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REVIEW PAPER

Is there an economic case for investing in nursing care – what does the literature tell us?

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Abstract

Aim. To determine the cost effectiveness of increasing nurse staffing or changing the nursing skill mix in adult medical and/or surgical patients?

Background. Research has demonstrated that nurse staffing levels and skill mix are associated with patient outcomes in acute care settings. If increased nurse staffing levels or richer skill mix can be shown to be cost-effective hospitals may be more likely to consider these aspects when making staffing decisions.

Design. A systematic review of the literature on economic evaluations of nurse staffing and patient outcomes was conducted to see whether there is consensus that increasing nursing hours/skill mix is a cost-effective way of improving patient outcomes. We used the Cochrane Collaboration systematic review method incorporating economic evidence.

Data sources. The MEDLINE, CINAHL, SPORTDiscus and PsychINFO databases were searched in 2013 for published and unpublished studies in English with no date limits.

Review methods. The review focused on full economic evaluations where costs of increasing nursing hours or changing the skill mix were included and where consequences included nursing sensitive outcomes.

Results. Four-cost benefit and five-cost effectiveness analyses were identified. There were no cost-minimization or cost-utility studies identified in the review. A variety of methods to conceptualize and measure costs and consequences were used across the studies making it difficult to compare results.

Conclusion. This review was unable to determine conclusively whether or not changes in nurse staffing levels and/or skill mix is a cost-effective intervention for improving patient outcomes due to the small number of studies, the mixed results and the inability to compare results across studies.

Keywords: acute care, economic evaluation, literature review, nurse sensitive outcomes, nurse skill mix, nurse staffing, nursing, patient outcomes

Why is this review needed?

- Nurses are often the target for cost cutting measures in hospitals despite the literature that shows adverse patient outcomes are associated with reduced nursing numbers.
- Nurses need to show they are a cost effective health care intervention.
- There are no recent reviews that cover the international literature on economic evaluations of nurse staffing/skill mix and patient outcomes.

What are the key findings?

- We could not determine whether changing nurse staffing levels is a cost effective intervention for improving patient outcomes due to the variable results and the inability to compare results across studies.
- It appears that increasing nurse staffing has a beneficial effect on patient outcomes, but this effect comes at a cost. It is up to funders to determine whether or not this cost is acceptable.
- There is some evidence that changing the skill mix may be more cost effective than increasing nursing hours although this requires further investigation.

How should the findings be used to influence policy/practice/research/education?

- We recommend the development of a reference case to define the costs and consequences that should be included in cost effectiveness studies of nurse staffing to allow for meaningful comparison and synthesis.
- Future studies should include a sensitivity analysis due to the uncertainty surrounding the effectiveness estimates and other variables.
- The evidence would benefit from cost utility studies to allow for comparison with other health care interventions.

Introduction

Today's healthcare environment is one where there are numerous interventions competing for limited healthcare dollars. Nurses are often seen as one of the most expensive components of any healthcare system, because of their large numbers when compared with other staff. For example in Australia in 2011, there were three times as many nurses employed as there were doctors, 214,321 nurses compared to 73,980 doctors (Health Workforce Australia 2013). These figures are reflected internationally, such as in the National Health Service in the UK where there were 347,944 nurses, 110,957 doctors and 76,163 allied health professionals working in hospital and community health services (Health & Social Care Information Centre 2013); and in the USA there is a 4:1 ratio of nurses to doctors (3,528,000 nurses compared with 806,000 doctors) (Deloitte Centre for Health Solutions 2012). As a consequence of their numbers, nurses are often the target for cost cutting measures (Behner *et al.* 1990, Dubois *et al.* 2006, Needleman *et al.* 2006, Twigg & Duffield 2009). However, it is unclear whether cutting nursing numbers to save money, actually does so, or whether it costs the hospital and society more in terms of patient adverse events and concomitant lost productivity and diminished quality of life.

Extensive research over several years has demonstrated that nurse staffing levels and skill mix (the proportion of hours of care provided by registered nurses) are associated with acute care patient outcomes, including mortality, failure to rescue and other adverse outcomes (Aiken *et al.* 2002, 2014, Needleman *et al.* 2002, Cho *et al.* 2003, Duffield *et al.* 2011, Twigg *et al.* 2011). Although a limitation of studies into the effectiveness of nurse staffing on reducing adverse outcomes is that they are observational rather than experimental, the number of studies and size of the patient populations is generally accepted as sufficient to establish association between staffing levels/skill mix and outcomes, even if it is not possible to show causality (Kane *et al.* 2007a,b, Shamliyan *et al.* 2009).

To strengthen the case for maintaining or increasing nurse staffing and skill mix at a level that will promote patient safety, it is also necessary to consider the cost effectiveness of nursing as an intervention. If increased nurse staffing and/or a richer skill mix can be shown to be cost-effective hospitals are more likely to staff at appropriate levels. Nurses must make a case for their cost effectiveness as an intervention that saves lives and prevents adverse outcomes. This requires economic evaluations of nurse staffing and skill mix (Michigan Nurses Association 2004).

Economic evaluation in health care has been defined as 'a comparison of alternative options in terms of their costs and consequences' (Drummond *et al.* 2005). Alternatively, it can be defined as an assessment of which treatments, including increased patient to nurse ratios and richer nursing skill mix, represent 'value for money', that is, how much does it cost to achieve better health outcomes with a new treatment when compared with an existing treatment (Pharmaceutical Benefits Advisory Committee (2013). Any economic evaluation should therefore include a consideration of both the costs (of treatment) and consequences (health outcomes) of a new treatment compared with an existing treatment. There are four main types of economic evaluation in health care: cost minimization, where the consequences are assumed to be the same so only the costs are compared; cost effectiveness, where a ratio of the

differences in costs and outcomes is calculated, that is, an incremental cost effectiveness ratio or ICER; cost utility, where the ICER is based on cost per quality adjusted life years (QALY); and cost benefit, where both costs and outcomes are valued in monetary terms (Simoens 2009, Gray *et al.* 2012).

Background

Over the last 10 years, there have been six reviews that have either focused on or included a review of economic evaluations of nurse staffing and skill mix. The most recent review was conducted by Shekelle (2013), who reviewed the literature published between 2009–2012 on nurse staffing ratios and in-hospital death and reported on 15 studies, four of which were economic evaluations. The author concluded that it was not possible to calculate the cost of increasing the nurse-patient ratio due to the lack of intervention studies in this area. Goryakin *et al.* (2011) conducted a scoping review of economic evaluations of nurse staffing, including the years 1989–2009 and reviewed 17 articles. They found that the cost effectiveness of nurse staffing was not easy to assess due to mixed results. Additionally, they identified several methodological issues for consideration in future studies to allow comparability across studies. These methodological issues included the need for: more intervention studies of nurse staffing, increased use of Markov modelling to extend the time horizon of studies, examination of societal perspectives, inclusion of post discharge costs and economic evaluations using QALYs.

Unruh (2008) also conducted a literature search on nurse, patient and financial outcomes of nurse staffing, covering the years 1980–2006 discussing 117 articles, 12 of which were economic studies of nurse staffing and patient outcomes and concluded that the results were inconclusive. Thungjaroenkul *et al.* (2007) completed a systematic review of the literature on nurse staffing, hospital costs and length of stay covering the years 1990–2006. They reviewed 17 studies and also found that results were mixed, with variables measured in different ways across studies. They recommended standardizing measures of cost and using micro-costing methods. The authors also recommended the use of prospective rather than retrospective designs and concluded that hospitals should be encouraged to use a richer skill mix, while acknowledging that it was not possible to draw strong conclusions due to the issues identified. Spetz (2005) focused on cost-effectiveness studies in an overview of the literature and commented on five studies of cost effectiveness of nurse staffing, identifying a lack of comparison to alternate staffing approaches as a weakness of the studies and a general low level of quality in the nursing economic literature. Lang *et al.* (2004) reviewed the literature between 1980–2003 to assess whether there was support for specific minimum nurse patient ratios and included nine papers focused on hospital financial outcomes. The authors reported that better staffing was cost neutral or cost saving, however, they dismissed eight of the nine studies as being too dated to be useful. In summary, none of the reviews answered the question of whether or not increasing nurse staffing or skill mix was cost effective due to the quality or variability of the published literature.

The review

Aim and review question

This review examined the literature on economic evaluations of nurse staffing and patient outcomes to see whether increasing nursing hours or changing the skill mix is a cost-effective way of improving patient outcomes. The question for this review was: what is the cost effectiveness of increasing nurse staffing or changing the nursing skill mix in adult medical and/or surgical patients?

Design

The systematic review was conducted using the Cochrane Collaboration systematic review method incorporating economics evidence, to develop search strategies, define inclusion and exclusion criteria and address risk of bias and synthesize findings (Higgins & Green 2011). The Agency for Healthcare Research and Quality (AHQR) recommended that systematic reviews of economic evaluations be used for 'comparing and contrasting how different investigators have chosen to structure their models and estimate key variables' and how the results differ based on these differing structures and assumptions (Walker *et al.* 2012, p. 1). This advice was incorporated into the review.

Search methods

The MEDLINE, CINAHL plus with full text, SPORTDiscus with full text and PsychINFO databases were searched in 2013 for published and unpublished studies in English with no date limits. In the MEDLINE database, we used combinations of the keywords: personnel staffing and scheduling, nursing staff, nursing skill mix, nurses, nursing hours per patient day, models of nursing, nursing intensity, costs and cost analysis, economics, business case, cost saving, patient

outcomes, mortality, pressure ulcer, infection, pneumonia, falls, venous thrombosis, central nervous system, gastrointestinal haemorrhage, heart arrest, cardiac shock, metabolic disease, respiratory insufficiency and length of stay. In the CINAHL, SPORTDiscus and PsychINFO databases the keywords used were personal staffing and scheduling, nursing hours per patient day, nursing care delivery systems, nursing staff, nurses, nursing education, models of care, healthcare delivery, nursing intensity, healthcare systems, nurse staffing models, costs and cost analysis, cost saving, business case, economic*, outcome* health care, patient outcome*, mortality, pressure ulcer*, infection, pneumonia, fall*, venous thrombosis, central nervous system, gastrointestinal haemorrhage, cardiac shock, metabolic diseases, respiratory failure and length of stay. We also reviewed the reference lists of prior literature and systematic reviews. The full search strategy is available from the authors. The review protocol was not registered.

Inclusion and exclusion criteria

This review focused on full economic evaluations where the costs of increasing nursing hours or changing skill mix were included and where the consequences included patient outcomes that have been identified as responsive to nursing intervention, that is, the quality and type of nursing care provided can influence whether or not patients develop these adverse outcomes in their hospitalization. These are known in the literature as nursing sensitive outcomes (NSOs) and include length of stay (LOS), failure to rescue (FTR), mortality, sepsis, falls, pressure injuries, pneumonia, deep vein thrombosis (DVT), urinary tract infections (UTI), ulcer/gastritis/upper gastrointestinal bleeding, shock, cardiac arrest, central nervous system complications, surgical wound infections, pulmonary failure and physiological/metabolic derangement (Aiken *et al.* 2002, Needleman *et al.* 2002, Kane *et al.* 2007a,b, Rafferty *et al.* 2007).

Studies were included that either measured or modelled the variables of interest. Any studies that did not link costs, nursing sensitive patient outcomes and staffing and/or skill mix were excluded. We included studies regardless of the methodology used to measure the effectiveness of nurse staffing/skill mix on patient outcomes. There are no randomized control trial (RCT) study designs in this area of research, hence all of the studies were based on retrospective observational data (Kane *et al.* 2007a).

The review was limited to studies that included patients in medical and/or surgical acute care wards in their analysis. Studies in emergency settings, intensive care units, perioperative settings and long-term care facilities were excluded, as were studies primarily focusing on maternity, newborn, paediatric, mental health or palliative care populations. We also excluded articles in languages other than English and articles describing health professionals other than nurses.

Search outcome

The search strategy produced 7994 papers, including duplicates. The title, abstract and keywords of these papers were scanned to see if they were relevant to the review. This scan identified 194 papers and the full text of these was obtained. Two authors read the full text of these articles to check if they met the inclusion/exclusion criteria. The main reasons for excluding articles at this stage were that they were conducted in a non-acute setting, they did not measure one of the variables of interest, or they did not link nurse staffing, costs and outcomes. Six of the articles were literature/systematic reviews and 24 papers included measures of nurse staffing or skill mix, nurse sensitive outcomes and costs in the patient populations of interest. After further review nine articles met the selection criteria, that is, they were full economic evaluations linking costs, outcomes and staffing/skill mix and were retained in the final review. The search outcome is illustrated in Figure 1.

Prior reviews

As mentioned, there were six prior reviews, either literature or systematic reviews, that had analysed economic evaluations of nurse staffing/skill mix identified in the search (Lang *et al.* 2004, Spetz 2005, Thungjaroenkul *et al.* 2007, Unruh 2008, Goryakin *et al.* 2011, Shekelle 2013). These reviews did not necessarily review just economic evaluations but covered the more general area of nurse staffing and outcomes. These reviews are listed in Table 1 in descending date order, showing the number of relevant economic studies included in each and the number of articles in each which met the inclusion/exclusion criteria for this review. Between them the previous reviews covered 47 studies, however, the most that any single review covered was 17 and only five of these met the inclusion/exclusion criteria for this review. Additionally, four studies were identified that met the inclusion/exclusion criteria that were not included in a previous review. We therefore proceeded with this review of nine articles.

Quality appraisal

Walker *et al.* (2012) on behalf of the Agency for Healthcare Research and Quality conducted a systematic review of quality assessment tools for evaluating best practices in

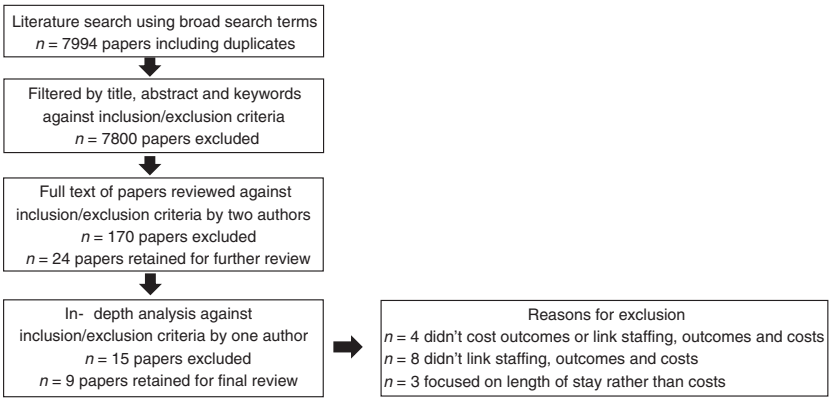

Figure 1 Search outcome.

Table 1 Details of previous systematic/literature reviews of economic evaluations of nurse staffing.

	Years covered	Number of economic articles reviewed	Number of reviewed articles which met our inclusion/exclusion criteria
Shekelle (2013)	2009–2012	4	3
Goryakin *et al.* (2011)	1989–2009	17	2
Unruh (2008)	1980–2006	12	3
Thungjaroenkul *et al.* (2007)	1990–2006	17	2
Spetz (2005)	No dates given	5	0
Lang *et al.* (2004)	1980–2003	9	1

conducting and reporting on economic evaluations in health care. They identified 10 checklists in the literature and found that although these checklists 'cannot guarantee that the results of an economic analysis are valid' (Walker *et al.* 2012, p. 15), with most aimed at the quality of reporting, rather than the quality of design, they are helpful in checking that the analysis has all the appropriate components. One of these tools was selected for use, the Quality of Health Economic Studies Checklist (QHES) developed by Chiou *et al.* (2003) which uses a weighted scoring system. It was used to assess the quality of the included studies, although no studies were excluded from the review on the basis of this checklist. Although the scoring system has not been validated, it allowed us to assess whether a study had the necessary components and allowed some indication of the relative merits of each study. We also used the Cochrane Collaboration advice for assessing the risk of bias in the effectiveness studies underlying the economic analyses (Higgins & Green 2011).

Data abstraction

Data were abstracted from each study to identify the type of economic analysis performed, the perspective taken by the authors (hospital or societal), whether the study was measured or modelled and if measured, details of the study population and setting. If the underlying effectiveness study used in the economic analysis was not detailed in the economic report, the effectiveness study was obtained and assessed for risk of bias using the Cochrane Collaboration advice. The source of the nurse, patient and cost variables and how they were measured was also summarized.

Synthesis

Due to a lack of consistency in methods and ways of reporting costs and outcomes it was not possible to analyse the data using meta-analysis. Therefore, the data were summarized narratively, comparing results where applicable.

Results

Excluded studies

Several studies were excluded from the review because they did not meet the inclusion/exclusion criteria, specifically they did not measure one of the variables of interest or did not link costs, staffing and outcomes. For researchers interested in the area of economic evaluations of nurse staffing/

skill mix, these papers still aid understanding of the variables of interest. The excluded articles of note were Flood & Diers (1998), Cho *et al.* (2003), McCue *et al.* (2003), McGillis Hall *et al.* (2004), Pappas (2008) and Dall *et al.* (2009).

Types of economic evaluations

There were four cost benefit analyses identified (Behner *et al.* 1990, Needleman *et al.* 2006, Shamliyan *et al.* 2009, Weiss *et al.* 2011) and five cost effectiveness analyses (Rothberg *et al.* 2005, Newbold 2008, Van den Heede *et al.* 2010, Li *et al.* 2011, Twigg *et al.* 2013). There were no cost minimization or cost utility studies identified in the review. A summary of included studies, including the quality assessment score, is presented in Table 2. For the complete quality assessment please refer to supplementary information in Table 3.

Of the nine studies reviewed, seven were conducted in the USA, one in Australia (Twigg *et al.* 2013) and one in Belgium (Van den Heede *et al.* 2010). Four of the studies were economic analyses reported alongside an effectiveness study (Behner *et al.* 1990, Li *et al.* 2011, Weiss *et al.* 2011, Twigg *et al.* 2013), where many variables were measured, while the other five studies were modelled from various data sources. Eight studies were conducted from the hospital perspective and one from both a hospital and societal perspective (Shamliyan *et al.* 2009).

Effectiveness studies

There was a high risk for bias identified in all of the effectiveness studies associated with the economic evaluations included in this review due to the nature of the study designs used to estimate the relationship between nurse staffing/skill mix and patient outcomes. Behner *et al.* (1990), Li *et al.* (2011), Weiss *et al.* (2011) and Twigg *et al.* (2013) conducted their own effectiveness studies. In the studies based on modelling of variables, Rothberg *et al.* (2005) used effectiveness data from Aiken *et al.* (2002) for their mortality estimates and Needleman *et al.* (2002) for their length of stay estimates. Shamliyan *et al.* (2009) used data from a meta-analysis of 27 published studies. Newbold (2008) used effectiveness data from the Aiken *et al.* (2003) study, Needleman *et al.* (2006) from their prior work in 2002 and Van den Heede *et al.* (2010) from a previous study by the authors in 2009. Of these, six were large cross-sectional observation studies that measured the association between nurse staffing and/or skill mix and nurse sensitive patient outcomes (Aiken *et al.* 2002, 2003, Needleman *et al.* 2002, Van den Heede *et al.* 2009, Li *et al.* 2011, Weiss *et al.* 2011), one was a meta-analysis of observational studies (Kane *et al.* 2007a), one was a small comparison study based on observational data (Behner *et al.* 1990) and one was a larger pre/post-analysis of observational data following an organizational change in staffing levels (Twigg *et al.* 2013). Although the quality of these studies was generally high, with the authors including confounding variables in their regression models, the observational designs, use of administrative data sets, estimation rather than measurement of some important variables and analysis at the hospital rather than the patient level means there is a high risk of bias in these studies with the level of evidence mostly level 4, or at best level 3 (Joanna Briggs Institute 2013). Due to this risk of bias, it is important to perform sensitivity analyses around the effectiveness estimates. Although five of the studies included some type of sensitivity analysis only Rothberg *et al.* (2005) conducted a sensitivity analysis around the effectiveness estimates.

Rothberg *et al.* (2005) also conducted sensitivity analysis on hourly nurse compensation, cost per hospital day, supply elasticity and relative risk of nurse dissatisfaction. In addition, they performed a probabilistic sensitivity analysis where they varied all their estimates to put confidence intervals around the cost effectiveness estimates. This was the only study that used sensitivity analysis to derive confidence intervals. Other authors conducted limited sensitivity analysis in relation to the cost of an adverse event and effect of repeat NSOs in the same patient (Twigg *et al.* 2013), changes in the discount rate (Van den Heede *et al.* 2010), cost of adverse events in age categories, health insurance and patient residence (Shamliyan *et al.* 2009) and the final cost measure (Li *et al.* 2011).

Cost estimates

Costs calculated in the studies were primarily the cost of nurse staffing. For the cost effectiveness studies Twigg *et al.* (2013) costed actual nursing hours pre and post intervention; Rothberg *et al.* (2005) calculated daily nursing costs per patient for each patient to nurse (PTN) ratio and also included a calculation of nursing costs and savings from decreased length of stay; Van den Heede *et al.* (2010) calculated the additional nurse hours required to meet the 75th percentile of nursing hours per patient day (NHPPD) compared with a 'do nothing' approach. Newbold (2008) calculated the cost of nursing staff for three PTN ratios combined with three skill mix ratios. Li *et al.* (2011) estimated the contribution of nursing costs to inpatient costs to

Table 2 Summary of included studies.

Article	Study group & country	Type of economic analysis, perspective & design	Nurse variables	Patient variables	Cost variables	Results
Behner *et al.* (1990) Quality Assessment 20/100	USA, 1 nursing unit, 132 patients with DRG 215	Hospital perspective Cost benefit Measured Two stage model, relationship between staffing levels and patient complications, then relationship between patient complications and length of stay	Staffing levels Ratio of required to actual hours	Length of stay Presence of complications Acuity level	Determined costs at the patient level by assigning patients to an acuity level based on their nursing resource needs and assigned a workload factor and cost to each of the acuity levels Used budget variance measures of rate variance, volume variance, efficiency variance	Understaffing 20% below required resulted in 30% increase in probability of patient having a complication. Those who experienced a complication had a mean length of stay of 3·5 days longer than those who did not. Additional costs associated with patients who develop complications are greater than the labour savings due to understaffing.
Li *et al.* (2011) Quality Assessment 59/100	USA, 139,360 admissions to 292 medical/surgical units at 125 Veterans Affairs medical centres	Hospital perspective Cost effectiveness Measured Retrospective cross-sectional study Two-step multi-level mixed effects linear regression analysis Association between inpatient care costs and nurse staffing, controlling for other variables	From national databases Total Hours per patient day (HPPD) RN skill mix Used aggregated monthly data	Controlled for patient variables Serious complication (pulmonary failure, metabolic derangement, wound infection, deep vein thrombosis, pneumonia, urinary tract infection, pressure ulcer, sepsis, shock/cardiac arrest, gastrointestinal bleed) Transfer to Intensive Care Unit	From national databases Cost per hospital admission (CPHA) (patient) Cost per bed day of care (CPBDC) (patient) (cost of admission divided by the length of stay)	Surgical: neither a higher RN skill mix nor greater total HPPD were associated with CPHA after controlling for predicted inpatient costs. Both RN skill mix and HPPD were associated with CPBDC Medical: RN skill mix was not associated with higher CPHA, but higher total HPPD was associated. RN skill mix and HPPD were associated with CPBDC.

Table 2 (*Continued*).

Article	Study group & country	Type of economic analysis, perspective & design	Nurse variables	Patient variables	Cost variables	Results
Needleman *et al.* (2006) Quality Assessment 69/100	USA, 799 acute care hospitals (used data from earlier study)	Hospital perspective Cost-benefit Modelled Regression analysis	Raising RN proportion to 75th percentile Raising nursing hours (RN/LPN) to 75th percentile Raising both (nursing hours and RN proportion) to the 75th percentile where each is below	Avoided deaths Length of stay Avoided adverse outcomes	Costs of avoided adverse outcomes and avoided days estimated from regression models Estimated variable and fixed costs Wage data based on 1997–2002 Current Population Surveys Other costs based on American Hospital Association Annual Survey	Cost savings exceed cost increases for raising RN proportion but not for raising nursing hours or raising both the hours and RN proportion together Most cost savings come from decreased LOS
Newbold (2008) Quality Assessment 62/100	USA, used data from the Aiken *et al.* (2003) study	Hospital perspective Cost effectiveness Modelled Used production theory	From Aiken *et al.* (2003) study Nine combinations of nurse/patient ratios and skill mixes	From Aiken *et al.* (2003) study Mortality (survival)	Bureau of Labour Statistics Wages of RNs and LPNs	Cost for each process ranged from a daily cost of $3280 for a survival rate of 976·2/1000 patients (8 PTN ratio/20% RNs) to a daily cost of $6305 for a survival rate of 983·5/1000 patients (4 PTN ratio/80% RNs). In all cases increasing the percentage of RNs or decreasing the PTN ratio increased the cost per day. The cheapest option to improve outcomes was to change the skill mix rather than the PTN ratio.

Table 2 (*Continued*).

Article	Study group & country	Type of economic analysis, perspective & design	Nurse variables	Patient variables	Cost variables	Results
Rothberg *et al.* (2005) Quality Assessment 88/100	USA	Hospital perspective Cost effectiveness Modelled Included sensitivity analysis	Patient to nurse ratios	Used mortality data from Aiken *et al.* (2002) and length of stay data from Needleman *et al.* (2002) Lives saved	Bureau of Labour statistics for wages, research literature Cost per patient – daily nursing labour cost + non-nursing costs × LOS	Costs per life saved vary depending on the ratio To change from 8–7 PTN, cost per life saved = $45,900 (or $24,900 with decreased LOS costs), to change from 5 to 4 PTN, costs per life saved = $142,000 (or $70,700 with decreased LOS costs)
Shamliyan *et al.* (2009) Quality Assessment 76/100	USA	Hospital and societal perspective Cost-benefit Modelled Random effects model and simulation models	RN full time equivalent (FTE)/patient day	From meta-analysis of 27 published studies on staffing and outcomes LOS, mortality, FTR, cardiac arrest, shock, unplanned extubation, respiratory failure, DVT, upper GI bleeding, falls, pressure ulcers, nosocomial infection, UTI, pneumonia, nosocomial blood stream infection	Based on relative changes in LOS and avoided adverse events with different staffing ratios Used nationally available data to calculate costs of: Years of potential life saved Value of lives saved per 1000 hospitalized patients Value of avoided patient adverse events RN cost/1000 hospitalized patients Calculated hospital net savings and societal net savings Savings/cost ratio	Increasing RN staffing by one RN FTE/patient day was associated with a positive savings-cost ratio and saved from between 210 683 and 604 169 years of life in medical and surgical patients with a productivity benefit of 2–10 billion Largest economic benefit corresponded to an 0·56–1·5 increase in RN FTE/patient day The hospital cost of increased nurse staffing exceeded the benefits
Twigg *et al.* (2013) Quality Assessment 72/100	Australia, All multi-day patients admitted to 3 teaching hospitals over a 2-year period (107,253 patients in pretest and 107,026 in post-test)	Hospital perspective Cost effectiveness Measured Longitudinal, retrospective study Pre/post implementation of NHPPD staffing method Logistic regression	Total nursing hours pre and post implementation Skill mix per cent Total nursing hours Total RN hours	Measured from hospital morbidity data Life years gained based on differences in FTR pre and post intervention	Hourly cost based on average nursing costs per hospital Cost of NSO prevented based on a published cost of an adverse event for a multi-day admission corrected for age and morbidity	Cost per life year gained was $8907.

Table 2 (*Continued*).

Article	Study group & country	Type of economic analysis, perspective & design	Nurse variables	Patient variables	Cost variables	Results
Van den Heede *et al.* (2010) Quality Assessment 82/100	Belgium, general cardiac postoperative nursing units, 9054 patients, 75 nursing units, 28 surgery centres	Hospital perspective Cost effectiveness Modelled	From Belgian Nursing Minimum Dataset NHPPD – sum of RN hours per nursing unit divided by the number of inpatient days per unit	From Belgian hospital discharge database Mortality Number of life years gained, multiplied number of avoided deaths × life expectancy of patients (determined from the literature)	Computed additional nurse hours required to meet 75th percentile of NHPPD, used the difference between the NHPPD of the unit and the NHPPD of the 75th percentile × number of postoperative inpatient days	Increasing staffing to the 75th percentile was associated with an ICER of €26,372 per avoided death and €2639 per life year gained
Weiss *et al.* (2011) Quality Assessment 59/100	USA, 4 Magnet hospitals, 16 units 1892 patients, randomly selected	Hospital perspective Cost-benefit Measured Retrospective multi-level regression analysis	Registered Nurse (RN) hours per patient day (RNHPPD) Non-RN hours per patient day (Non-RNHPPD) Split between overtime and non-overtime hours RN vacancy rate	Unplanned readmissions in 30 days Emergency department (ED) visits in 30 days Quality of discharge teaching scale Readiness for hospital discharge scale	Costed nurses according to US Bureau of Labour Statistics data Used patient level financial data from the hospitals cost accounting database Calculated change in patient net revenue from reduced readmission/ED visit	RN non-overtime and RN overtime were sig for readmission, RN overtime was sig for ED visits Increasing RN non-overtime by 1SD (0·75 hours per patient day) cost hospitals $198 per patient but saved payers $607 per patient Reducing RN overtime by 1SD (0·07 hours per patient day) saved hospitals $8 per patient

calculate the change in cost for a one unit change in the staffing variable.

For the cost benefit studies Needleman *et al.* (2006) calculated the cost of raising the proportion of registered nurse (RN) hours to the 75th percentile, raising the number of licenced practical nurse (LPN) hours to the 75th percentile and raising both to the 75th percentile. Shamliyan *et al.* (2009) calculated the RN cost per patient day. Weiss *et al.* (2011) measured the monthly nursing hours per patient day and costed them by multiplying the hourly cost by the standard deviation by the average LOS. Behner *et al.* (1990) measured the recommended to actual nursing hours expressed as a percentage based on patient acuity for each day of the patients' stay and calculated the cost savings from understaffing.

Various published salary data were used for the nurse staffing costs such as the Belgian Ministry of Public Health (Van den Heede *et al.* 2010), United States (US) Current Population Surveys (Needleman *et al.* 2006), US Bureau of Labor Statistics (Rothberg *et al.* 2005, Newbold 2008, Shamliyan *et al.* 2009, Weiss *et al.* 2011) and the US Centers for Medicare & Medicaid Services Wage Index File (Li *et al.* 2011). Twigg *et al.* (2013) and Behner *et al.* (1990) did not state the source of their salary data.

Consequences

Consequences of changes in nurse staffing/skill mix were measured in various ways. In the cost effectiveness studies, Twigg *et al.* (2013) calculated the difference between the

expected and observed NSOs for the intervention and costed adverse events according to data published by Ehsani *et al.* (2006) to calculate the cost of the intervention. They also calculated life years gained from the 'failure to rescue' outcome, calculating the difference between the average age of those who experienced a 'failure to rescue' and the average Australian life expectancy based on OECD (2011) data, pre and post intervention. Rothberg *et al.* (2005) measured effectiveness as deaths averted for each PTN ratio. Van den Heede *et al.* (2010) calculated avoided deaths from observational patient data if increasing staffing to the 75th percentile and life years gained by multiplying avoided deaths by the life expectancy of patients, with survival rates determined from two studies (Sergent *et al.* 1997, Kvidal *et al.* 2000). Newbold (2008) mapped the survival rate for each of three PTN ratios combined with three skill mix ratios to give a cost per production process. Li *et al.* (2011) calculated the cost per hospital admission and cost per bed day of care based on inpatient costs derived from the VHA decision support system.

In the cost-benefit studies many different consequences were costed. In Needleman *et al.* (2006) the cost of adverse outcomes and avoided days of stay, estimated with regression modelling, were calculated, with costs based on data from the American Hospital Association (AHA) annual survey and Medicaid cost reports separating variable costs from fixed costs. Shamliyan *et al.* (2009) calculated the net benefit of saved lives, net benefit of avoided adverse events and net benefit of decreased length of stay. The monetary cost of saved lives was estimated using average present value of future lifetime earnings from Haddix *et al.* (2003), the value of avoided adverse events was calculated from charge per case data from the Healthcare Cost and Utilization Project & United States Agency for Healthcare Research and Quality (2000) and the value of decreased LOS was given as the average cost of one patient day although the source of these cost data was not stated. Savings were reduced by 40% to account for variable costs. The authors calculated a savings/cost ratio for each outcome as the net benefit/RN cost. Weiss *et al.* (2011) calculated the impact for the hospital from changes in net revenue from reduced readmission/ED visits costed at the patient level from the hospital accounting system and calculated the impact on payers by costing the reimbursement payments to the hospital and physicians from hospital post discharge use. Physician payments were estimated using the Medicaid physician reimbursement formula. Behner *et al.* (1990) calculated the cost of adverse outcomes and increased length of stay at the patient level for those who experienced understaffing at 20% below the standard nursing hours, although the source of the costing data was not stated.

Is increasing nurse staffing cost effective?

Results of the economic benefit of increasing nurse staffing levels and changing skill mix in these studies were mixed. The cost values reported here are the costs reported in the included studies adjusted to 2013 USD using purchasing power parity and GDP deflator indices (Higgins & Green 2011, International Monetary Fund 2014). Behner *et al.* (1990) found that staffing at 20% below required was associated with additional costs from complications that were greater than the labour savings, costing an additional US $28,441 for the study sample. In contrast Weiss *et al.* (2011) found that payers save US$652 per admission, but the hospital loses US$213 per patient when the RN HPPD level is higher (by one standard deviation 0·75). Similarly, Li *et al.* (2011) found that costs per admission were positively associated with increased HPPD among medical admissions (US $202 per additional HPPD) but not among surgical admissions. Higher costs per hospital day were associated with higher HPPD and RN skill mix for medical admissions (US $97 per additional HPPD and US$7 per 1% increase in skill mix) and surgical admissions (US$138 per additional HPPD and US$16 per 1% increase in skill mix).

Two studies provided evidence that changing skill mix was more cost effective than increasing RN hours. Needleman *et al.* (2006) found that increasing the RN proportion to the 75th percentile was associated with a cost saving of US$303 million (across the whole sample – 799 hospitals) while increasing licenced hours (RNs and LPNs) to the 75th percentile resulted in a cost of US$7·3 billion and increasing both nursing hours and proportion of RN hours to the 75th percentile cost US$7·1 billion. Similarly Newbold (2008) concluded that the cheapest option to improve outcomes was to change the skill mix rather than the nurse patient ratio, although unlike Needleman *et al.* (2006) he found that in all cases increasing the percentage of RNs or decreasing the nurse patient ratio (PTN) increased the cost per day with reported costs ranging from a daily cost of US $4,030 for a survival rate of 976·2/1000 patients (8 PTN ratio/20% RNs) to a daily cost of US$7,746 for a survival rate of 983·5/1000 patients (4 PTN ratio/80% RNs).

In the only study conducted from a societal perspective, Shamliyan *et al.* (2009) found that increasing RN staffing by one RN full time equivalent (FTE) per patient day was associated with a positive savings-cost ratio and would save from between 210,683 (female medical patients) and 604,169 (male surgical patients) years of life in medical and

surgical patients with a productivity benefit of US$3·6 to US$13 billion. However, they found that from the hospital perspective, the cost of increased nurse staffing exceeded the benefits.

In the three studies that calculated an incremental cost effectiveness ratio (ICER) there was a cost associated with saving lives, with all costs within reasonable levels for the funding of interventions (as reported by the authors through comparison to the cost of other interventions). These ICERs cannot be directly compared due to the different nature of the staffing comparisons they used. Rothberg *et al.* (2005) estimated a cost per life saved of US$56,394 (or US$30,593 if decreased LOS costs are included) when changing the ratio from 8–7 patients per nurse and a cost per life saved of US$174,464 (US$86,864 if decreased LOS costs are included) while changing the ratio from five to four patients per nurse. Van den Heede *et al.* (2010) calculated that increasing NHPPD to the 75th percentile compared with a 'do nothing' approach was associated with an ICER of US$25,702 per avoided death and US$2,572 per life year gained, while Twigg *et al.* (2013) calculated a cost per life year gained of US$14,123 when comparing an increase in NHPPD from pre to post intervention.

There is some evidence that the cost effectiveness of nurse staffing is not linear. Shamliyan *et al.* (2009) found that the largest economic benefit corresponded to a 0·56–1·5 increase in RN FTE/patient day, decreasing with a further increase to 2·5 RN FTE/patient day. Rothberg *et al.* (2005) also found a non-linear relationship where the rate of incremental cost increase accelerated while the rate of mortality decrease decelerated resulting in progressively higher ICERs for each one patient decrease in the PTN ratio. Newbold (2008) also reported diminishing returns for both increasing the RN ratio and for decreasing the PTN ratio.

Discussion

All the studies identified in this review were either cost benefit or cost effectiveness analyses. The study authors used a variety of methods to conceptualize and measure costs and outcomes, making it difficult to directly compare results across studies. This variability was also identified by previous reviewers (Thungjaroenkul *et al.* 2007, Unruh 2008, Goryakin *et al.* 2011). The quality scores of the studies using the QHES Instrument ranged from 20–88 out of a possible 100, with the Rothberg *et al.* (2005) study meeting more of the quality criteria than the other studies. All but one of the studies were conducted from the hospital perspective, rather than a societal perspective. Weinstein *et al.* (1996) recommended that cost effectiveness studies be conducted from the societal perspective, although hospitals may be more interested in the direct financial impact on themselves alone. The studies could have been improved by including the societal perspective as well as the hospital perspective, including incremental analysis, including or increasing the sensitivity analysis around variable estimates, increasing the time horizon of the studies and greater discussion of limitations and bias. Similar methodological limitations were also identified by Spetz (2005) and Goryakin *et al.* (2011) in their reviews.

A major limitation of all the studies is the quality of the underlying effectiveness studies on which estimates of the relationship between adverse outcomes and staffing/skill mix levels are based. There are no RCTs in this area of research. In general studies are based on observational data, often with very large datasets (Kane *et al.* 2007a, Shekelle 2013). Correspondingly, there was a high risk for bias identified in all of the effectiveness studies associated with the economic evaluations included in this review. The high likelihood of bias in the effectiveness studies affects the validity of the economic evaluation. Due to this risk of bias it is important to perform sensitivity analyses around the effectiveness estimates. Although five of the studies included some type of sensitivity analysis, only Rothberg *et al.* (2005) conducted a sensitivity analysis around the effectiveness estimates.

Is increasing nurse staffing cost effective?

The results of the economic benefit of increasing nurse staffing or changing nurse skill mix were mixed, with some studies showing a saving and some a cost with results dependent on how variables were measured, the population they were measured in and how nurse staffing or skill mix were conceptualized. It was not possible to arrive at a clear conclusion as to whether increasing nurse staffing or changing skill mix was a cost-effective intervention to improve patient outcomes. There is some evidence that the cost effectiveness of nurse staffing is not linear. This area requires further investigation that would be aided by the development of a reference case for cost effectiveness studies.

Developing a reference case guideline

It is difficult to compare the results across studies because of the different ways costs and consequences were measured. It would be helpful to develop a reference case for determining the cost effectiveness of nurse staffing to ensure that any future studies are comparable. A reference case is a guideline for the conduct of cost effectiveness

studies that presents a standard protocol or framework for how the nurse staffing or skill mix variable should be measured, which items should be included in costs, what discounting is required, how consequences should be measured, the time horizon that should be considered and the perspective that should be taken. Such studies should also include sensitivity analyses that incorporate different realistic changes to cost and benefit variables. The Panel on Cost Effectiveness in Health and Medicine provided some useful guidelines for how to achieve this (Weinstein *et al.* 1996). The reference guideline would ideally be able to be applied internationally, although variations in data available in different countries may lead to differences in what can be included. Nonetheless any reference case development should take into account ways to incorporate an international perspective to allow comparability between countries.

The development of a reference case guideline would also help to improve the quality of economic evaluations of nurse staffing. International standards in relation to the funding of new therapies and technologies recommend economic evaluations using ICERs based on quality adjusted life years (QALYs) and the development of a base reference case as the preferred methodology (Weinstein *et al.* 1996, Canadian Agency for Drugs & Technology in Health 2006, National Institute for Health and Care Excellence (2013), Pharmaceutical Benefits Advisory Committee 2013). Additionally, the use of ICERs based on QALYs and a well-defined reference case allows interventions to be compared both in and across intervention types. Willingness to pay (WTP) thresholds for funding of new interventions are primarily published in terms of cost per QALY (with limited WTP thresholds based on life years gained) and so use of cost-utility analysis would enable researchers to compare their study findings against generally accepted WTP thresholds (Kaplan & Bush 1982, George *et al.* 2001, Simoens 2009, Shiroiwa *et al.* 2010). Whether the use of QALYs in cost effectiveness studies of nurse staffing and skill mix is feasible is an area that requires further discussion when developing a reference guideline.

Limitations

This review was limited to English language studies; so the authors may have missed some studies of relevance. There were other studies that investigated some aspects of the economics of nurse staffing that were not included in this review because they did not comprise a full economic evaluation linking costs, outcomes and staffing, however, it may be that some of these papers would still aid an understanding of this topic. All of the studies that were identified are limited because of the design of the effectiveness studies that underpin the economic analyses. There were no effectiveness studies based on randomized controlled trials and therefore effectiveness estimates and the economic estimates based on these must be interpreted with caution. Only one study used sensitivity analysis to account for this limitation (Rothberg *et al.* 2005).

Conclusion

There is a large body of literature that demonstrates that nurse staffing levels and skill mix are important factors in ensuring the quality of care for patients in acute care settings. In comparison, there are only a small number of studies that have investigated the cost of changing staffing levels and skill mix in relation to the cost of adverse outcomes of care. Due to the small number of studies, the variable results and the inability to compare results across studies, the authors were unable to determine conclusively whether or not changes in nurse staffing levels is a cost-effective intervention for improving patient outcomes. The way comparisons were made does not allow the identification of a nurse patient ratio or skill mix that is most cost effective. In general, it seems that although increasing nurse staffing and/or changing skill mix has a beneficial effect on patient outcomes, this effect comes at a cost. It is up to payers to determine whether or not this cost is acceptable. It may be that from a hospital perspective, increasing nurse staffing is not a cost-effective intervention whereas from the societal perspective it is, however more high-quality studies are required in this area, using a well-defined reference base case. There is some evidence that changing the skill mix may be more cost effective than increasing nursing hours although this requires further investigation.

Recommendations

The authors recommended the development of a reference case guideline, with expert consultation, to define the cost and consequences that should be included in cost effectiveness studies of nurse staffing to allow for meaningful comparison and synthesis of future studies. Future studies should also include a sensitivity analysis due to the uncertainty surrounding the effectiveness estimates and other variables. Additionally, more studies from the societal perspective need to be conducted. We found no cost-utility studies in the literature, which may be due to the difficulty of measuring variables due to the large scale nature of

nurse staffing studies, however if feasible, the evidence would benefit from cost utility studies to allow for comparison with other healthcare interventions.

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Author contributions

All authors have agreed on the final version and meet at least one of the following criteria [recommended by the ICMJE (http://www.icmje.org/ethical_1author.html)]:

- substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data;
- drafting the article or revising it critically for important intellectual content.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site.

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