evidence is not based on validated methods for determining staffing requirements. Other factors may also influence staffing requirements including ward layout and size but the evidence is not strong. The extent to which day of the week might be an influential factor independent of case mix turnover and acuity is unclear. While varying staffing requirements between day and night seems self-evident, increasing acuity and high turnover in hospitals may make this distinction increasingly questionable.

Evidence gaps / need for future research

This review has identified significant evidence gaps, most significantly a small amount of research undertaken in the UK that could better identify relationships between different staffing configurations and patient safety outcomes.

- Few studies here have analysed data in a manner that allows the effect of actual staffing levels, as opposed to variation in staffing, to be readily determined. This might be remedied through a more detailed review and contact with authors but also presents a challenge for how staffing is modelled in future research.
- The outcomes measured generally represent failures of care, not positive 'quality'.
- Current measures of quality relevant to nurse staffing do not reflect contributions of health care assistants.
- There is insufficient evidence derived from the UK
- There is no economic evidence of direct relevance to inform NHS decision making

Much could be achieved if existing data were more suited to the purpose of identifying safe staffing

- In particular, the safety thermometer could be a rich source of data if minor additions that could facilitate risk adjustment were made to data gathered. Age of

patient (as opposed to a single age related category of over 65) could be easily added as could simple patient level description related to case mix.

- Research to develop standard approaches to risk adjustment to facilitate comparison should be undertaken.
- Measures of missed care that can be routinely derived (as opposed to collected intermittently) should be investigated and validated by exploring their associations with outcomes
- Economic analyses based on NHS data are required to inform decision making

Addendum: Systematic reviews of nurse staffing / patient outcomes & UK studies

i) Systematic reviews of nurse staffing / patient outcomes.

The agreed scope and protocol for evidence review 1 focussed on studies that were able to clearly highlight the issue of "skill mix" in the nursing team on hospital wards. The timeframe and resource available for our review did not permit us to review all of the very large number of studies in the field and so we focussed on the most relevant. This led to the exclusion of studies that had not controlled for other members of the nursing team in some way and where the nurse staffing variable was not clearly restricted to ward based nursing staff. However, while the validity of these studies to make decisions about ward staffing levels and *which* nursing groups are associated with particular outcomes is limited, they can contribute to the weight of evidence relating to the overall association.

There are two high quality reviews (limited to North American studies) that give a good overall picture and we summarise them here.

KANE, R. L., SHAMLIYAN, T. A., MUELLER, C., DUVAL, S. & WILT, T. J. 2007. The Association of Registered Nurse Staffing Levels and Patient Outcomes: Systematic Review and Meta-Analysis. *Medical Care,* 45**,** 1195-1204 10.1097/MLR.0b013e3181468ca3.

This review included studies found in a comprehensive search databases, including Medline, CINAHL, Cochrane databases, BioMed Central, federal reports, American Nurses Association, and Digital Dissertations from February to June 2006 to identify epidemiologic studies conducted in the United States and Canada that investigated the association between nurse staffing and patient outcomes. The review included 96 studies. Increased RN staffing (additional full time equivalent per patient day) was associated with lower hospital related mortality in surgical (OR, 0.84; 95% CI, 0.80-0.89 – 8 studies), and medical patients (OR, 0.94; 95% CI, 0.94-0.95 – 6 studies). An increase by 1 RN per patient day was associated with a decreased odds ratio of hospital acquired pneumonia (OR, 0.81; 95% CI, 0.67-0.98 – 4 studies), and cardiac arrest (OR, 0.72; 95% CI, 0.62-0.84 – 5 studies) among all patients. Among surgical patients, odds of failure to rescue (OR, 0.84; 95% CI, 0.79-0.90 – 5 studies)

surgical wound infection (OR 0.15 95% CI 0.03-0.82 – 1 study) and hospital acquired bloodstream infections (OR 0.64 95% CI 0.46-0.89 – 5 studies) were reduced and length of stay was shorter by 24% (OR, 0.69; 95% CI, 0.55-0.86 – 3 studies) with higher nurse staffing.

SHEKELLE, P. G. 2013. Nurse–Patient Ratios as a Patient Safety Strategy. A Systematic Review. *Annals of Internal Medicine,* 158**,** 404-409.

This review integrated a 'review of reviews' (guided by explicit criteria) based on Kane (op cit), a narrative review published in 2009 (Tourangeau, 2011) (10 additional studies) and 15 new primary studies.

The conclusions of this review confirmed the conclusions of the Kane review (and our own). "*The strongest evidence supporting a causal relationship between higher nurse staffing levels and decreased inpatient mortality comes from a longitudinal study in a single hospital that carefully accounted for nurse staffing and patient comorbid conditions* [15]*…Limiting any stronger conclusions is the lack of an evaluation of an intervention to increase nurse staffing ratios. The formal costs of increasing the nurse–patient ratio cannot be calculated because there has been no evaluation of an intentional change in nurse staffing to improve patient outcomes"*

[15] NEEDLEMAN, J., BUERHAUS, P., PANKRATZ, V. S., LEIBSON, C. L., STEVENS, S. R. & HARRIS, M. 2011. Nurse staffing and inpatient hospital mortality. *N Engl J Med,* 364**,** 1037-45. – included in evidence review 1.

ii) UK based studies

In the course of our review we found three studies that gave specific information on levels of staffing in English hospitals. One, with a main outcome of mortality, was excluded from the review as it did not control for care assistant staffing. It used data from the late 1990s. The second used nurse reported missed care as its outcome. This study used more recent data (2009/10) The main outcome of the third study was staffing levels and organisational attributes on nurse outcomes. This was part of a set of studies known as the Hospital Outcome Study with researchers from Scotland, England, the United States, Canada and West Germany.

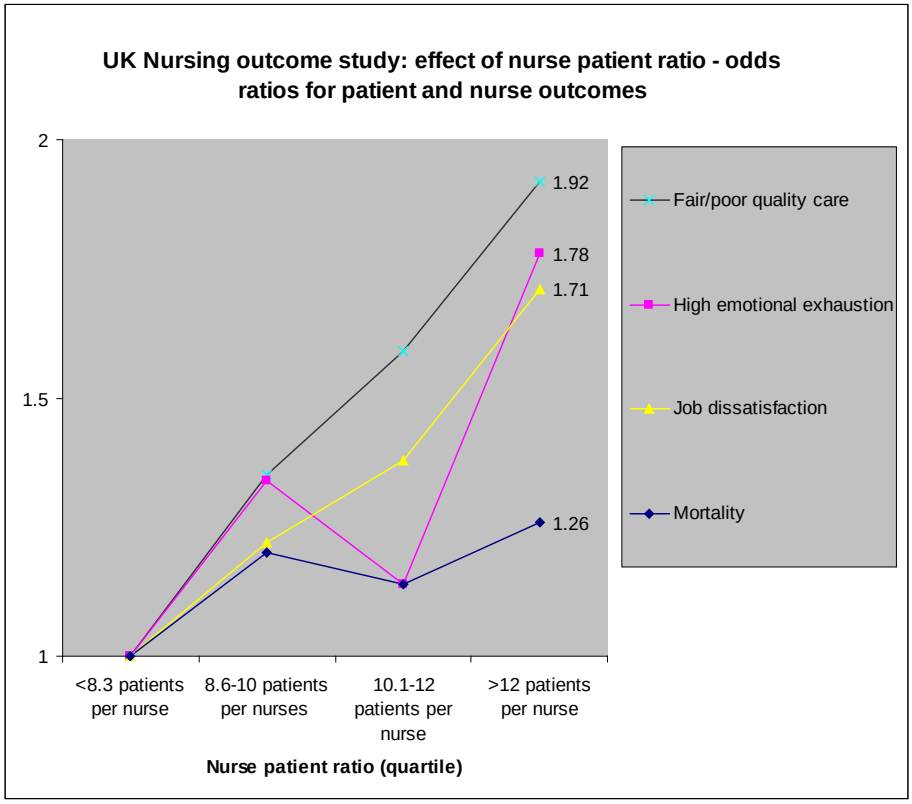
a. Mortality

RAFFERTY, A. M., CLARKE, S. P., COLES, J., BALL, J., JAMES, P., MCKEE, M. & AIKEN, L. H. 2007. Outcomes of variation in hospital nurse staffing in English hospitals: Cross-sectional analysis of survey data and discharge records. *International Journal of Nursing Studies,* 44**,** 175-182.

This cross-sectional analysis combined nurse survey data (N = 3984) with discharge abstracts of general, orthopaedic, and vascular surgery patients (N = 118 752) in 30 English acute trusts. Patients and nurses in the quartile of hospitals with the most favourable staffing levels (the lowest patient-to-nurse ratios) had consistently better outcomes than those in hospitals with less favourable staffing.

Patients in the hospitals with the highest patient to nurse ratios (12.4–14.3) had 26% higher mortality (95% CI: 12–49%) than patients in those with the lowest ratios (6.9–8.3 patients per nurse); the nurses in those hospitals were approximately twice as likely to be dissatisfied with their jobs, to show high burnout levels, and to report low or deteriorating quality of care on their wards and hospitals.

Most of the increased risk in mortality occurred between the best staffed hospitals compared to any hospital with lower staffing (see figure).



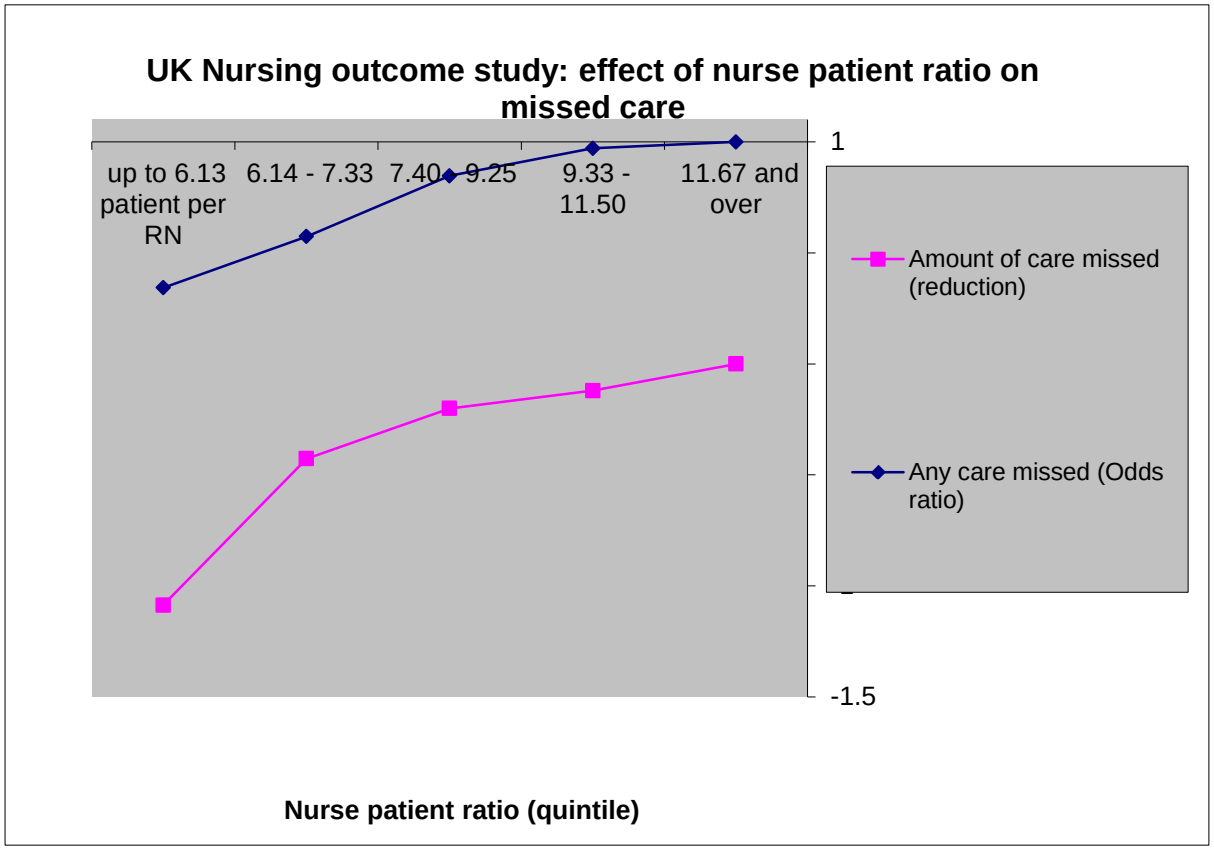
b. Missed care

BALL, J. E., MURRELLS, T., RAFFERTY, A. M., MORROW, E. & GRIFFITHS, P. 2014. 'Care left undone' during nursing shifts: associations with workload and perceived quality of care. BMJ Qual Saf, 23, 116-25.

This study examined the nature and prevalence of care left undone by nurses in English National Health Service hospitals and assessed whether the number of missed care episodes reported by nurses is associated with nurse staffing levels and nurse ratings of the quality of nursing care and patient safety environment. Data were derived from a cross-sectional survey of 2917 registered nurses working in 401 general medical/surgical wards in 46 general acute National Health Service hospitals in England.

Most nurses (86%) reported that one or more care activity had been left undone due to lack of time on their last shift. Most frequently left undone were: comforting or talking with patients (66%), educating patients (52%) and developing/updating nursing care plans (47%). The number of patients per registered nurse was significantly associated with the incidence of 'missed care' ($p<0.001$).

When registered nurses cared for 6.13 or fewer patients the odds of missing any care and the rate of care missed were significantly reduced (OR 0.343 p<0.001, beta -1.087, p<0.001) compared to the lowest staffed wards (11.67 patient per nurse or worse). (See figure)



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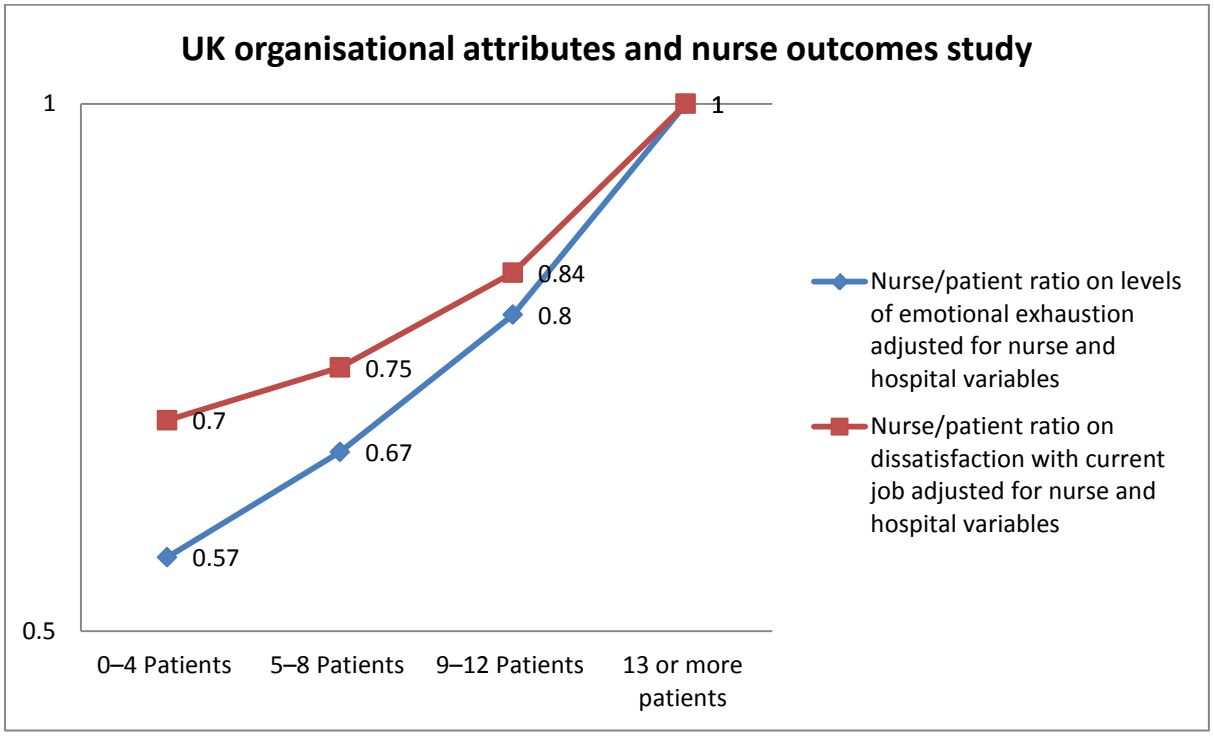
This study found no significant association with HCA staffing and no significant interaction between RN and HCA staffing. While we assessed this study as having high external validity (++) because it included a random sample of wards from a random sample of English hospitals, there are potential limitations in internal validity (+). The most significant of this is that the measure is nurses' reports of care left undone on the last shift. While this subjective measure has been shown to relate to other measures of quality its validity as an objective measure of 'missed care' is uncertain. This and similar studies suggest a line of development for quality measures rather than providing a solution.

c. Nurse staffing levels and organisational attributes

SHEWARD, L., HUNT, J., HAGEN, S., MACLEOD, M. & BALL, J. 2005. The relationship between UK hospital nurse staffing and emotional exhaustion and job dissatisfaction. *Journal of Nursing Management,* 13**,** 51-60.

This study explored the relationship between nurse workload, nurse characteristics, and hospital variables and nurse outcomes, specifically job dissatisfaction and burnout. Fifty nine adult, acute, multi-speciality hospitals employing 100 nurses minimum in England and Scotland formed the sample. Data derived from a 1999 survey of 19 454 registered nurses in Scotland and England (50% response rate).

The study showed statistically significant relationships between nurse patient ratios and emotional exhaustion and dissatisfaction with current job. Compared to nurses reporting the worst staffing (patient to nurse ratio 13 or more patients per nurse) nurses reporting better staffing were significantly less likely to report emotional exhaustion (adjusted odds ratios 0–4 Patients 0.57 [95% CI 0.46–0.71] 5–8 Patients 0.67 [0.55–0.81] 9–12 Patients 0.80 [0.71–0.92]) and job dissatisfaction (OR 0–4 Patients 0.70 [95% CI 0.58–0.83], 5–8 Patients 0.75 [0.66–0.85], 9–12 Patients 0.84 [0.72–0.99]).



a. Other UK studies

For completeness we identified two additional studies reporting associations between nurse staffing levels and patient outcomes in the UK. Neither of these met criteria for inclusion in

the main review. Both studies reported associations in terms of linear regression coefficients only and therefore cannot be used directly to estimate the effects of given staffing levels.

SHULDHAM, C., PARKIN, C., FIROUZI, A., ROUGHTON, M. & LAU-WALKER, M. 2009. The relationship between nurse staffing and patient outcomes: A case study. *International Journal of Nursing Studies,* 46**,** 986-992.

This study explored the association between nurse staffing levels and a range of possible nurse sensitive outcomes in a single specialist hospital trust over 1 year. Patient outcomes were not controlled for case mix in any way and hence the results appear to be inevitably confounded. The only significant result was a significantly higher rate of sepsis in wards with higher nurse staffing levels.

JARMAN, B., GAULT, S., ALVES, B., HIDER, A., DOLAN, S., COOK, A., HURWITZ, B. & IEZZONI, L. I. 1999. Explaining differences in English hospital death rates using routinely collected data. *BMJ,* 318**,** 1515-20.

This study examined the association between a number of hospital level variables and standardised hospital mortality rates using routine data from English hospitals 1991-1995. Nurse staffing was measured at the hospital level and therefore was not restricted to nurses working on hospital wards. The study found no associations between the number of nurses per bed and mortality but did find a significant association between the proportion of health care assistants (termed auxiliary nurses) and mortality. Hospitals with a higher proportion of HCAs had higher mortality rates.

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Study Details	Population and setting	Staffing variables	Outcomes and control variables	Results	
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	**Notes / comments**
Ausserhofer et al. (2013)	Europe	RN and non-registered nurses	Staffing levels Skill mix levels Rationing of nursing care levels	Higher skill mix levels were significantly associated with increased odds of pneumonia (odds ratio 1.026, p 0.033 95% CI 1.002-1.051). No significant association between RN staffing and pneumonia (odds ratio 0.956, p=0.460, 95% CI 0.850-1.077). No significant association between RN staffing/skill mix and patient satisfaction (odds ratio 0.896, p=0.066, 95% CI 0.797-1.007 / odds ratio 1.004, p=0.691, 95% CI 0.983-1.027), pressure ulcers (odds ratio 0.852, p=0.073, 95% CI 0.716-1.015 / odds ratio 0.994, p=0.700, 95% CI 0.962-1.026), falls (odds ratio 1.107, p=0.074, 95% CI 0.990-1.238 / odds ratio 1.011, p=0.343, 95% CI 0.988-1.035), UTI (odds ratio 0.972, p=0.587, 95% CI 0.878-1.076 / 1.014, p=0.186, 95% CI 0.993-1.036) and catheter-related bloodstream infections (odds ratio 1.502, p=0.525, 95% CI 0.881-1.066 / odds ratio 1.003, p=0.776, 95% CI 0.982-1.024)	Nurse reported outcome data used, giving a rough estimate of patient adverse events that may be subject to bias
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between patient safety climate & nurse-related organisational factors (staffing levels, missed care) with patient outcomes	General medical, surgical and mixed medical-surgical units of acute care hospitals	The association between patient to registered nurse ratio, implicit rationing of nursing care, skill mix (% non-registered nurses on the total number of nurses) and outcomes (patient safety climate)			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional; multilevel multivariate logistic regression	A national sample of Swiss hospitals from all three national language regions	35	State of health (poor, fair, good. Very good, excellent) Educational level (no education, obligatory school, vocational, higher school, university)	No significant association between RN staffing and medication errors (odds ratio 0.948, p=0.320, 95% CI 0.854-1.053). No significant association between skill mix and medication errors (odds ratio 0.995, p=0.683, 95% CI 0.973-1.018)	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Weak (-)	Units – random sample from university and center care hospitals. All units in primary care hospitals were included in order to attain sample size. Hospitals – convenience sample using criteria: >60 acute care beds; employing > 50 RNs; geographical location; hospital type	132	Bed size Ownership Services provided Hospital type (university, center care, primary care) Hospital run for profit	No nurse outcomes reported	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Strong (++)		997	Yes		

Study Details	Population and setting	Staffing variables	Outcomes and control	Results	

			variables		
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	**Notes / comments**
Ball et al. (2013) .	UK	RN, HCA (defined as Other nursing care staff, HCSW)	Missed care	None reported	The study analyses self-report nurse data which may be biased to the understanding of the missed care components. Aimed at controlling variation, missed care included 13 core components of nursing work,. Examples: −adequate patient surveillance −adequate documentation of nursing care −administering medication on time −develop or update nursing care plans/care pathways −educating patients and/or family −frequent changing of patient's position −pain management −preparing patients and families for discharge −undertaking treatments/procedures
Study Aim	**Setting**	**Staffing Variables**			
Assess whether the number of missed care episodes is associated with nurse staffing levels and nurse ratings of the quality of nursing care and patient safety environment.	Thirty one general acute hospital trusts. Stratified random sample of up to five general medical and five surgical wards from hospitals operated by the Trust. 401 wards (mixed medical/surgical) were included. ICU were excluded.	The association between staffing and missed care			
Study design	**Source Population**	**Sample size (Hospitals)**	**Nurse level adjustment**	**Process outcomes**	
Cross-sectional	Hospitals in the study come from a random stratified sample of 64 out of 341 NHS general acute hospital Trusts. This ensured mix by size, teaching status and region.	46 hospitals in 31 Trusts	None reported	Missed care	
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Moderate +	5 medical and 5 surgical wards of each of the selected hospitals were included.	401	Ward type	-Decreased number of patients per nursing staff, lower missed care- 6.13 or fewer patients per RN: OR 0.343 95% CI, 0.222 -Patients per RN <6.14 Pt per RN significantly lower number of missed care items (Beta 11.-1.087, p<0.001) and odds of at least one item of care missed (OR .343, p<0.001) compared to 11.67 or more nurses per patient 6.14 to 7.33 Pt Per RN significantly lower odds of at least one item of care missed (OR 0.574, p=0.019) compared to 11.67 or more nurses per patient. - non-significant relationship between patients per HCSW and either outcome (trend to worse outcomes with more HCSW). Missed care on vital signs: for ⩽ 6.13 patients per RN OR=0.39 L95=0.29 U95 0.54 compared to OR=0.80 L95=0.61 U95=1.06 for 9.33-11.50 patients per RN (Adequate patient surveillance category). For paper work (taken from adequately document nursing care) OR=0.58 L95=0.41 U95=0.81 compared to OR=0.98 L95=0.74 U95=1.31 (same number of patients per RN used in vital signs).	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Strong ++		2 844 nurse staff	Yes		
Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	**Notes / comments**

Blegen et al. (2011)	US	RN, LPN, HCA	Patient/clinical outcomes Safety net status	Higher total hours per inpatient day were associated with infection due to medical care (beta-0.233* 95% CI -0.37 to -0.09 p<0.01) and a rate of higher than expected LoS (beta-0.002* 95% CI -0.002 to -0.001 p<0.01). Having a higher proportion of RN hours (compared to LPN and Assistants) in the nursing hours was associated with lower failure to rescue (beta-0.008* 95% CI -0.01 to -0.004 p<0.01). Higher total hours per inpatient day were associated with lower CHD mortality (beta -0.087 95% CI -0.15 to -0.02 p<0.05). Having a higher proportion of RN hours (compared to LPN and Assistants) in the nursing hours was associated with lower infection due to medical care (beta-0.027 95% CI -0.05 to -0.005 p<0.05). Higher total hours per inpatient day were associated with failure to rescue (beta 0.023 95% CI -0.05 to 0.000 p<0.1). Higher total hours per inpatient day were associated with pressure ulcers (beta -0.036 95% CI -0.08 to 0.01 NS) and post-operative sepsis (beta -0.058 95% CI -0.17 to 0.05 NS). Having a higher proportion of RN hours (compared to LPN and Assistants) in the nursing hours was associated with higher CHD mortality (beta 0.03 95% CI --0.01 to 0.02 NS) lower pressure ulcers (beta-0.005 95% CI -0.02 to 0.01 NS), lower post-operative sepsis (beta -0.015 95% CI-0.05 to 0.02 NS) and no difference in rate of higher than expected LoS (beta .000 95% CI 0.00 to 0.00 NS).	Results of this study are limited by the relatively small size of the sample and by the fact that the sample only included teaching hospitals. Results not generalisable.
Study Aim	**Setting**	**Staffing Variables**			
To assess the association between staffing and patient outcomes and to assess whether safety net status affects this relationship	General medical/surgical adult units in hospitals belonging to the University HealthSystem Consortium (UHC)	Staffing levels measured as nursing hours per patient day by registered/unregistered nurses/nursing support staff			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient level adjustment**	**Process outcomes**	
Cross sectional	Hospitals that were regular or affiliate members of the UHC	54	Age Ethnicity Gender Diagnosis Comorbidities Socioeconomic status	No process outcomes reported	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Strong (++)	Convenience sample of hospital belonging to the UHC, that had contributed data to both their clinical and operational datasets	872	Technology index Teaching status Hospital / ward level case mix - Medicare case-mix index Other -Safety-net status	No nurse outcomes reported	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Moderate (+)		1.1 million patients	No		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were**	**Outcomes**	**Patient outcomes**	

		studied?			
Blegen et al. (1998)	USA	RN, LPN, HCA	Pressure ulcers, falls, mortality, hospital acquired pneumonia, CAUTI Medication errors	Controlling for acuity (closely correlated with staffing level as used to set staffing levels), total hours of nursing care was not significantly related to any of the patient outcomes. Proportion of RN hours was not significantly related to falls, infections, complaints or death, but was significantly related to pressure ulcers (standardised coefficient = -0.485, two tailed alpha < 0.05).	Diverse mix of units in a single hospital, with no patient level risk adjustment and no adjustment for unit type.
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing (level and mix) and patient outcomes	All in-patient units in a single 880 bedded university hospital (diverse mix including – medical, surgical, critical care, psychiatric paediatric)	The association between total hours of nursing care, skill mix (proportion of RNs) and adverse outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Retrospective observational	All inpatient units in single hospital	1	None	No significant association between medication errors and total nurse staffing (beta -0.202), except where RN staffing was above 87.5%, where errors increased (possible confounding effect of ICU). Higher proportion of RNs associated with lower rates of medication error (beta -0.53, p <0.1).	
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Weak	Census of units	42	Average monthly patient dependency score for each unit		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Weak		21,783 discharges(all patient records in financial year 1993)	No		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Blegen, Vaughn (Blegen and Vaughn, 1998)	USA	RN, LPN, HCA	Patient: Falls (per 1000 patient days) Cardiopulmonary arrests (per 1000 patient days) Process: Medication errors (oral and IV, per 1000 patient days)	Total hours of care not significantly associated with patient falls or cardiac arrests. Proportion of RNs significantly associated with fewer falls (beta -4.56, p<0.05) but not cardiac arrests (beta=-.08 p>.1)	The mix of diverse units (and small sample size) may have had a confounding effect. Case mix (applied at hospital level) was significantly associated with medication admin errors (beta -.344 p<0.05) & cardiac arrests (beta -.372 p<0.05) but not falls. No significant associations with time of year.
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing levels and patient outcomes	Mix of units in hospitals (25 medical/surgical, 8 ITU, 4 obstetric (including nursery) and 3 'skilled-care' units (housed in hospital but independently licensed as 'skilled care units')	The association between nursing hours per patient day and the proportion of RN delivered care with the falls and cardiopulmonary arrests			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Retrospective observational	Hospitals were members of a consortium the Institute for Quality Healthcare (IHQ)	11 hospitals	No patient level adjustment.	Medication errors significantly higher with more hours of care (beta .497, .323, p<0.05) . Errors per 1000 doses (beta -.576 p<0.05)) and per 1000 days (beta -.278, p<.1) significantly lower with higher proportion of RN.	
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
moderate	Convenience sample of 11 hospitals based on membership of IHQ, a consortium that has a shared 'comparative occurrence reporting system'. Geographical spread and hospital characteristics not reported.	39 units Rationale for sample of units not provided.	Unit type controlled for. Average Medicare case mix score applied at hospital level. Data by quarter – season controlled for.	None	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
moderate		Not reported	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Chang and Mark (2011)	US		Nurse mix	No patient outcomes reported	Data was collected between 2003-2004, so results may not reflect reality of date of publication. Use of incident reports can have low sensitivity and give rise to potential bias reporting problem
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between learning climate, nurse staffing (work dynamics and nurse mix) and medication errors	General medical / surgical units in non-federal, not-for-profit and non-psychiatric hospitals	The association between Nursing hours per patient day by registered/unregistered nurses/nursing support staff, nurse to patient ratio, skill mix (%RN in skill mix) and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient level adjustment**	**Process outcomes**	
Cross-sectional	Randomly selected hospitals in US	146	Age Health status Previous hospitalisation	Richer RN skill mix (vs HCA/LPN) associated with fewer medication administration errors (beta -0.145, p<0.01).	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Weak (-)	Random sample drawn from non-federal, not-for-profit and non-psychiatric hospitals that had minimum 99 licensed beds. Two general medical-surgical or medical-surgical speciality units from each hospital were invited to participate	286		No nurse outcomes reported	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Strong (++)		2860	No		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Cho et al. (2003)	US	RN, HCA, LPN	Nurse staffing levels	All hours had a positive relationship with pressure ulcers (OR = 1.13). Significant inverse relationship for RN Hours and RN Proportion with pneumonia. 1 RN hour increase was associated with a decrease of 8.9% (OR=0.91) in pneumonia odds. OR = 0.3686 for RN Proportion on pneumonia. See table 2 (adjacent cell) for all data (which has been summarised). Adverse events were associated with increased mortality, with sepsis having the greatest impact OR=7.40. Patient characteristics also had a significant relationship with mortality. When primary payer was categorised as "other" (self-pay and no charge) had the highest probability of death. 95% CI, OR=1.26 (1.08, 1.47) p<.01 This was followed by Medicaid patients OR=1.21 (1.08, 1.37) p<.01	The study also looked at staffing-level associations with medical costs
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing levels and patient outcomes (adverse events, morbidity, mortality and medical costs)	232 acute care hospitals in California, 20 common surgical diagnosis-related groups (DRGs) were selected as the patient groups. Final study sample consisted of 124,204 patients.	The association between NHPPD, skill mix (proportion of RNs) and patient adverse events			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient level adjustment**	**Process outcomes**	
Retrospective observational	Hospital, nurse staffing and financial data were taken from the Hospital Financial Data produced by California's Office of Statewide Health Planning and Development (OSHPD) (released by the AHRQ)	232	Age Ethnicity Gender Diagnosis Socioeconomic status	Associations to costs were not in relation to staffing but to adverse events. "All adverse events were associated with increased costs."	
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Strong	A convenience sample of hospitals and patients was made trying to create a homogenous group representative of the target population.		Socioeconomic status Bed size Ownership Teaching status		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Moderate		124 204 patients	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Donaldson (2004)	US	RN, LPN, HCA,	Patient safety Nurse worload	As staffing increased, falls/1000 patient days decreased, with the strongest predictor being mean percent RN hours of care. The greater the number of RNs who have a BSN or higher degree that there are on a ward, the fewer falls/1000 patient days there are (rho = -.26, p = .03). Percentage of patients with hospital acquired hospital ulcers was significantly (rs = -.25, 63 df, p <.05) associated with mean staffing ratio and with percent days with the staffing under 100% for the week prior to the prevalence study. The percent of patients in restraint was significantly associated with the percent of RNs currently certified (Rs = -.41, 54 df, p = .002)	Internal validity moderate as the study did not measure or control for differences in patient mix, risk or acuity - factors which may affect the relationships between the key variables. Study aimed to minimalize bias by measuring and analysing staffing at unit level to avoid potential impact of aggregation on measurement sensitivity.
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between staffing and adverse events, including how the 'pace' (workload/admissions/discharges/transfers) of patient care impacted on patient safety	General medical/surgical adult units in acute care, not-for-profit hospitals (urban and rural)	The association between nurse hours per patient day, ratio of required to actual hours of care, skill mix (RN/LVN/non-RN/LVN care hours as % total care hours) and patient outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient level adjustment**	**Process outcomes**	
Prospective, descriptive correlational design	Non-for profit hospitals participating in the CalNOC Project (Californian Nursing Outcomes Coalition)	25	Age	No process outcomes reported	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Moderate (+)	Convenience sample of CalNOC hospitals in urban and rural sites with an average daily census of 100 - >400	No unit sample size reported	Ownership Rural /urban designation	No nurse outcomes reported	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Strong (++)		No patient/nurse sample size given	No		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Duffield et al. (2011)	Australia	RN and non-RN	Nursing workload Work environment Patient outcomes	More RN/CNS hours per patient hours were significantly ($p \leqslant .01$) associated with 3/11 OPSN: decreased rates of decubiti, pneumonia, and sepsis (parameters not given). An increase in the proportion of RN/CNS hours was associated with significant decreases in 7/11 OPSN: decubiti, GI bleeding, physiological/metabolic derangement, pulmonary failure, sepsis, and shock. Higher proportion of hours worked by ENs associated with higher rate of falls (beta 2.14 p-0.03)	Weak internal validity. Risk adjustment is limited with evidence of residual confounding
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing (fewer RNs), increased workload and unstable unit environments with patient outcomes	General medical/surgical units in acute care hospitals	Association of % RNs, nurse to patient ratio, skill mix			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional (combined with longitudinal retrospective)	Hospitals contributing to the HIE (Health Information Exchange) database and representing the following four groupings: Principal/major referral and specialist; major metropolitan; major regional; other regional	19 for cross-sectional 27 for longitudinal	Diagnosis Comorbidities	Association reported with proportion of nurses who usually work on the ward. Fewer medication errors were associated with more nurses working on their usual unit and more overtime.	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Weak (-)	Two parts to study. In part 1 a convenience sample was selected; in part 2 a random sample. Both samples were selected from the 4 hospital groupings (see source population)	80 (43 matched for longitudinal)	Case mix similarity / specialist status	No nurse outcomes reported	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Moderate (+)		5885 (cross sectional) 2,675,428 (longitudinal)	No		

Study Details	Population and setting	Staffing variables	Outcomes and control variables	Results	Notes / comments
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Estabrooks et al. (2005)	Canada	RN, HCA, LPN	Hospital nursing characteristics (skill mix, well-being)	Hospitals with higher proportion of skill Mix, higher RN-to-non-RN ratios, were associated with lower rates of 30-day patient mortality, OR, 0.83 [95% CI (0.73, 0.96)].	
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing characteristics and patient outcomes (mortality)	General medical wards in acute care hospitals in Alberta. Patient population consisted of admissions for myocardial infarction, congestive heart failure, chronic obstructive pulmonary disease, pneumonia, or stroke. Reasons for ward selection: acute cases, high-volume and high crude death rates	The association between WTE/FTE per patient day/bed and skill mix (proportion of RNs) and mortality			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient level adjustment**	**Process outcomes**	
From extraction	Study derived from the Alberta arm of the larger International Hospital Outcomes study. 49 out of 109 hospitals in Alberta with at least 20 beds and 5 nurses providing survey data were included in the study.	49	Age Gender Diagnosis Comorbidities Vital status at discharge	Vital signs	
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Strong ++	Convenience sample based on hospital size (≥20 beds) and with information for at least 5 nurses surveyed (according to the Alberta Association of Registered Nurses registry records)	NA	Socioeconomic status Bed size Technology index Teaching status		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Moderate +		Happy to just go with patient samples where relevant – go with whichever one best indicates the size of the study	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Frith et al. (2010)	Canada	RN, LPN, UAP	RN/LPN hours per patient day Skill mix (%RN)	No association found between RN / LPN staffing and any individual adverse outcome. Higher % RN significantly associated with fewer total complications. An increase of 1% in RN percentage in staffing reduced the number of adverse events by 3.4%.	Although validity rated as weak, data had to meet external standards for reimbursement / quality reporting.
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing and patient outcomes (hospital acquired conditions and LoS)	General medical/surgical units in Catholic Health Initiatives (CHI) Corporation hospitals	The association between RN/LPN/UAP Hppd, RN/LPN/UAP % skill mix and patient outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional	Hospitals in the Catholic Health Initiatives (CHI) Corporation	4	Age Comorbidities Diagnosis	Higher RN and LPN staffing significantly associated with reduced LoS (beta for relationship with log LoS -.16, -.24, p<0.01). Decrease of 16.5% for one extra hour of RN, 5.7% for an extra hour of LPN (median case mix). RN % associated with lower Los - 1% increase in RN associated with 4.2% decrease in LoS. Similar but lower effect for LPN %	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Weak (-)	Convenience sample of medical/surgical units, excluding those where intravenous vasoactive drips were administered or where there were more than 10% paediatric patients during the study period	11	None reported	No nurse outcomes reported	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Weak (-)		34,838	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Frith et al. (2012)	US	RN, LPN	Skill mix (RN/LPN)	No patient outcomes reported	Sampling of wards is uncertain, so unclear whether study is eligible population representative
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing/skill mix and medication errors	General medical/surgical units in a single community hospital	The association between RN hours/LPN hours per equivalent patient day (HPEqPD), and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Retrospective observational	Medical/surgical units in community hospitals	1	Age Ethnicity Gender Comorbidities Diagnosis	RN hours per patient day associated with fewer medication administration errors (beta -0.07 $p< 0.05$). More LPN hours associated with more medication errors (beta .85, $p<0.01$)	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Moderate (+)	Convenience sample based on sufficient numbers of medication errors and sufficient data for hierarchical linear modelling	9	No unit/hospital level adjustment	No nurse outcomes reported	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Weak (-)		31,080 patients	No		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Hart and Davis (2011)	USA	RN, LPN, HCA	Pressure ulcers Falls Cardiac arrest calls Medication errors	Higher total nursing hours associated with reduced falls with injury (beta −0.051, NS) and pressure ulcer (beta −0.485 p<0.05). Higher HCA associated with fewer falls (beta −0.286, NS) and more pressure ulcers (beta .301, NS)	
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing and patient outcomes (at the hospital unit level)	Acute nursing units in 5 hospitals	Assessed association of NHPPD, staffing skill mix, and percent RN hours by agency staff, with outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional, Retrospective observational	Convenience sample of wards participating in NDNQI data collection	5		Total nursing hours, RN hours, HCA hours associated with lower rate of medication errors (betas -0.065, -0.251,--.176)	
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Weak	5-hospital integrated health care system in an urban city in a south-eastern state. Sample of 26 acute care nursing units (15 MS, 3 telemetry, and 8 critical care [CC]). Data for a 24-month period used.	26	stratified by unit type		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Weak			No		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
He et al. (2013).	USA	RN, HCA, LPN		Higher NHPP not significantly associated with mortality (OR 1.01 95% CI .99, 1.03 p= .30). Higher proportion of RNs (skill mix) compared to HCA and LPN associated with lower mortality (OR 0.96 95% CI 0.93, 1.00 p= .05 per 10% increase)	
Study Aim	**Setting**	**Staffing Variables**			
To examine the impact of patient-level risk adjustment on the associations of unit-level nurse staffing and 30-day inpatient mortality.	All Veterans Affairs hospitals with units having 100+ discharges of acute care units, specifically intensive care, medical, surgical, medical surgical mixed, step-down, and spinal cord injury units. Discharge records of patient between October 2007 and September 2008 were included in the sample.	The association between NHPPD, skill mix (proportion of RNs) and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional	Patient discharges of eligible acute care units	446	Age Ethnicity Gender Diagnosis Comorbidities		
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Strong ++	Convenience sample based on number of discharges (100+)	128	From high risk adjustment model non-ICU only Ward case mix		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Strong ++		Patients: 23 6447	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Ibe et al. (2008)	Japan	RN LPN	Pressure ulcers Falls Patient experience (also physical restraints)	Regression, standardized betas Pressure Ulcers: RNPPD 0.321 (p=0.072), Associate NPPD -0.493 (p=0.043),Other HPPD -0.860 (p=0.018), %RN -1.301 (p=0.014), r2 0.316 Physical Restraints: RNPPD 0.156 (p=0.353), Associate NPPD 0.331 (p=0.150),Other HPPD 0.407 (p=0.233), %RN 0.782 (p=0.118), r2 0.383 Falls and patient satisfaction not reported in detail, no significant associations	
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing and patient outcomes	Acute care units in 42 hospitals in Tokyo and surrounding area. The units defined as acute phase of medical and nursing care (by the payment system)	Assess the relationship between nurse staffing (nursing hours, skill mix, and the intensity of nursing-care needs) and patient outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional/ Retrospective observational	Convenience sample – Study members had participated in 'California Nursing Outcomes Coalition' (CalNOC) conference.	42	Intensity of nursing care needs score		
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Weak	Convenience sample	87			
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Moderate		Patient number unclear, 317,393 patient days	No (unit level analysis)		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Kutney-Lee et al. (2013)	USA	RN, HCA, LPN	Mortality Failure to rescue (for subgroup of surgical patients)	Increases in staffing level and skill mix not significantly associated with mortality (beta 0.65, p.35, beta 1.89 p=0.08) or FTR (beta .3 p=.89, beta 4.08 p=0.23). Mortality and FTR significantly associated with increased proportion of RNs with a degree (beta -2.12, p<0.01, beta -7.47, p<0.01)	
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse educational levels and outcomes (staffing as a control variable)	Acute Hospitals in Pennsylvania	Nurse to patient ratios (self reported) and nurse education levels at two points in time from general med/surgical units (1999 and 2006)			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Retrospective observational	Acute care hospitals in Pennsylvania	134	Age, diagnosis, co-morbidities		
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
strong	Nurses surveyed at random (across hospital) in a sample of 80% of acute care hospitals in Pennsylvania	Not reported	Technology index Teaching status		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
moderate		(1999 – 52% response. 2006 – 39% approx) Average of 80 and 48 respondents from each of the 134 hospitals in 1999 and 2006, respectively	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Lake et al. (2010)	US	RN, LPN, NA	Skill mix (RN/LPN/NA) Magnet status Patient falls	An increase in RN Hppd has a significant association (r = -.29, p < .001) with a decrease in the fall rate in ICUs; 1 x additional RN Hppd = 3% decrease in the fall rate. An increase in LPN/NA Hppd has a significant association (r = .12 for LPN Hppd, r = .10 for NA Hppd, p < .001) with an increase in fall rate in ICUs; 1 x additional LPN/NA Hppd = 2 - 4% increase in fall rate.	The age of the data (2004) limits results, as policy changes since that date may have altered the roles of nursing staff and the incidence of patient falls. The age of the data also limits the generalizability of the results to present day hospitals. The fall rates were aggregated from unit level and may reflect differing subsets of unit types in the Magnet and non-Magnet subgroups. More accurate findings could have been achieved with better risk adjustment.
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between staffing, hospital Magnet status and patient falls	General medical/surgical and intensive care, step-down & rehabilitation units in Magnet and non-Magnet hospitals	The association between RH Hppd, LPN Hppd, NA Hppd and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional (retrospective observational)	Hospitals contributing to the NDNQI database	636	Age Gender	No process outcomes reported	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Moderate (+)	Convenience sample based on selected nursing units in participating hospitals contributing to NDNQI database	5388	Bed size Ownership Teaching status Hospital's structural characteristics Region, urban versus rural (Northwest, Midwest, West, South)	No nurse outcomes reported	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Moderate (+)		113,067 patients	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Manojlovich et al. (2011)	US, Canada	RN, LPN	Falls MRSA infection	MRSA infections: Active ingredient (ed/exp/sk) -1.12 (p=0.03)Intensity: (FTE/rnptratio/RN-HPPD) -1.15 (p=0.001) Falls: Active ingredient (ed/exp/sk) -0.66 (p=0.001) Intensity: (FTE/rnptratio/RN-HPPD) -0.48 (p=0.001)	Small sample size (26 units in 2 hospitals) without risk adjustment. Risk stratification (unit type surgical, medical and mixed wards) and cluster adjustment.
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurses staffing and patient outcomes	Inpatient units: medical, surgical, medical/surgical	The association between NHPPD, skill mix (proportion of RNs) and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Retrospective observational		2	List from extraction (if only nurse outcomes measured insert that here and indicate 'nurses')		
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Weak	Convenience sample - hospital in Ontario and one in Michigan	26	From extraction		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Weak		Happy to just go with patient samples where relevant – go with whichever one best indicates the size of the study	Yes / no / unclear from extraction		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
McGillis Hall et al. (2004)	Canada	RN, RPN & unregulated staff	Nursing hours Patient safety outcomes Patient complexity	Higher proportion of professional nursing staff (RNs/RPNs) associated with fewer wound infections ($p<0.05$, no parameters given). Higher proportion of professional nursing staff (RNs/RPNs) associated with medication errors ($p<0.01$), no parameters given)	The results of this study are limited to teaching hospitals only
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between staffing models and costs and patient outcomes	General medical / surgical and obstetric units in teaching hospitals.	The association between nurse to patient ratios, skill mix (proportion of RNs/RPNs) and outcomes (medication errors & infections)			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional	Hospitals comprised of the total teaching hospital in one province (Ontario, Canada)	19	No patient or nurse level adjustments reported	The fewer RNs and RPNs employed on the unit, the fewer hours of nursing care used. In contrast, the higher the proportion of unregulated staff on the unit, the greater the nursing hours costs.	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Weak (-)	Convenience sample comprised of all teaching hospitals in designated area	77	No unit/hospital level adjustment reported	No nurse outcomes reported	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Moderate (+)		No sample size recorded	No		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Needleman et al. (2011)	USA	RN	Staffing variation levels of RN	-Mortality and exposure to below-target shifts. Risk of death increased with exposure to increased number of below-target shifts. Hazard ratio per below-target shift, 1.02 95% CI, 1.01 to 1.03 p<0.001. When number of below-target shifts restricted to in ⩽5 days after admission, hazard ration increased to 1.03 95% CI, 1.02 to 1.05 p<0.001. When exposure specified in a window of previous 6 shifts, hazard ratio was 1.05 95% CI, 1.02 to 1.07 p=0.001. -High-turnover shifts and increased risk of death. Analyses that included all hospital admissions and cumulative exposure during ⩽30 days, hazard ration per high-turnover shift was 1.04 95% CI, 1.02 to 1.06 p<0.001. When restricted to those in ⩽5 days, hazard ratio increased to 1.07 95% CI, 1.03 to 1.10 p<0.001	
Study Aim	**Setting**	**Staffing Variables**			
Examine the association between mortality and variations in staffing at the unit level in a single institution with Magnet hospital designation.	All staffing shifts of eligible wards in one tertiary academic medical center, mixed medical/surgical were analysed. Wards excluded paediatric, labour and delivery, behavioural health and inpatient rehabilitation units.	The association between NHPPD and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Retrospective observational	Patient census, admissions, transfers, and discharges data were obtained from the hospital electronic data systems.	1	Nurse: non-RN staff controlled in analysis		
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Strong ++	Convenience sample of wards in one hospital	43	Cumulative number of shifts during which a patient had been in an ICU		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Moderate +		176 696 nursing shifts	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
O'Brien-Pallas et al. (2010a)	Canada	%RN	Staffing resources/utilisation levels Nurse-patient ratios	Higher patient to nurse ratio significantly associated with decreased good/excellent quality of patient care (beta -0.25, p<0.05, odds ratio 0.78) and with increased longer than expected LOS (beta 0.303, p<0.05, odds ratio 1.35). No significant association between skill mix and good/excellent quality of patient care (beta -1.98, odds ratio 0.82, NS) and longer than expected LOS (beta 1.193, odds ratio 1.13, NS).	Limited in generalizability as study only conducted in cardiac and cardiovascular nursing units.
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between staffing, work environment and nurse and patient variables on system outcomes	Cardiac and cardiovascular inpatient units in non-teaching and teaching hospitals	The association between nurse patient ratio, skill mix (proportion of RN worked hours) and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Prospective correlational design with cross-sectional and longitudinal components	Hospitals with cardiac and cardiovascular units in hospitals within two Canadian provinces (Ontario & New Brunswick)	6	Number of diagnoses Resource intensity weight Medical consequences Health status on admission	No significant association between patient to nurse ratio and patient care interventions omitted or delayed (beta -0.03, odds ratio 1, NS) and therapeutic interventions omitted or delayed (beta 0.173, odds ratio 1.2, NS). No significant association between skill mix and patient care interventions omitted or delayed (beta -0.1, odds ratio 1, NS) and therapeutic interventions omitted or delayed (beta -1.32, odds ratio 0.9, NS)	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Moderate (+)	Convenience sample which met the following criteria: high patient volumes in the cardiac Case Mix Group of interest	24	No unit/hospital level adjustment reported	No significant association between patient to nurse ratio and absenteeism (beta -0.09, odds ratio 0.91, NS). No significant association between skill mix and absenteeism (beta -0.95, odds ratio 0.91, NS)	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Weak (-)		1198	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
_ENREF_22O'Brien-Pallas et al. (2010b)	Canada	RN, LPN & RPN	Turnover	No significant associations reported and no parameters given. Frequent use of temporary nurses linked to concerns about patient satisfaction	Weak validity. A highly complex and multifaceted study using large complex datasets and diverse data sources, including varying definitions/quality and availability of information. Almost half the units did not meet the inclusion criteria for analysis. Self-reporting surveys were used, which can potentially be open to error
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nursing turnover and patient care	General medical / surgical, intensive care, obstetrics, paediatrics, psychiatric and rehabilitation units in a broad cross-section of hospitals.	The association between NHPPD, skill mix (total worked hours from RNs divided by total worked hours of RN/LPN/RPNs) and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional (and longitudinal)	A broad sample of hospitals across 10 provinces	41/wave 1 and 39/wave 2 (overlap of same hospitals in both waves was not reported)	Age Gender Diagnosis (condition, severity, complexity)	Higher staffing significantly associated with decreased medical errors (beta -0.129, SE 0.0608, odds ratio 0.88, p<0.05). No significant association between skill mix and medical errors (-0.200, SE 6.6818, odds ratio 0.98, NS). No significant association between full-time mix and medical errors (beta 4.029, SE 3.3347, odds ratio 1.50 NS)	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Weak (-)	Random ward sample and convenience hospital sample	182/wave 1 and 163/wave 2 (overlap of same units in both waves was not reported)	Units classified into 9 types: combined medical/surgical unit, ICU, Medical Unit, Obstetrics/Gynaecology, Paediatric Hospital, Paediatric Unit within Adult Hospital, Psychiatric, Rehab/LTC/Geriatric and Surgical Unit	No significant association between staffing and nurses' mental health (beta -0.137, SE 0.1400, NS) and nurses' job satisfaction (beta -0.319, SE 0.2798, NS). No significant association between skill mix and nurses' mental health (beta 13.482, SE 19.7185, NS) and nurses' job satisfaction (beta 20.514, Se 36.7158, NS). No significant association between full-time mix and nurses' mental health (beta 4.061, SE 6.1147, NS) and nurses' job satisfaction (beta -17.897, SE 11.1972, NS)	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Weak (-)		8,138	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Park et al. (2012)	USA	RN, LPN, HCA	Failure to rescue (validated AHRQ algorithm used to define FTR)	More RN HPPD associated with higher FTR (beta 0.081 95% CI 0.127, 0.035 p<0.05). More non RN hours associated with higher FTR (0.018 beta -0.024 to 0.059) NS.	Patient turnover significantly associated with FTR (beta 0.001 95% CI 0.0001, 0.001 p <0.05). When patient turnover increased from 48.6% to 60.7% on non-ICUs, the beneficial effect of non-ICU RN staffing on FTR was reduced by 11.5%. Turnover X RN hours significant interaction. The effect of RN staffing is attenuated at higher turnover, implying a higher staffing requirement
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing and patient	Not for profit teaching hospitals	The association between RN HPPD and failure to rescue, examining the effects of patient turnover.			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional/Retrospective observational	Convenience sample drawn from 234 hospitals (based on availability of data)	42	Age Gender Diagnosis Co-morbidities	None	
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Strong	Convenience sample of hospitals, with census of eligible patients (surgical patients with FTR complications) within each.	759	Technology index Hospital / ward level case mix Controlled for effects of: Patient turnover Patient dependency / acuity	None	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Moderate		Approx. 1,000,000 patients All surgical patients with FTR complications are included. Staffing measured on all general inpatient units, or solely surgical ones	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Patrician et al. (2011)	USA	RN, HCA, LPN	Medication administration errors (MAE)	Total NCHPPS (1-h decrease) increased odds of falls & falls with injury in medical/surgical units (OR 1.07, 1.15 p<0.05) . 10% decrease in the % RN increased odds of falls & falls with injury (OR 1.11, 1.30 p<0.05). 10% decrease in the % LPN increased the odds of falls (OR 1.08 p<0.05) but not falls with injury	
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurses staffing and adverse events at the shift level.	Thirteen hospitals of the military health system located in geographic proximity to pre designated study hub sites were included. Shifts data from 2003 and 2006 were generated. All nursing staff working in medical/surgical, step down and critical care units was included.	The association between patient to nurse ratios (per shift), skill mix (proportion of RNs) and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Retrospective observational	Military hospitals contributing to the Military Nursing Outcomes Database (MilNOD)	13	None reported (a reported limitation of the study is the lack of adjustment for risk of falling or for risk of MAE.		
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Strong ++	Convenience sample of military hospitals located in designated geographical location. A data set of 115 062 consecutive nursing staff shifts working in eligible wards between 2003 and 2006 was generated.	115 062 consecutive shifts	Hospital: size		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Strong ++			Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Potter et al. (2003)	USA	RN, LPN, HCA (Patient care technician)	RN staffing levels	Nursing hours was significantly associated with distress (negative) patient self care willingness (negative) and self care index (negative) and falls per thousand patient days (negative). No significant association with pain, anxiety, sleep quality, health status, medication errors or measures of satisfaction. The percentage of RN hours was negatively correlated with patient pain and self-care ability, and positively correlated with patient health status and five of the seven measures of post discharge patient satisfaction ($p<.05$).	Although the study is prospective, the baseline against which the measures are compared is from a sample o patients 'in the past'. The baseline was established and ward data was collected prospectively with a different sample of patients.
Study Aim	**Setting**	**Staffing Variables**			
Establish a baseline data of existing relationships between staffing levels and patient outcomes. Measure the impact of organisational changes related to allocation of human resources.	All acute general care medical units (N=32) of one tertiary care 879 bed-size hospital were included in the study.	The association between NHPPD, skill mix (proportion of RNs) and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Prospective observational	Patient baseline established with results from VAS (Visual Analogue Scale) and one question about perceived health status used in the National Center for Health Statistics Health Interview Survey	1	Diagnosis		
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Moderate +	All acute units in the hospital that met the eligibility criteria were included. Ambulatory or outpatient clinics, operating rooms, emergency room, labour and delivery rooms, and intensive care units were excluded.	32	None reported		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Weak -		3 418 patients	Unclear		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Seago et al. (2006)	US	RNs and non-RNs	Staffing hours and staffing mix	Higher total hours per patient day were associated with higher levels of patient satisfaction with pain management (beta 2.44 SE 0.62 p<0.01), with requests for assistance (beta2.21 SE 0.86 p<0.01), with instruction (beta 3.18 SE 0.74 p<0.01). Richer skill mix was associated with higher levels of patient satisfaction with pain management (beta 13.63 SE 3.6 p<0.01), with requests for assistance (beta 22.9 SE 5.0 p<0.01) and with instruction (beta 9.94 SE 4.8 NS). Higher total hours per patient day were associated with higher failure to rescue from medication errors (beta 0.98 SE 0.12 <0.01). Richer skill mix was associated with lower failure to rescue from medication errors (beta -1.3 SE 0.55 NS). Higher total hours perpatient day were associated with higher failure to resue from ulcers (beta -0.872 SE 0.95 NS). Richer skill mix was associated with higher failure to rescue from ulcers (beta -5.7 SE 2.8 NS)	Limited validity as small sample/restricted to one hospital. Possible error in self-reported survey data gives rise to potential bias
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between staffing and positive patient outcomes (in particular failure to rescue outcomes – medication errors and ulcers)	General medical/surgical acute care units in a large urban tertiary care teaching hospital	The association between RN Hppd, non-RN Hppd, total Hppd, skill mix (proportion of RN hours divided by total hours) and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Retrospective observational (longitudinal repeated measures,4 yrs)	Teaching hospitals that provide similar services and that partner with medical schools and residential training facilities	1	No patient or nurse level adjustment reported	Higher total labour dollars were associated with higher failure to rescue from ulcers (beta 0.00001 SE 0.000004 p<0.01)	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Weak (-)	Convenience sample from teaching hospitals	3	No unit/hospital level adjustment	No nurse outcomes reported	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Weak (-)		No patient or nurse sample size recorded	No		

Study Details	Population and setting	Staffing variables	Outcomes and control variables	Results	Notes / comments
Author (Year) Shever et al. (2008)	**Country** *USA*	**Which staff groups were studied?** *RN and 'total care givers'*	**Outcomes** *Costs per patient hospitalisation (in dollars)*	**Patient outcomes** *Average CGPR RN for hospitalization (mean RN HPPD = 9.47) [best staffing category] GEE estimate = 0.105, p <.001, ratio of change in cost = 1.110, mean cost change in dollars = $ 1736.27 (Median cost change $1021.60) Average CGPR RN for hospitalization (mean RN HPPD = 6.64) GEE estimate = 0.054 p = 0.001, ratio of change = 1.055, Mean cost change $871.22 (median $512.62); Average CGPR RN for hospitalization (mean RN HPPD = 5.56) GEE estimate = −0.008, p= 0.540, ratio of change = 0.992, Mean cost change = $−128.72 (median $−75.74) Average CGPR RN for hospitalization (mean RN HPPD = 4.07) [worse staffing category) GEE estimate = 0.674, p <.001, ratio of change = 1.144 (per 0.2) Mean cost change $2273.50 (Median $1337.70)*	
Study Aim	**Setting**	**Staffing Variables**			
Association of nursing surveillance on hospital costs per patient, using nurse staffing level and skill-mix as two controls.	*Acute mid-western tertiary hospital*	*NHPPD - the average amount of RN time per hour (averaged over the duration of the patient's hospitalisation)*			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Retrospective observational	*Patients > 60 identified as being at risk of falls, in acute tertiary hospitals*	1	*Age, diagnosis, co-morbidities* *Time on ICU* *Occupation* *severity of illness*		
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
weak	*All patients older than 60, at risk of falls in a single tertiary hospital, over a 4 year period*	*Not reported*	*None*		
External Validity		**Sample size (Patients & or nurses)** *7851 patients,* *10187 hospitalisations*	**Control for clustering of outcomes in units (wards ' hospitals')**		
weak			*GEE used to report results (but only single sites and units not defined, so not for clustering my place)*		

Study Details	Population and setting	Staffing variables	Outcomes and control variables	Results	Notes / comments
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Sochalski et al. (2008)	USA	RN, LPN	Nurse staffing levels	Overall each additional Nursing hour (RN+LVN) per patient day was not significantly associated with AMI mortality (-.14% decrease per NHPPD, NS) or FTR (0.02% increase per NHPPD, NS). Similar finding for each staff group independently. For hospitals with lower initial staffing the relationship with AMI staffing was statistically significant. Benefits decreased with higher staffing. For hospitals with more than 7 patients per nurse an increase in RN / all NHPP lead to a decrease in AMI mortality of .71% /2,75% (p<0.05 / p<0.01), for hospitals with 6-7 patients per nurses it was .52/1.14 (p<0.05 / p<0.01) 5-6 (.35/.56 P<0.05/0.01), 4-5 .19/.28 (p>0.05/p<0.05)	
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing and improvement in patient outcomes for hospitals having different baseline staffing levels	All staff from medical / surgical units and ICUs, all patients. discharged from short-term acute care California hospitals from 1993 to 2001 and having either (1) a principal diagnosis of AMI,11 or (2) a major general, orthopaedic, or vascular surgical procedure	The association between NHPPD, skill mix (proportion of RNs) and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional (fixed effects regression analyses)	Hospitals contributing to the California's Office of Statewide Health Planning and Development (OSHPD) and annual Medicare case-mix index data files from the Centers for Medicare and Medicaid Services.	343	List from extraction (if only nurse outcomes measured insert that here and indicate 'nurses')		
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Stong ++	Convenience sample of all California hospitals with data available before the legislation of mandated-ratio was implemented were included.	NA	Socioeconomic status Bed size Ownership Teaching status Hospital/ward level case mix Area wage index		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Moderate +		454 351 patients	Unclear		

Study Details	Population and setting	Staffing variables	Outcomes and control variables	Results	Notes / comments

Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Spetz et al. (2013)	USA	RN, LPN, HCA	Pressure ulcers Falls Failure to rescue Length of stay Surgical site infections (post-surgical infection – PSI)	An additional hour of NIW-adjusted RN HPPD was associated with approx. 2.4% fewer deaths following a postoperative complication at the 25th percentile of HPPD, 2.0% fewer at the median, and 1.7% fewer at the 75th percentile (NS). For all other PSIs, an increase in HPPD is estimated to increase the incidence of adverse events (NS). Significant decrease in The mean LOS for patients experiencing PSI decreased significantly, with a larger decline found among hospitals with RN HPPD at the 25th percentile (−10.0%, $p < .001$) and at the median (−7.0%, $p < .001$). The LOS also decreased with the addition of nurses for pressure ulcers and postoperative respiratory failure (NS). The LOS rises for postoperative sepsis, and the relationship is mixed for PE/DVT (NS).	
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing and patient outcomes	Census of all medical/surgical hospital patients	Association between NHPPD and outcomes			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional/Retrospective observational	All nonfederal general acute care hospitals in California	278	Age Diagnosis Comorbidities Nursing Intensity weights (NIW)		
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Strong	Census of hospitals reporting to Californian state-wide (mandatory) database	Not reported	Bed size Ownership Technology index		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Strong		26,684,752 patients	n/a hospital level		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Staggs and Dunton (2012)	USA	RN, LPN, unlicensed assistive personnel	nurse turnover	No patient outcomes reported	Weak in terms of external validity, as hospital sample was random and not representative of all US hospitals. Results not generalizable.
Study Aim	**Setting**	**Staffing Variables**			
To assess the association between staffing level / skill mix and nursing turnover rates	General medical/surgical, critical care and psychiatric in Magnet status/government and non-government acute care hospitals	Staffing levels measured as Nursing Hours per Patient Day			
Study design	**Source Population**	**Sample size (Hospitals)**	**Nurse level adjustment**	**Process outcomes**	
Retrospective observational; longitudinal	Hospitals contributing to the NDNQI database	306	Age	No process outcomes reported	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Weak (-)	Convenience sample from hospitals contributing to the NDNQI database; unit must have submitted 18 months of turnover data in previous 2 year period and must have submitted staffing data for at least 12 of those months	1884	Location - metropolitan, micropolitan, rural. Bed size, ownership; teaching status; Magnet status	Higher skill mix levels were significantly associated with lower staff turnover (beta -0.036 SE 0.011 95% CI 0.94-0.98 p<0.001). Total nurse staffing level did not have a significant effect on turnover (No parameters reported)	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Weak (-)		Not reported	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Tschannen et al. (2010)	*USA*	*RN, LPN, HCA (nurse assistants)*	*Retention* *Nurse turnover*	*None reported*	Study is only generalizable to hospital of similar characteristics. Survey data is nurse self-reported.
Study Aim	**Setting**	**Staffing Variables**			
To assess the relationship between missed nursing care, nurse turnover, and intention to leave	*Mixed medical/surgical adult care units in rehabilitative, intermediate, and intensive care units in hospitals of size ranging between 60 and 913 beds.*	*Staffing levels measured as NHPPD*			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional	*Hospitals contributing to the MISSCARE survey*	10 acute-care hospitals.	*Nurses:* *Age* *Gender* *Education background*	-Larger missed care associated with higher turnover rates (r=.23, p < 0.05)	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Moderate *+*	*Convenience sample based on hospital bed size*	110	*Unit*	HPPD associated with less missed care (r=-.32 p<0.01) but not intention to leave (r=.02 NS) or turnover (-.07 NS). Skill mix not associated with missed care (r=.01 NS). Higher skill mix, greater intention to leave and turnover among the unit staff (r=.34,.32) p < 0.01, in univariate models but not in multivariate model	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Strong *++*		*4 288 nursing staff*	Unclear		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Unruh et al. (2007)	US	RN, LPN, NA	Nurse absenteeism Nurse workload	"Higher RN absenteeism was related to more patient deaths when patient load is also high (beta 0.033 p<0.001). High patient load was related to greater numbers of incident reports (beta 5.4561 p<0.05). Although regressions were also run separately for LPNs and NAs, none showed statistically significant results and so these are not reported."	This was a case study of one hospital so the results cannot be generalised. Results for absenteeism were not particularly robust since the data for absenteeism and staffing had to be aggregated to a monthly basis to match the monthly quality data.
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse absenteeism and quality of patient care	General medical / surgical, intensive care, oncology, neuro-medical progressive care, pulmonary progressive care and cardiac progressive care units in one hospital	The association between RN/LPN/NA worked hours per patient day, RN/LPN/NA absenteeism hours and quality of patient care			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Retrospective observational	Unclear. Sample hospital was 'part of a large hospital system in the southeast USA'	1	Other - Case mix variable (from Case Mix Index) was used to capture patient characteristics which could contribute to patient outcomes and which were therefore controlled	Higher RN absenteeism was related to higher restraint use when patient load is also high. High RN absenteeism was independently associated with fewer uses of alternatives to restraints. Although regressions were also run separately for LPNs and NAs, none showed statistically significant results and so these are not reported	
Internal Validity	**Selection procedure**	**Sample size (units)**	***Unit / hospital level adjustment***	**Nurse outcomes**	
Weak (-)	Convenience sample	6	Ward level case mix	No nurse outcomes reported	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Weak (-)		15,192	No		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Weiss et al. (2011)	USA	RN, HCA, LPN	Readmission [quality of discharge teaching, patient perception of discharge readiness, and emergency department (ED) visits]	Higher RNHPD significantly associated with higher QDTS "content delivery" scale (beta 0.27). No significant relationship with non RN staffing (beta 0.04, NS)	
Study Aim	**Setting**	**Staffing Variables**			
Assess the association between nurse staffing and cost-benefits (in relation to patient discharge)	Study targeted adult English speaking medical –surgical patients admitted to acute care hospitals, who were discharged directly to home.	The association between NHPPD, skill mix (proportion of RNs) and patient discharge variables, and cost-benefits of unit nurse staffing			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional	Acute care hospitals	4	Age Ethnicity Gender Diagnosis Comorbidities Socioeconomic status		
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Moderate	Convenience sample of four Magnet hospitals in a single health care system in Midwestern United States selected, convenience sample of units within each.	16	Vacancy rate, turnover		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Weak		1,892 patients	Yes		

Additional Economic Studies

Study Details	Population and setting	Staffing variables	Outcomes and control variables	Results	Notes / comments
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Dall et al. (2009)	US	RN	RN hours		A literature review on associations between RN staffing level in hospitals and patient risk for: Patient risk for UTI, Hospital-acquired pneumonia, Pressure ulcer, Upper gastrointestinal bleeding, Sepsis, Shock/cardiac failure, Pulmonary failure, Central nervous system complications, Deep vein thrombosis, Postoperative infection, Adverse drug events, and Patient falls. Patient nosocomial complications, healthcare expenditures, and national productivity. Outcomes not reported at ward/hospital level
Study Aim	**Setting**	**Staffing Variables**			
Quantify the economic value of professional nursing.	Medical and surgical patients in non-federal acute care hospitals.	Describe key relationships studied e.g. "The association between NHPPD, skill mix (proportion of RNs) and outcomes" relationship between registered nurse staffing levels and nursing-sensitive patient outcomes in acute care hospitals The association between patient risk of a particular NSO and HPPD.			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Simulations, combining published evidence of the impact of increasing nurse staffing levels on a range of outcomes with estimates of incidence of these outcomes from regional or national data sources	"Hospitals contributing to the NIS hospital discharge data for 2005. NIS data was linked to the American Hospital Association's Annual Survey of Hospitals"	610	Age, sex, race, primary payer, DRG, number of diagnoses at admission, type of admission (scheduled or unscheduled)	Increase RN hours to 75th percentile resulted in: **Avoided mortality**: 5,900 estimated from DRG risk-adjusted logistic regression. **Hospital days avoided**: 3,600,000 estimated from DRG risk-adjusted Poisson regression. **Costs Savings**: 6,100; **Additional**: 11,039; estimate from information reported in study-increase of 133,000 FTE RNs at annual cost of $83,000 (salary $57,820 and 30.4% benefits). **Net**: 4,939	
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
	Convenience sample based on hospital type and year	NA	Hospital: Ownership, size, teaching status, rural/urban, region		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
		5.4 million discharges	Yes		

Study Details	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Needleman et al. (2006)	US	RN	RN hours		Length-of-stay (days) Urinary tract infection Hospital-acquired pneumonia Shock/cardiac arrest Upper GI bleeding Failure to rescue Source of estimates reported: "Authors' estimates using data from J. Needleman et al., "Nurse-Staffing Levels and Quality of Care in Hospitals," New England Journal of Medicine 346, no. 22 (2002): 1415–1422, updated to 2002 based on 1997 and 2002 American Hospital Association annual survey data and on wage data for nurses employed in hospitals from the Current Population Survey."
Study Aim	**Setting**	**Staffing Variables**			
Construction of national estimates of the cost of increasing hospital nurse staffing and associated reductions in adverse outcomes.	Medical and surgical patients in non-federal acute care general hospitals in 11 states.	"The association of increased nurse staffing and outcomes"			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Simulations, regression analyses conducted on the impact of increasing nurse staffing levels on a range of outcomes with estimates of incidence of these outcomes from regional or national data sources	"Hospitals contributing to the American Hospital Association (AHA) annual survey and Medicare cost reports database"	799		Estimates of 1. increasing proportion of registered nurses to 75th percentile: Avoided mortality: 354; Avoided NSO: 59,938; Hospital days avoided: 1,507,493; Costs: Savings: 1,053, Additional: 811, Net: -242 2. increase number of licensed nurses to 75th percentile without changing proportion of registered nurses Avoided mortality: 597 Avoided NSO: 10,813 Hospital days avoided: 2,598,315 Costs: Savings: 1,719, Additional: 7,538, Net: 5,819 3. increasing the proportion of registered nurses while also increasing the number of licensed nurses (a combination of 1 & 2) Avoided mortality: 942 Avoided NSO: 70,416 Hospital days avoided: 4,106,315 Costs: Savings: 2,772[e], Additional: 8,488 Net: 5,716	
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**		
	Reported in Needleman 2001, 2002 "Nurse-Staffing Levels and Quality of Care in Hospitals," New England Journal of Medicine 346, no. 22 (2002): 1415–1422.		Hospital size Location Teaching status		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
		Reported in Needleman et al., "Nurse-Staffing Levels and Quality of Care in Hospitals," New England Journal of Medicine 346, no. 22 (2002): 1415–1422. The sample had 5,075,969 medical and 1,104,659 surgical discharges. B	Unclear		

Study Details	Population and setting	Staffing variables	Outcomes and control variables	Results	Notes / comments
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Shamliyan et al. (	US (based on a meta-analysis prepared for the Agency for Healthcare Research and Quality)	RN			Overall findings: Increased RN staffing in ICU and (up to some level) in surgical units was associated with lower hospital-related mortality and adverse patient events and The association was not found in medical units. **The report offers a conceptual framework for assessing additional staff cost against potential savings due to avoided deaths and adverse events.**
Study Aim	**Setting**	**Staffing Variables**			
Analysis of societal savings from avoided deaths and patient adverse events through changes in staffing levels. (Analysis of cost ratio of increased RN-to-patient ratios associated with hospital-related mortality and patient adverse events)	Studies in meta-analysis included patients in ICU surgical and medical units	"The association of staffing levels and outcomes"			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Meta-analysis of observational studies				ICU – increase RN staffing Avoided mortality: 648,378 Avoided NSO: NA Hospital days avoided: NA Costs: Savings: 1,478,933[f], Additional: 589,680 Net: 889,253	
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		

<table>
<tr><td>Study Details</td><td>Population and setting</td><td>Staffing variables</td><td>Outcomes and control variables</td><td>Results</td><td>Notes / comments</td></tr>
<tr><td>Author (Year)</td><td>Country</td><td>Which staff groups were studied?</td><td>Outcomes</td><td>Patient outcomes</td><td></td></tr>
<tr><td>Twigg et al. (2013)</td><td>Australia</td><td>RN and LPN</td><td rowspan="3"></td><td rowspan="3">Increase in nursing hours associated with: 1. CNS complications (O Pre = 497/O Post = 489 - Expected = 486 - p = 0.92). 2. Wound infection (O Pre = 909/O Post =</td><td rowspan="8">Central nervous system complications deep vein thrombosis/pulmonary embolus, pressure ulcers, gastrointestinal bleeding, pneumonia, sepsis, shock/cardiac</td></tr>
<tr><td>Study Aim</td><td>Setting</td><td>Staffing Variables</td></tr>
<tr><td></td><td>General medical and surgical wards in three adult acute hospitals</td><td></td></tr>
<tr><td>Study design</td><td>Source Population</td><td>Sample size (Hospitals)</td><td>Patient (nurse) level adjustment</td><td>Process outcomes</td></tr>
<tr><td>Retrospective observational</td><td rowspan="5">Data were obtained from a previous Australian study reported in Twigg D., Duffield C., Bremner A., Rapley P. & Finn J. (2011) The impact of the nursing hours per patient day (NHPPD) staffing method on patient outcomes: a retrospective analysis of patient and staffing data. International Journal of Nursing Studies 48, 540–548.</td><td>3</td><td>Patient:
Age
Ethnicity
Gender
Diagnosis
Comorbidities</td><td rowspan="5">Net cost was estimated based on 1202 NSOs averted (savings) and 493 NSOs having incurred an additional cost. Other NSOs did not demonstrate difference at</td></tr>
<tr><td>Internal Validity</td><td>Selection procedure</td><td>Sample size (units)</td><td>Unit / hospital level adjustment</td></tr>
<tr><td>Strong
++</td><td>52</td><td>NA</td></tr>
<tr><td>External Validity</td><td>Sample size (Patients & or nurses)</td><td>Control for clustering of outcomes in units (wards ‘ hospitals’)</td></tr>
<tr><td>Moderate
+</td><td>Patients: 107,253 pre compared with 107,026 post. Total 214,279</td><td>Yes</td></tr>
</table>

Reviews staffing requirements

Study Details	**Review details**	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Search**	**Country**	**Which staff groups were considered?**	**Outcomes**	Review summarises the workload/nursing intensity literature up to 1992. Describe three broad categories of workload management systems based on patient profiles, critical indicators of care and nursing task documents. Several ways to quantify care hours based on expert or nurse estimates of time per patient category or nursing task. Little evidence of comparability of different workload measurement systems. Available evidence suggests high correlation between system, but lack of comparability. Most of the studies on reliability assessed interrater reliability. Agreement was lower for global items and required integrated judgements across items. Discussion of several dimensions of validity. Face validity important to support acceptance of nurses. Predictive validity most important to predict nurse-staffing requirements.	
Edwardson and Giovannetti (1994)	1977-1992 Medline, CINAHL, Health Planning and Administration *Screened n= NA* *FT screened n=NA* *Included n=NA*	*Not described*	*No information on skill mix*	*Not applicable*		
Study Aim	**Inclusion/Exclusion criteria**	**Setting**	**Associated Factors of staffing requirements**	**Study design**		**Critical appraisal**
1. Describe approaches to workload measurement 2. Identify measurement issues	*Included n=NA* Inclusion: Studies of measurement of nursing workload with minimal level of systematic testing and sufficiently described development	All settings including: acute hospitals, long-term care facilities, ambulatory and community settings including public health and home care	Needs for bathing, feeding, ambulation, observation, special treatments, psychosocial support and teaching not complete but sufficient to predict care requirements.	*Literature Review*		*Not described*

Study Details	**Review details**	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Search**	**Country**	**Which staff groups were considered?**	**Outcomes**	Defines nursing workload or nursing intensity *"as the amount and type of nursing resources needed to care for an individual patient on a daily basis"*. Productivity is defined as "*the relationship between the amount of acceptable output produced and the input required to produce the output. Acceptable presumes that commonly held and generally acceptable standards exist".* Workload nurse outcome association: • Short-time increase in productivity leads to long-term health costs (1 study) • Overtime associated with sick leave (1 study) • Higher rates of sick leave for full-time nurses over part-time nurses (1 study) • 23% increase in burnout and 15% increase in job dissatisfaction with increase of 1 patient per nurse (1 study	Several studies of the workload patient outcome association are described, which is out-dated given the more recent review in this document. The review also compares the evidence base for four workload management systems: PINI, PRN, GRASP and Medicus.
O'Brien-Pallas et al. (2005)	-2005 unkown *Screened n= approx. 1000* *FT screened n=NA*	*Not described*	*RNs, Bachelor degrees, agency nurses*	*Not applicable*		
Study Aim	**Inclusion/Exclusion criteria**	**Setting**	**Associated Factors of staffing requirements**	**Study design**		**Critical appraisal**
1. Define concepts of nursing workload and productivity 2. Present theoretical underpinnings of nursing workload and productivity 3. Critically examine factors that influence nursing workload and productivity	*Included n=93* Inclusion: Papers advancing the theoretical underpinnings of workload and productivity Empirical studies investigating workload and productivity in relation to patient, nurse, and system outcomes	All settings	Patient characteristics: • Age • Nursing diagnose • Medical diagnose • Comorbidities • Complications • Clinical instability • Illness severity Provider characteristics • Bachelor degree • Experience • Autonomy • Exhaustion Staffing patterns • Productivity levels ~85% • Agency nurses Organization of patient care. • Caseload • time spent on non-nursing tasks • Continuity of care	*Literature Review*		*Not described*

Study Details	Review details	Population and setting	Staffing variables	Outcomes and control variables	Results	Notes / comments
Author (Year)	**Search**	**Country**	**Which staff groups were considered?**	**Outcomes**	Overall seven studies with reliability/validity assessment identified. Tested instruments are Army Classification System, PINI, PRN80, RAFAELA and RIMS. Review concludes that 1) difficulties with workload measurement are overarching theme 2) definitions and descriptions of nursing work continue to be described as inadequate 3) insufficient evidence on reliability and validity 4) need for nursing- sensitive performance indicators and outcomes Design considerations of workload management systems: • Parsimony • minimal additional workload requirement • a basis in expert nurse judgment • true reflection of nursing work • indicators that measure patient complexity, optimal required nursing care, available resources, and relevant organizational attributes.	
Fasoli and Haddock (2010)	1983-2010 Medline, CINAHL, SSCI, Embase, CDSR, BIOSIS *Screened n= 375* *FT screened n=NA*	*United States, Canada, Great Britain, Finland and Australia*		*Not applicable*		
Study Aim	**Inclusion/Exclusion criteria**	**Setting**	**Associated Factors of staffing requirements**	**Study design**		**Critical appraisal**
1. Identify the literature on patient classification/acuity systems 2. Identify validated staffing models 3. Identify classification variables to consider in staffing model	*Included n=63* Not specified	General inpatient medical/surgical setting	Patient • Complexity (Nursing diagnosis, DRG) • Severity (length of stay) • Dependency/functional status, activities of daily living • Transports • Age • Care needs: observation, obesity, postdischarge needs, psychosocial Nurse • Education • Experience • Skill mix Unit/Organisation • Stability/maturity • Volume • Patient turnover • Interdisciplinary relationships/communication • Support services • Unit complexity/variation (inpatient type and treatment) • Autonomy/work environment • Protocol-driven care • Multitasking (high frequency/low volume)	*Integrative Review*		*Own assessment based on validity, reliability, simplicity/efficiency, utility, objectivity and acceptability*

Study Details	**Review details**	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Search**	**Country**	**Associated Factors of staffing requirements**	**Outcomes**	Five categories were identified influencing nursing workload: the hospital and ward, nursing team, individual nurse, patient and family and meta-characteristics. The variables were also classified, based on their cause–effect relationship. Some factors have a direct impact on the patient-nurse relationship, while others have an effect on the work fluency or on the subjective perception of the nursing workload. A conceptual model was built, based on the interaction between both classifications and derived from the systems theory.	
Myny et al. (2011)	1970-2009 PubMed, Embase, CINAHL, BNI, Elin, Engineering Village, snowballing *Screened n= 1782* *FT screened n=87*	United States, Canada, Great Britain, Japan, Australia and Netherlands	Meta-characteristics • Scarcity Hospital/ward characteristics • Shift schedule • Nursing care model • Practice environment • Low decision authority • Number of beds • Crowding • Nurse/bed ratio • Understaffing • Staffing model • Number of calls • Support service resources • Technical complexity • Number of emergency admissions Nursing team characteristics • Temporary staff • Experience • Skill mix Nurse characteristics • Efficient work organisation • Environmental uncertainty • Stress Patient/family characteristics • Complexity of patient care • More diverse patient population • Disruptive behaviour • Age • Patient turnover • Length of Stay	*Not applicable*		
Study Aim	**Inclusion/Exclusion criteria**	**Setting**		**Study design**		**Critical appraisal**
1. Which non-direct patient care factors are related to the difference in nursing workload 2. The development of a conceptual model to describe the relation between non-direct patient care factors and nursing work- load	*Included n=30* Studies describing non-direct patient care factors associated with nursing workload English, Dutch, German or French	Acute care hospital setting		*Integrative Review*		Research Appraisal Checklist (RAC)

Study Details	**Review details**	**Population and setting**	**Staffing variables**	**Outcomes and control variables**	**Results**	**Notes / comments**
Author (Year)	**Search**	**Country**	**Which staff groups were considered?**	**Outcomes**		
Huisman et al. (2012)	1984-2011 PubMed, JSTOR, Scopus *Screened n*= 798 *FT screened n=NA*	Not available	Not available	*Not applicable*		
Study Aim	**Inclusion/Exclusion criteria**	**Setting**	**Associated Factors of staffing requirements**	**Study design**		**Critical appraisal**
1. Is healthcare design related to Patient/family/staff outcomes?	*Included n*=61 Articles referring to the physical environment in the title and abstract. Articles were excluded that concerned aspects of medical treatment or wound healing	Acute care hospital setting	• Non identified	*Systematic Review*		Levels of evidence

Additional studies staffing requirements

Study Details	Population and setting	Staffing variables	Outcomes and control variables	Results	Notes / comments
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Blegen et al 2008. (Blegen et al., 2008)	USA	RN, LPN, CNA	Impact of staff supply in diverse geographic regions on staffing levels of hospitals		
Study Aim	**Setting**	**Staffing Variables**			
To assess the impact of nurse supply in the geographic areas surrounding hospitals on staffing levels in hospital units, while taking into account other factors that influence nurse staffing.	Community hospitals of different geographical regions in the USA. Mixed medical/surgical adult units: (intensive care, medical/surgical, telemetry/stepdown) units in participating hospitals.	TNHPPD RNHPPD LPNHPPD CNAHPPD			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional	Data from hospitals from the U.S. Census report, National Council of State Boards of Nursing, and The Centers for Medicare and Medicaid Services	47 hospitals (from 11 clusters)		Larger hospital wards have lower RN hours per patient day (beta -0.027, p<0.01), with an increase of one bed reducing the care time per patient by 1.6 minutes. Larger units have also a lower proportion of RNs (beta - 0.002, p<0.001) and licensed staff (RNs + LPNs, beta -0.001, p<0.05).	
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Weak -	Convenience sample of community hospitals based on First: Clusters of large hospitals, bed size <200 from 1999 AHA data, 2 clusters with at least 10 non-federal, non-university affiliated, acute care general hospitals were randomly selected from 4 stratified region data and Second: random sample of hospitals in each cluster. Two random clusters were selected too. Total 11 geographical areas. Data was collected for the calendar year 2000 (all this being part of the Nurse Staffing and Quality of Care study (NINR NR01 04937).	279 patient care units	Bed size Technology index Teaching status		
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ' hospitals')**		
Strong ++			Yes		

Study Details	Population and setting	Staffing variables	Outcomes and control variables	Results	Notes / comments
Author (Year)	**Country**	**Which staff groups were studied?**	**Outcomes**	**Patient outcomes**	
Hurst (2008)	UK	Ward sister, staff nurses, nursing assistants	FTE to bed ratio as staffing requirement in high quality wards	NA	
Study Aim	**Setting**	**Staffing Variables**			
To improve nursing efficiency and effectiveness by capitalising on the best ward design features	Acute inpatient care	FTE to bed ratio			
Study design	**Source Population**	**Sample size (Hospitals)**	**Patient (nurse) level adjustment**	**Process outcomes**	
Cross-sectional	English trusts	40 hospitals	NA	Ward type (FTE) 1. Nightingale (1.43) 2. Bay (1.41) 3. Night/Bay (No data) 4. Hub/Spoke (1.31) 5. Racetrack (1.18) 6. Split site (5.38) 7. Other (2.44)	
Internal Validity	**Selection procedure**	**Sample size (units)**	**Unit / hospital level adjustment**	**Nurse outcomes**	
Weak -	Convenience sample	375 wards	Ward types (Nightingale, Bay, Nightingale/Bay Hub, Spoke, Racetrack, Split, Other) Specialty	NA	
External Validity		**Sample size (Patients & or nurses)**	**Control for clustering of outcomes in units (wards ‘ hospitals’)**		
Weak -		NA	No		

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Appendices

Base search strategy questions 1-3

Database, Host, Date Searched, Year Searched Added Keywords	Search Strategy	Results
Ovid MEDLINE(R) 1996 to January Week 4 2014 Searched on 30/01/2014 Search Limited to 2006-current Keywords Added: QUESTION 1 2006 TO	1 exp Nurses/ (39956) 2 Nursing Staff, Hospital/ (19990) 3 (nurse or nurses or nursing).tw. (166343) 4 (RN or "RNs" or "RN's").tw. (6068) 5 Nurses' Aides/ (1986) 6 ("healthcare assistant*" or "health care assistant*").tw. (296) 7 Nursing Administration Research/ (1905) 8 Nursing Audit/ (1798) 9 Models Nursing/ (8353) 10 Nursing Service Hospital/ (1383) 11 or/1-10 (196456) 12 exp Hospitals/ (96922) 13 exp Hospital Units/ (46926) 14 hospital*.tw. (495376) 15 (acute adj3 (ward* or unit*)).tw. (3146) 16 (acute adj3 care).tw. (12476) 17 (medical adj3 (unit* or ward*)).tw. (6786) 18 (surgical adj3 (unit* or ward*)).tw. (5932) 19 Inpatients/ (9872)	4233

CURRENT SEARCH MEDLINE	20 (inpatient* or "in-patient*").tw. (755198) 21 (patient* adj3 surgical).tw. (38159) 22 ("medical-surgical" or "surgical-medical").tw. (3180) 23 (postsurgical or "post surgical").tw. (8691) 24 or/12-23 (1241211) 25 (skill* adj1 mix*).tw. (486) 26 skillmix*.tw. (5) 27 (staffmix* or "staff mix*").tw. (67) 28 staffing.tw. (5679) 29 understaff*.tw. (263) 30 "under staff*".tw. (29) 31 "Personnel Staffing and Scheduling"/ (9217) 32 (staff* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory)).tw. (4977) 33 (staff* adj3 (sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage or efficient* or efficienc* or inefficien*)).ti. (129) 34 Health Manpower/ (3311) 35 manpower.tw,fs. (29821) 36 (workload* or workforce* or shift or shiftwork* or shifts or overtime or capacity).tw. (331806) 37 Workload/ (12895) 38 or/25-37 (376700) 39 11 and 24 and 38 (7620) 40 (nursing and hours and patient and day).tw. (270) 41 NHPPD.tw. (5) 42 (nurs* and hours and care).tw. (2716) 43 (nurs* and work* and hours).tw. (1458) 44 (nurs* adj3 "patient* ratio*").tw. (221)	

	45 "nurse-patient-ratio".tw. (39) 46 (nurs* adj3 "patient* number*").tw. (2) 47 (nurs* adj staffing).tw. (778) 48 (nurs* and staffing and hospital*).tw. (1126) 49 (nurs* and staffing and ward*).tw. (150) 50 (nurs* and staffing and unit*).tw. (746) 51 (nurs* and safe* and staffing).tw. (350) 52 (nurs* and adequate* and staff*).tw. (953) 53 (nurs* and inadequate* and staff*).tw. (530) 54 (nurs* and understaff*).tw. (121) 55 (nurs* and "under staff*").tw. (13) 56 ("nurs* unit*" and (organi?ation or characteristic* or outcome* or level*)).tw. (314) 57 (nurs* and staffing and outcome*).tw. (701) 58 (nurs* and staff* and burnout).tw. (307) 59 (nurs* and staff* and stress).tw. (821) 60 (nurs* and staff* and fatigue).tw. (121) 61 (nurs* and staffing and practice).tw. (484) 62 "care left undone".tw. (3) 63 ("missed care" or "missing care").tw. (29) 64 (nurs* and skillmix*).tw. (2) 65 (nurs* and "skill* mix*").tw. (308) 66 (nurs* and (staffmix or "staff mix")).tw. (45) 67 (nurs* and magnet and staff*).tw. (133) 68 or/40-67 (7836) 69 39 or 68 (13127) 70 (MAU or "assessment unit*" or maternal or maternity or obstetric* or "accident and emergency" or "A&E" or "emergency room* or HIV or burns").tw. (142436) 71 Emergency Medical Services/ or Emergency Service, Hospital/ (50883)	

	72 Maternal Health Services/ or Hospitals, Maternity/ or Obstetrics/ (12168) 73 Community Mental Health Services/ or Mental Health Services/ or "United States Substance Abuse and Mental Health Services Administration"/ (23572) 74 Psychiatric Department, Hospital/ or Emergency Services, Psychiatric/ or Hospitals, Psychiatric/ or Psychiatric Nursing/ (14909) 75 (mental or mentally or psychiatry or psychiatric).tw. (193845) 76 exp Intensive Care Units/ or Burns Units/ or Burns/ or HIV Infections/ or Acquired Immunodeficiency Syndrome/ (181726) 77 (ICU or "intensive care unit*").tw. (56971) 78 exp "Homes for the Aged"/ (5969) 79 ("nursing home*" or "care home*" or "medical home*").tw. (15340) 80 exp residential facilities/ or exp nursing homes/ or Outpatients/ (28500) 81 or/70-80 (626705) 82 or/15-18,21-23 (72277) 83 69 not (81 not 82) (8881) 84 limit 83 to yr="2006 -Current" (4965) 85 (editorial or comment or letter).pt. (825651) 86 84 not 85 (4899) 87 limit 86 to english language (4520) 88 exp child/ or exp infant/ (918546) 89 (child* or infant* or schoolchild* or preschool* or "pre-school*" or pediatric* or paediatric* or toddler* or newborn* or neonatal or baby or babies).tw. (750873) 90 88 or 89 (1112615) 91 exp adult/ (3079078) 92 adult*1.tw. (485370)	

	93 91 or 92 (3291089) 94 87 not (90 not 93) (4233)	
Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations January 30, 2014 (MEIP) Searched on 30/01/2014 Search Limited to 2006-current Keywords Added: QUESTION 1 2006 TO CURRENT SEARCH MEDLINE	As per Medline using free text terms	561

EMBASE Ovid 1974 to 2014 January 30 Search Limited to 2006- current Searched on 31/01/201 4 Keywords Added: QUESTION 1 2006 TO CURRENT SEARCH EMBASE	1 Nurses/ (71662) 2 Nursing staff/ (54918) 3 Nursing/ (195177) 4 (nurse or nurses or nursing).tw. (363049) 5 (RN or "RNs" or "RN's").tw. (11585) 6 Nursing Assistant/ (3662) 7 ("healthcare assistant*" or "health care assistant*").tw. (434) 8 or/1-7 (505465) 9 Hospital/ or Teaching Hospital/ or Magnet Hospital/ or General Hospital/ or Teaching Hospital/ (276321) 10 Hospital Patient/ (73168) 11 hospital*.tw. (1132017) 12 (inpatient* or "in-patient*").tw. (1625587) 13 Inpatient/ (73168) 14 or/9-13 (2621563) 15 (patient* adj3 surgical).tw. (82936) 16 (acute adj3 (ward* or unit*)).tw. (6697) 17 (acute adj3 care).tw. (22625) 18 (medical adj3 (unit* or ward*)).tw. (15040) 19 (surgical adj3 (unit* or ward*)).tw. (12179) 20 Surgical Ward/ (3313) 21 (patient* adj3 surgical).tw. (82936) 22 ("medical-surgical" or "surgical-medical").tw. (6525) 23 (postsurgical or "post surgical").tw. (18230) 24 or/15-23 (153754) 25 14 and 24 (77035) 26 Skill Mix/ (123) 27 (skill* adj1 mix*).tw. (761) 28 skillmix*.tw. (7) 29 (staffmix* or "staff mix*").tw. (85) 30 staffing.tw. (11381)	5364

	31 understaff*.tw. (477) 32 "under staff*".tw. (46) 33 "staff deficien*".tw. (7) 34 Personnel Management/ (50253) 35 Total Quality Management/ (22857) 36 "organization and management"/ (362172) 37 (staff* adj3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory)).tw. (9524) 38 (staff* adj3 (sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage or efficient* or efficienc* or inefficien*)).ti. (247) 39 ("personnel staffing" or "personnel shortage" or "personnel schedul*").tw. (180) 40 Health Care Manpower/ (10092) 41 Manpower Planning/ (827) 42 manpower.tw. (7714) 43 (workload* or workforce* or shift or shiftwork* or shifts or overtime or capacity).tw. (662508) 44 Workload/ (27748) 45 or/26-44 (1092175) 46 8 and 25 and 45 (2577) 47 (nursing and hours and patient and day).tw. (613) 48 NHPPD.tw. (6) 49 (nurs* and hours and care).tw. (5528) 50 (nurs* and work* and hours).tw. (2907) 51 (nurs* adj3 "patient* ratio*").tw. (335) 52 "nurse-patient-ratio".tw. (75) 53 (nurs* adj3 "patient* number*").tw. (4) 54 (nurs* adj staffing).tw. (1097)	

	55 (nurs* and staffing and hospital*).tw. (1892) 56 (nurs* and staffing and ward*).tw. (267) 57 (nurs* and staffing and unit*).tw. (1248) 58 (nurs* and safe* and staffing).tw. (513) 59 (nurs* and adequate* and staff*).tw. (1944) 60 (nurs* and inadequate* and staff*).tw. (1024) 61 (nurs* and understaff*).tw. (182) 62 (nurs* and "under staff*").tw. (16) 63 ("nurs* unit*" and (organi?ation or characteristic* or outcome* or level*)).tw. (602) 64 (nurs* and staffing and outcome*).tw. (951) 65 (nurs* and staff* and burnout).tw. (513) 66 (nurs* and staff* and stress).tw. (1564) 67 (nurs* and staff* and fatigue).tw. (217) 68 (nurs* and staffing and practice).tw. (705) 69 "care left undone".tw. (5) 70 ("missed care" or "missing care").tw. (37) 71 (nurs* and skillmix*).tw. (2) 72 (nurs* and "skill* mix*").tw. (414) 73 (nurs* and (staffmix or "staff mix")).tw. (55) 74 (nurs* and magnet and staff*).tw. (158) 75 or/47-74 (14858) 76 46 or 75 (16681) 77 (MAU or "assessment unit*" or maternal or maternity or obstetric* or "accident and emergency" or "A&E" or "emergency room* or HIV or burns").tw. (320040) 78 Emergency Health Service/ (68459) 79 Maternity Ward/ or Maternity Care/ or Obstetrics/ (41451) 80 Community Mental Health/ or Mental Health Service/ or Mental Health Center/ (51090) 81 Psychiatric Department, Hospital/ or Emergency Services,	

	Psychiatric/ or Hospitals, Psychiatric/ or Psychiatric Nursing/ (113664) 82 (mental or mentally or psychiatry or psychiatric).tw. (472040) 83 exp Intensive Care Unit/ or Burn/ or Human Immunodeficiency Virus Infection/ or Acquired Immune Deficiency Syndrome/ (421065) 84 (ICU or "intensive care unit*").tw. (117080) 85 exp "Home for the Aged"/ (10991) 86 ("nursing home*" or "care home*" or "medical home*").tw. (31398) 87 residential home/ (5733) 88 Outpatient/ or outpatient*.tw. (166637) 89 or/77-88 (1524255) 90 76 not (89 not 24) (11524) 91 (editorial or comment or letter).pt. (1314055) 92 90 not 91 (11466) 93 exp child/ or exp infant/ (1826229) 94 (child* or infant* or schoolchild* or preschool* or "pre-school*" or pediatric* or paediatric* or toddler* or newborn* or neonatal or baby or babies).tw. (1845807) 95 93 or 94 (2612649) 96 exp adult/ (4659638) 97 adult*1.tw. (962552) 98 96 or 97 (5182226) 99 92 not (95 not 98) (10462) 100 limit 99 to (english language and yr="2006 -Current") (5364)	
Database - CINAHL Plus with Full Text	S1 (MH "Nursing Staff, Hospital (13,040) S2 (MH "Acute Care Nurse Practitioners") (283) S3 (MH "Nurses+") (157,605) S4 TI ((nurse or nurses or nursing)) OR AB ((nurse or nurses or	2291

EBBCO HOST Searched 01/02/2014 Search Limited to 2006-current Keywords Added: QUESTION 1 2006 TO CURRENT SEARCH CINAHL	nursing)) (355,892) S5 TI ((RN or "RNs" or "RN's")) OR AB ((RN or "RNs" or "RN's")) (13,617) S6 (MH "Nursing Assistants") (5,693) S7 TI (("healthcare assistant*" or "health care assistant*")) OR AB (("healthcare assistant*" or "health care assistant*")) (776) S8 (MH "Surgical Patients") (5,294) S9 TX (acute N3 surg*) (6,415) S10 TX (acute N3 medical) (6,654) S11 TX (surgical N3 (unit* or ward*)) (15,212) S12 TX (medical N3 (unit* or ward*)) (33,478) S13 TI (("medical-surgical" or "surgical-medical" or postsurgical or "post surgical")) OR AB (("medical-surgical" or "surgical-medical" or postsurgical or "post surgical")) (4,448) S14 S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 (430,355) S15 S8 OR S9 OR S10 OR S11 OR S12 OR S13 (58,017) S16 S14 AND S15 (15,597) S17 (MH "Skill Mix+") OR (MH "RN Mix") (1,973) S18 TI ((skillmix* or "skill mix*" or staffmix* or "staff mix*")) OR AB ((skillmix* or "skill mix*" or staffmix* or "staff mix*")) (795) S19 TI ((understaff* or "under staff*")) OR AB ((understaff* or "under staff*")) (330) S20 (MH "Personnel Staffing and Scheduling+") (21,401) S21 TI ((staff* N3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory))) OR AB ((staff* N3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory))) (5,688) S22 TI ((staff* N3 (sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate*	

	or inadequac* or short or shortage or efficient* or efficienc* or inefficien*))) OR AB ((staff* N3 (sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage or efficient* or efficienc* or inefficien*))) (1,885) S23 (MH "Nursing Manpower") (4,705) S24 TI ((manpower or workload* or workforce* or shift or shiftwork or shifts or overtime)) AND AB ((manpower or workload* or workforce* or shift or shiftwork or shifts or overtime or capacity)) (2,556) S25 (MH "Workforce") (4,922) S26 (MH "Nursing Care Delivery Systems") OR (MH "Nursing Care Studies") OR (MH "Nursing Intensity") (1,484) S27 TX "safe staffing" Search modes - Boolean/Phrase (2,643) S28 S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 (39,331) S29 S16 AND S28 (1,388) S30 TX NHPPD (69) S31 TX "nursing hours per patient day" (202) S32 TX (nurs* and magnet and staff*) (4,707) S33 TI ((nurs* and staff* and burnout)) OR AB ((nurs* and staff* and burnout)) (379) S34 (MH "Burnout, Professional") (4,700) S35 TI ("missed care" or "missing care") OR AB (("missed care" or "missing care")) (20) S36 TI "care left undone" OR AB "care left undone" (5) S37 TI (nurs* N3 "patient ratio*") OR AB (nurs* N3 "patient ratio*") (383) S38 TI (("nurs* unit*" N5 (organi?ation or characteristic* or	

	design or outcome* or level* or turnover or acuity or dependence))) OR AB (("nurs* unit*" N5 (organi?ation or characteristic* or design or outcome* or level* or turnover or acuity or dependence))) (142) S39 TI (patient* N5 acuity) OR AB (patient* N5 acuity) (1,068) S40 S30 OR S31 OR S32 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 (11,070) S41 S15 AND S40 (2,034) S42 S29 OR S41 (3,112) S43 S29 OR S41 Limiters - Published Date: 20060101-20141231 (2,291)	
COCHRANE LIBRARY (Wiley) Central Issue 1 of 12 Jan 2014 CDSR Issue 1 of 12 Jan 2014 DARE Issue 1 of 4 Jan 2014 NHSEED Issue 1 of 4 Jan 2014 Search	#1 MeSH descriptor: [Nursing Staff, Hospital] this term only 341 #2 (nurse or nurses or nursing):ti,ab 12149 #3 (RN or "RNs" or "RN's"):ti,ab 161 #4 MeSH descriptor: [Nurses' Aides] this term only 48 #5 ("healthcare assistant*" or "health care assistant*") 41 #6 MeSH descriptor: [Nursing Administration Research] this term only 35 #7 MeSH descriptor: [Nursing Audit] this term only 48 #8 MeSH descriptor: [Models, Nursing] this term only 156 #9 #2 or #3 or #4 or #5 or #6 or #7 or #8 12323 #10 MeSH descriptor: [Hospitals] explode all trees 2763 #11 MeSH descriptor: [Hospital Units] explode all trees 2896 #12 hospital*:ti,ab 50784 #13 acute near/3 care:ti,ab 965 #14 (acute near/3 (ward* or unit*)):ti,ab 322 #15 (medical near/3 (unit* or ward*)):ti,ab 724	Total: 1152 CDSR 490 DARE 56 HTA 6 NHSEED 38 CENTRAL 562

Limited to 2006-current Searched 02/02/2014 Keywords Added: QUESTION 1 2006 TO CURRENT SEARCH COCHRANE CDSR COHRANE DARE COCHRANE CENTRAL COCHRANE HTA COCHRANE NHSEED	#16 (surgical near/3 (unit* or ward*)):ti,ab 782 #17 MeSH descriptor: [Surgery Department, Hospital] this term only 50 #18 ("medical-surgical" or "surgical-medical" or postsurgical or "post-surgical"):ti,ab 1501 #19 (mixed near/3 (surgical and medical)):ti,ab 24 #20 (surgical near/3 patient*):ti,ab 4315 #21 (patient* near/3 (surgical or medical)):ti,ab 6965 #22 #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 58062 #23 #9 and #22 3426 #24 #1 and #22 177 #25 #23 or #24 3443 #26 MeSH descriptor: [Personnel Staffing and Scheduling] this term only 100 #27 skill* near/3 mix* 66 #28 staff* near/3 mix* 32 #29 staffing 9074 #30 (understaff* or "under staff*") 13 #31 735 (staff* near/3 (level* or ratio* or resourc* or model* or number* or mix* or rota* or rosta* or roster* or schedul* or overtime or supervision or supervisory)) #32 151 (staff* near/3 (sufficient* or sufficiency or adequate* or adequac* or target* or insufficient* or insufficienc* or inadequate* or inadequac* or short or shortage or efficient* or efficienc* or inefficien*)) #33 MeSH descriptor: [Health Manpower] this term only 11 #34 manpower 499 #35 (workload* or workforce* or shift or shiftwork* or shifts or overtime or capacity):ti,ab 18503 #36 MeSH descriptor: [Burnout, Professional] this term only 118	

	#37 burnout 240 #38 #27 or #28 or #29 or #30 or #31 or #32 or #33 or #34 or #35 or #36 or #37 27738 #39 #25 and #38 891 #40 NHPPD 0 #41 "nursing hours" 14 #42 nurse* near/3 "patient ratio*" 46 #43 "nurse-patient ratio*" 29 #44 nurs* near/2 staffing 1620 #45 ("nurs* unit*" and (organi?ation or characteristic* or outcome* or level*)) 81 #46 nurs* near/5 burnout 27 #47 nurs* near/5 stress 240 #48 nurs* near/5 fatigue 63 #49 nurs* and magnet and staffing 38 #50 (nurs* and (skillmix* or "skill mix*" or "staffmix*" or "staff mix*")) 55 #51 (nurs* and ("patient dependency" or "patient acuity")) 24 #52 #40 or #41 or #42 or #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 2059 #53 #39 or #52 from 2006 to 2014 1169 (1152 from central, cdsr, dare, HTA, NHSEED) Last Saved: 02/02/2014 14:35:18.123	
ECONLIT EBSCO Searched	Searched CEA registry – no results 2006-2014 https://research.tufts-nemc.org/cear4/SearchingtheCEARegistry/SearchtheCEARegistry.aspx ECONLIT Search: Limiters - Published Date: 20060101-20141231; Publication Type: Journal Article	23 (econlit)

02/02/2014 Search Limited 2006-2014 Keywords: ECONLIT QUESTION 1 2006 TO CURRENT SEARCH	S1 nurs* AND staffing 29 S2 (nurs* and (understaff* or "under staff*")) (2) S3 (nurs* and (skillmix* or "skill mix*" or staffmix* or "staff mix*")) (49) S4 (nurs* and "patient turnover") (6) S5 ("surgical ward" or "medical ward") (0) S6 ("medical unit*" or "surgical unit*") (7) S7 "medical-surgical unit*" (2) S8 (nurs* and ratio* and patient*) (12) S9 S1 OR S2 OR S4 OR S5 OR S6 OR S7 OR S8 (47) (23 SELECTED FOR DOWNLOAD)	

Included studies:

AUSSERHOFER, D., SCHUBERT, M., DESMEDT, M., BLEGEN, M. A., DE, G. S. & SCHWENDIMANN, R. 2013. The association of patient safety climate and nurse-related organizational factors with selected patient outcomes: a cross-sectional survey. *International Journal of Nursing Studies,* 50**,** 240-252.

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Evidence tables (see separate document)

Example completed quality appraisal /GRADE checklist.

Summary checklist

Reviewer	Jane		
Study full ref	BLEGEN, M. A., GOODE, C. J. & REED, L. 1998. Nurse staffing and patient outcomes. Nurs Res, 47, 43-50.		
Short ID	Blegen and Goode 1998		
Scores	**Internal**	**External**	Comments
2 strong (++)			
1 moderate (+)			
0			
Design			
Study design & analysis cross sectional (0) or allows for cause / effect (exposure precedes outcome) 2			Cross-sectional
	0		
2.2 Is the setting applicable to the UK?			
• Did the setting differ significantly from the UK?			Acute hospital in the US
• UK ++		1	
• Other developed countries +			
Other -			
1.1 Is the eligible population or area representative of the source population or area?			
• Consider whether hospitals potentially included in the study are representative of acute general hospitals in that country / state (+1)			Single hospital, mixed specialty of units
• Were the wards/ staff / patients eligible to be included in the hospitals representative of general / medical and / or surgical units [census/ stratified / random samples of med / surg units or patients] (+1)		0	
1.2 Do the selected participants or areas represent the eligible population or area?			
• What % of selected hospitals agreed to participate (+1)			
• What % of eligible individuals (staff / patients) participated (60% + is acceptable)?(+1)			
• Was the data derived from administrative systems and complete (Give +1)			
Were the inclusion or exclusion criteria explicit and appropriate?		1	
3.1 Were the outcome measures and procedures reliable?			
• Were main patient outcome measures subjective or objective (give ++ for objective measures)			
• How reliable were outcome measures (e.g. inter- or intra-rater reliability scores)?			
Was there any indication that measures had been validated (e.g. validated against a gold standard measure or assessed for content	2		
3.2 Were the outcome 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)	2		
4.1 Was the study sufficiently powered to detect an effect (if one exists)?			
• Where there sufficient units / hospitals / wards 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) +		0	
• Other -			
2.1 How well were likely confounding factors identified and controlled?			
• For main patient outcomes. Was there patient level risk adjustment for patient AGE, DIAGNOSIS and COMORBIDITY(++)			
• For falls rates etc was there stratification by unit type (+)	0		
4.2 Were the analytical methods appropriate?			
• Was there adjustment for clustering of data within wards / hospitals? (+ 1)			
Where relevant was there control for ward / hospital characteristics (+1)	0		
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?	1		
	Overal bias	Overal Ext validity	
5.1 Are the study results internally valid (i.e. unbiased)?	*Do not edit below line*		
• 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.			

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Additional studies economics

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Additional studies staffing requirements

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No control for staffing by unregistered nursing / support staff

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