1-1-2013

The economic benefits of increased levels of nursing care in the hospital setting

Diane E. Twigg
Edith Cowan University

Elizabeth Geelhoed

Alexandra Bremner

Christine M. Duffield

10.1111/jan.12109
This is the accepted version of the following article: Twigg, D. E., Geelhoed, E., Bremner, A., & Duffield, C. M. (2013). The economic benefits of increased levels of nursing care in the hospital setting. Journal of Advanced Nursing, 69(10), 2253-2261. Published in final form here. This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Self-Archiving.

The economic benefits of increased levels of nursing care in the hospital setting

ABSTRACT

Aims: To assess the economic impact of increased nursing hours of care on health outcomes in adult teaching hospitals in Perth, Western Australia.

Background: Advancing technology and increased availability of treatment interventions are increasing demand for health care while the downturn in world economies has increased demand for greater efficiency. Nurse managers must balance nurse staffing to optimise care and provide efficiencies.

Design: This longitudinal study involved the retrospective analysis of a cohort of multi-day stay patients admitted to adult teaching hospitals.

Methods: Hospital morbidity and staffing data from September 2000 until June 2004, obtained in 2010 from a previous study, were used to analyse nursing-sensitive outcomes pre and post implementation of the Nurse Hours per Patient Day staffing method, which remains in place today. The cost of the intervention comprised increased nursing hours following implementation of the staffing method.

Results: The number of nursing-sensitive outcomes was 1,357 less than expected post implementation and included 155 fewer 'failure to rescue' events. The 1,202 other nursing-sensitive outcomes prevented were 'surgical wound infection', 'pulmonary failure', 'ulcer, gastritis, upper gastrointestinal bleed' and 'cardiac arrest'. One outcome, pneumonia, showed an increase of 493. Analysis of life years gained was based on the failure to rescue events prevented and the total life years gained was 1,088. The cost per life year gained was AUD$8,907.

Conclusion: The implementation of the Nurse Hours per Patient Day staffing method was cost-effective when compared with thresholds of interventions commonly accepted in Australia.

Key words: healthcare quality, health policy, nurses, patient outcomes, staffing, cost effectiveness

Summary statement

What is already known about the topic?

- Higher nurse staffing levels and a richer skill mix have been associated with improved patient outcomes.
- Internationally, improved nurse staffing levels have been associated with economic benefits.
- The available evidence does not examine the economic impact of increased nursing hours in the Nurse Hours per Patient Day staffing method.

What this paper adds

- Increased nursing hours in acute hospitals resulting from using the Nurse Hours per Patient Day staffing method was considered cost-effective when using accepted thresholds for life years gained.
- The Nurse Hours per Patient Day staffing method was associated with avoidance of specific nursing-sensitive outcomes, which demonstrates parallel improvements in the quality of care.

Implications for practice and/or policy

- Investment in increased nursing hours via the Nurse Hours per Patient Day staffing method has proven a cost-effective initiative with clinical benefits.
- Further research is needed to better cost specific nursing-sensitive outcomes and determine the economic benefits of nurse staffing changes at ward level.

Introduction

This paper discusses the economic benefits of increased levels of nursing care and reports the findings of a study that assessed the cost-effectiveness of increased nursing care on health outcomes. It builds on previous analysis (Twigg et al. 2011, Twigg et al. 2012) by examining the cost-effectiveness of the staffing method and by 'incorporating a more complex individual measure of patient risk aggregated by hospital' (Twigg et al. 2011). To date an economic evaluation has not been undertaken in an Australian setting.

Background

The recent downturn in world economies has increased pressure on public and private health services to increase efficiency in an environment where advancing technology and increased availability of treatment interventions are increasing demand for health care. Seventy-two percent of the recurrent cost per 'case-mix-adjusted' separation is staff related (medical and non-medical labour) (Australian Institute for Health and Welfare 2010) and as nursing is the largest workforce in health, nurse managers are increasingly forced to make difficult decisions. Nurse managers must decide the number and mix of nursing staff needed to optimise safe patient care within the limitations of budgetary constraints (Twigg and Duffield 2009). In a recent report, the Australian Nursing Federation (ANF) observed that excessive workloads are common within the Australian health care setting (Australian Nursing Federation 2009). Nursing workloads and patient outcomes are inextricably linked (Aiken et al. 2002a). Simply put: 'If there are not enough nurses, the workload for each nurse is increased' (ANF, 2009). Inadequate time reduces nurses' ability to deliver adequate patient care and forces nurses to leave work undone which directly impacts on patient outcomes (Duffield et al. 2011, Kalisch 2006).

Higher nurse staffing levels and a richer skill mix (a higher proportion of registered nurse (RN) hours) have been linked with improved patient outcomes in many studies (Aiken et al. 2003, Aiken et al. 2002b, Rafferty et al. 2007, Tourangeau et al. 2007, Kane et al. 2007). Fifteen states and one district in the United States of America have enacted regulations or legislation aimed at improving nurse staffing. California was the first state to do so in 1999 and numerous studies about the impact of these changes have been undertaken (Donaldson and Shapiro 2010). A synthesis of these studies found that the nurse-to-patient ratio fell and the nursing hours per patient day increased. However, the authors did not establish any significant impact on patient safety indicators (Donaldson and Shapiro 2010) although they noted that adverse outcomes did not increase despite the case-mix index suggesting a sicker patient group. On the other hand, Aiken et al. (2010) found the mandated ratios in California were associated with lower mortality when compared to two states (Pennsylvania and New Jersey) without legislation. The continuous (24 hour 7 days a week) surveillance provided by registered nurses (RNs) is key to early detection and prompt intervention for deteriorating patients (Aiken et al. 2002b, Estabrooks et al. 2005). Nurses also have the capacity to proactively minimise adverse events and subsequent negative patient outcomes (Aiken et al. 2003). This function, however, depends on adequate nurse staffing levels in terms of both the volume of nursing and the mix of nurses (Aiken et al. 2003, Needleman et al. 2011).

Two Australian studies found similar results (Duffield et al. 2011, Twigg et al. 2011). The first study, undertaken in New South Wales (NSW) found a higher proportion of RNs was associated with a statistically significant decrease in pressure ulcers, gastrointestinal bleeding, sepsis, shock, physiologic/metabolic derangement, pulmonary failure and failure to rescue (Duffield et al. 2011). The same study found increased rates of deep vein thrombosis with improved skill mix (Duffield et al. 2011). The second study, undertaken in Western Australia (WA) over four years, evaluated implementation of the Nurse Hours per Patient Day (NHPPD) staffing method (Twigg et al. 2011). Twigg et al. (2011) found decreased rates of nine nursing-sensitive outcomes (NSOs), including mortality, at hospital level, and significant decreased rates of five NSOs at ward level, following implementation of NHPPD.

This research evidence has put hospitals on notice to implement appropriate nurse staffing levels and a better skill mix (Clarke and Aiken 2006) as illustrated by the mandated staffing changes described previously. However, budgetary constraints and the labour market often limit the ability of hospitals to implement higher levels of nurse staffing and administrators have expressed concerns about the cost implications (Needleman and Buerhaus 2003). In response, a number of papers modelled the potential impact of fewer or additional nursing hours, given the association with NSOs. Many have argued that significant financial savings are to be gained by improving nurse to patient ratios (Needleman et al. 2006, Rothberg et al. 2005, Newbold 2008). Needleman et al. (2006) used data from the landmark 2002 study of 799 hospitals to argue the economic and social case for increasing nurse staffing levels. They found improving the RN mix (higher proportion of RN hours) to the 75th percentile while maintaining the total hours of care resulted in significant cost savings via reductions in length of stay and/or adverse outcomes. Although increasing total hours of care (RNs and licensed practical nurses) to the 75th percentile produced a larger reduction in length of stay, improvements in adverse outcomes were not so great and did not offset the increased hours of care. Needleman et al. (2006) estimated 6,700 inpatient deaths could be avoided by increasing nursing staffing, mostly by a richer RN mix.

Newbold (2008) used production theory techniques to suggest staffing profiles that maximised patient outcomes and minimised costs. Reinterpreting Aiken et al.'s (2003) data, Newbold (2008) suggested increasing the number of graduate RNs as a percentage of the workforce was the most cost effective way to improve patient outcomes. Thungjaroenkul et al. (2007) found that the proportion of RNs (skill mix) was inversely related to costs. More recently, Weiss, et al. (2011) found that units with higher RN non-overtime staffing had lower odds of readmission. Their projected total savings was $409.59 per hospitalised patient per standard deviation increase in RN non-overtime staffing. For the 16 units studied, this represented US$11.64 million total savings.

Staffing at the nurse-to-patient level has also been examined from the context of a patient safety intervention (Rothberg et al. 2005). Rothberg et al. estimated that decreasing the patient-to-nurse ratio from 8:1 to 4:1 would reduce patient mortality and cost US$136,000 per life saved. This cost compares favourably to, for example, thrombolytic therapy in acute myocardial infarction at US$182,000 per life saved (Catillo et al. (1997) cited in Rothberg et al. 2005) or routine cervical cancer screening at US$432,000 per life saved (Charny et al. 1987 cited in Rothberg et al. 2005). This is supported by another study (Dall et al. 2009) that found the economic value of each additional full time RN ranged from US$58,100 to US$62,500 because of an associated reduction in nosocomial complications and, therefore, reduced medical costs. These analyses (Needleman et al. 2006, Rothberg et al. 2005, Dall et al. 2009, Weiss et al. 2011) indicate there is also an economic argument to improve nurse staffing.

Comment [MP1]: Charny et al.

The study

Aims

The aim of this study was to assess the cost-effectiveness of increased nursing hours of care on health outcomes of patients in adult tertiary teaching hospitals following a direction from the Australian Industrial Relations Commission to implement the NHPPD staffing method (Australian Industrial Relations Commission 2002). Specifically, the study:

i) Assessed the net cost of intervention by comparing the costs of increased nursing staff with the savings in terms of reduced NSOs.

ii) Evaluated the cost per life year gained of increased nursing hours on mortality outcomes.

Data were obtained in 2010 from a previous Australian study (Twigg et al. 2011) that demonstrated an association between improved health outcomes and increased hours of nurse staffing following implementation of the NHPPD staffing method (Twigg and Duffield 2009). The study was set in Perth, the capital city of WA, which is the largest state in Australia. The population of WA was 2,317,100 in 2010, with over 1.2 million residing in metropolitan Perth (Australian Bureau of Statistics 2010). The three metropolitan adult tertiary teaching hospitals have a total of 1,449 beds, which provide 'a comprehensive range of clinical services including trauma, emergency (except obstetrics), critical care and acute medical and surgical services' (Twigg et al. 2011). For the purposes of this study we have assumed that when the observed number of nursing-sensitive outcomes varied from the expected number, the primary reason for the difference was the NHPPD, however other factors may also have contributed.

Design

This longitudinal study involved the retrospective analysis of a cohort of all multi-day stay patients (medical and surgical) admitted to the three teaching hospitals for more than 24 hours from September 2000 to June 2004.

Sample

Data comprised 22 months prior to implementation of the NHPPD staffing method (pre-implementation), 6 months transition (data not included) and 22 months following implementation of the NHPPD staffing method (post-implementation). Rates of 13 NSOs were calculated using the hospital morbidity data associated with each of these admissions. NSOs were defined as a 'variable patient or family caregiver state, condition, or perception responsive to nursing intervention' (Mass et al. 1996, Johnson and Lass 1997, Irvine et al. 1998). The specific NSOs included in this study were based on the Needleman et al study (2002) and comprised: **c**entral nervous system complications, deep vein thrombosis/pulmonary embolus, pressure ulcers, gastrointestinal bleeding, pneumonia, sepsis, shock/cardiac arrest, urinary tract infection, failure to rescue, physiologic/metabolic derangement, pulmonary failure, wound infections and mortality.

The sample also included nursing hours in the three adult tertiary hospitals' NHPPD wards. In Australia, an RN is defined as a nurse who is on the register maintained by the Nursing and Midwifery Board of Australia (NMBA) to practise nursing. Currently, RN education is a minimum three-year degree from a tertiary education institution (Australian Institute for Health and Welfare 2008). Australia's enrolled nurses (ENs) are also registered by the NMBA. Their minimum educational requirement is a one-year diploma from a higher education institution (Australian Institute for Health and Welfare 2008). ENs are similar to the US and Canadian licensed practical or vocational nurses, who undertake a 12 to 18-month training program emphasising technical tasks and skills (Page 2004).

Data collection

Patient data were sourced from patient discharge abstracts from September 2000 to June 2004 extracted from the hospitals' morbidity systems. Data were identified for inclusion based on the process described in Tourangeau and Tu (2003) and were used to develop the risk adjustment model.

Ethical considerations

This study was granted ethical approval by the Human Research Ethics Committee of Edith Cowan University and the Human Research Ethics Committee of the study hospitals.

Data analysis

All analyses were conducted using PASW version 18 Release 18.0.2 April 2010.

Pre- and Post-implementation comparisons

Comparisons of patient characteristics pre and post implementation were undertaken using chi-square tests (gender, indigenous status, country of birth, season of admission, referral source, major diagnostic category, care type,) and two sample independent t-tests (age, DRG cost weight).

Individual patient risk adjustment

For each of the 13 categorical NSOs, a multivariable logistic regression model that adjusted for the patient and admission characteristics listed above was fitted to the pre-NHPPD intervention data. These models were applied to patients in the post-implementation period and the predicted probabilities from these models were used to calculate the expected frequency of each nursing-sensitive outcome post-implementation. The difference between the expected and observed frequencies of each nursing-sensitive outcome for the post-implementation period was calculated and the significance of this difference was tested using chi square analysis. The only NSOs included in the economic analysis were those that demonstrated statistical significance ($p<0.004$, based on the Bonferroni correction for multiple comparisons to reduce the probability of false positives; i.e. testing 13 outcomes $0.05/13 = 0.0038$) (Hair et al. 2010 p. 437).

Measurement of costs - *Nursing variables*

The cost of the intervention comprised increased hours of nursing staff following implementation of the NHPPD staffing method. Staff records (n=140,060) were used to collect nursing hours over the study period. Total numbers of nursing hours provided by RNs and ENs were collected for the pre-implementation period (22 months) and the post-implementation period (22 months). Hourly rates for RNs and ENs were based on total annual salaries (including on-costs such as annual leave) and an average 40 hour working week. Staff data were sourced from the Department of Health Western Australia Human Resource Data Warehouse. Nursing variables included in the database were skill mix percent, total nursing hours and total RN hours. Only productive hours (nursing hours of care excluding annual leave sick leave and workers compensation) were included. Three adult acute hospitals, 52 wards and the associated nurse hours for each ward were included. The hourly cost was based on the average nursing costs for each hospital.

Cost savings were based on the net reduction in NSOs (refer to Table 1 for listing of NSOs.) The cost of NSOs prevented was taken as an average cost and based on a published cost of an adverse event for a multiple day admission corrected for age and comorbidity (Ehsani et al. 2006). All costs were referenced to a single calendar year using health index deflators.

Measurement of NSOs and cost-effectiveness

NSOs were assessed, as previously described. The outcome for life years gained was based on pre and post intervention differences in ‘failure to rescue’. Future life years gained were discounted at 3% to reflect time preference, that is, benefits sustained currently have greater value than those in the future.

The cost of the intervention as described above was compared with the net number of NSOs averted in order to establish the total net cost, which was compared with the net number of discounted life years gained to establish the cost per life year gained.

Validity and reliability

This study used data previously collected by hospitals in WA and recorded in their hospital morbidity databases. Although secondary data from medical records may be subject to coding error, validation studies confirm the accuracy and reliability of WA hospital morbidity data (Teng et al. 2008, Brameld et al. 1999). For example, Teng et al. (2008) found the positive predictive value of case mix coding of heart failure as the principal diagnosis was 99.5% when compared to the medical chart diagnosis. Sensitivity analysis was used to validate the robustness of the cost-effectiveness ratio by testing levels of uncertainty within the analysis.

Results

Patient demographics

Characteristics of the patient population were similar across the three hospitals and were consistent for both the pre and post implementation periods of analysis (patient population 107,253 compared with 107,026). While there was a significant difference in age (60.3 pre and 60.8 post implementation) (t-test $p<0.001$), this difference was not considered clinically relevant. The increase in Diagnostic Related Group cost weight between the pre and post-implementation period was also significant (t-test $p<0.001$), suggesting increased patient complexity post-implementation (refer Table 2).

Nursing hours

Nursing hours increased by 590,568 hours in the post-implementation period, comprising 409,987 more RN hours and 180,580 more EN hours. Agency hours, which included RN and EN hours, reduced by 21,333 hours (refer Table 3). Across all hospitals the skill mix (RNs/ (RNs + ENs)) changed very little, but decreased slightly from 87% pre-implementation to 85% post-implementation. Hence, cost-effectiveness was calculated assuming no change in skill mix and based on costs incurred and life years gained.

Cost-effectiveness

The total number of NSOs prevented was 1,357 including 155 'failure to rescue' events and 1,202 other NSOs comprising 'surgical wound infection', 'pulmonary failure', 'ulcer, gastritis, upper gastrointestinal bleed' and 'cardiac arrest' (refer to Table 4). One NSO, pneumonia, showed an increase of 493. Net cost was estimated based on 1,20*2* NSOs averted (savings) and 493 NSOs having incurred an additional cost. Other NSOs did not demonstrate difference at the 0.004 significance level (refer to Table 1).

Analysis of life years gained was based on the 155 failure to rescue events prevented post intervention. The average age of all inpatients who experienced a failure to rescue event was 73.8 years, and the average life expectancy for Australians was 81.8 years in 2008 (Index mundi 2011), therefore the total life years gained was 1,240. To adjust for future benefits (time preference), life years were discounted at 3%, so that total life years gained became 1088 years.

Total nursing hours increased by 590,568 hours (refer to Table 3); costing AUD$16,833,392 based on proportional contribution of RNs and EN average salary costs. As previously reported (Twigg and Duffield 2009), when the staffing method was introduced the increases were achieved by increasing nursing numbers rather than a reliance on agency nurses or overtime. The cost per adverse event was AUD$10,074 (Ehsani et al. 2006) and the total cost averted was AUD$7,142,466 (for four NSOs averted and one NSO increased), leading to a net intervention cost of AUD$9,690,926. The cost per life year gained was AUD$8,907.

Sensitivity analysis

Our cost of the NSO prevented was taken from published work and corrected for age and comorbidity, however, sequelae of adverse events frequently depend on the original cause of admission and we were unable to validate this figure directly. If we underestimated the cost of an adverse event by 50%, (assume NSO cost of AUD$15,000) then the cost per life year gained becomes AUD$5,697. Conversely, if we overestimated the cost of a NSO by approximately the same amount so that the cost was AUD$5,000, then the cost per life year gained becomes AUD$12,213 (discounted).

Our cost-effectiveness ratio may overestimate in that not all NSOs occur in different patients and the cost per NSO prevented is potentially less when more than one NSO occurs in the same patient. To test the impact of repeat events we analysed frequency data to estimate the number of events in the same individual. The data suggest that up to 25% of events occurred in the same individual. If only 75% of NSOs prevented are considered to lead to resource savings, then cost per life year gained becomes AUD$14,064 (discounted), suggesting that the result is only moderately sensitive to a number of repeat events in the same individual. When analysis included only NSOs prevented (i.e., excluding the increased pneumonia events), the net cost of the intervention became AUD$12,108,948 and the cost per life year gained was AUD$4,324.

Discussion

A reasonable threshold for cost-effectiveness in Australia is $30-60,000 per life year gained (Eichler et al. 2004), hence the implementation of the NHPPD staffing method was cost-effective under all scenarios. These results are in keeping with the findings in the literature (Rothberg et al. 2005, Dall et al. 2009) and suggest increasing nurse staffing is a cost-effective patient safety intervention. Furthermore, these results fall within the cost-effectiveness thresholds of the United States of America, the United Kingdom and Sweden suggesting broader application that that of Australia (Eichler et al. 2004). In addition, the implementation of the NHPPD staffing method was associated with the avoidance of 1,202 other NSOs (surgical wound infection, pulmonary failure, ulcer, gastritis, upper gastrointestinal bleed and cardiac arrest) demonstrating parallel improvements in the quality of care. The significant increase in the pneumonia rates is an anomaly that cannot be easily explained. Pneumonia is susceptible to severe fluctuations according to influenza prevalence but we were unable to ascertain whether this was the cause for the increase. However, one of the three hospital's senior managers advised that a focus on coding pneumonia as a complication had occurred during the study period (T. Basile, personal communication, 2012) suggesting that the increase in pneumonia may have been related to a change in data capture. These results suggest the increased expenditure on nursing salaries was justified from a cost-effective threshold even though the business case for increased nurse staffing could not be made on the basis of cost savings. That is, the intervention is a cost-effective expenditure compared with other accepted health interventions although financial returns in averted illness do not exceed the financial investment in nurse salaries. This raises the question: What is the community prepared to pay for quality health care (Needleman et al. 2006)?

There were some limitations to this study. Agency hours were not included in the analysis as they represented < 10% of all RN and EN nursing hours. The study was unable to control for variation in the staffing levels of other disciplines or for variation across hospitals, which may have masked benefits since they were averaged across hospitals. The study did not take into account changes in treatments or medications that may also have contributed to changes in NSOs. The study was also unable to control for secular trends, however, over the study period health services were relatively static as a major review and planning process for the future of health services was underway (Health Reform Committee 2004). The data did not have sufficient detail to undertake a probabilistic sensitivity analysis, however, elementary sensitivity analysis was undertaken to determine the effect of variation in the variables. Finally, an average cost for NSOs was used as costing data on specific nurse sensitivity outcomes was unavailable.

Conclusion

This study demonstrates that the investment in the increased nursing hours associated with the implementation of the NHPPD staffing method has been a cost-effective initiative based on the accepted Australian threshold. The findings of this study are timely as the Council of Australian Governments (COAG) has established Health Workforce Australia to examine a number of matters including a National Training Plan with a goal of self-sufficiency in the supply of doctors, nurses and midwives by 2025 (Health Workforce Australia 2012). Better costing of specific NSOs would strengthen future research examining the economic benefits of changes in staffing methods and hours of care. In addition, this study has focussed on the changes in NSOs across adult acute hospitals in WA. Staffing decisions occur at the ward level and larger national studies examining the economic benefits of staffing changes at a detailed ward level would further refine the evidence to support the allocation of scarce nursing resources.

References

Aiken, L.H., Clarke, S.P., Cheung, R.B., Sloane, D.M. & Silber, J.H. (2003) Educational levels of hospital nurses and surgical patient mortality. *Journal of the American Medical Association,* **290**(12), 1617-1623.

Aiken, L.H., Clarke, S.P., Sloane, D.M., Sochalski, J. & Silber, J.H. (2002a) Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *Journal of the American Medical Association,* **288**(16), 1987-1993.

Aiken, L.H., Clarke, S.P., Sloane, D.M., Sochalski, J.A. & Silber, J.H. (2002b) Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *Journal of the American Medical Association,* **288**(16), 1987-1993.

Aiken, L.H., Sloane, D.M., Cimiotti, J.P., Clarke, S.P., Flynn, L., Seago, J.A., Spetz, J. & Smith, H.L. (2010) Implications of the California Nurse Staffing Mandate for Other States. *Health Services Research,* **45**(4), 904-921.

Australian Bureau of Statistics (2010) Australian Demographic Statistics, Dec 2010 Vol. 2011 Australian Bureau of Statistics, Canberra.

Australian Industrial Relations Commission (2002) Exceptional Matters Order. Vol. 2009 Sydney.

Australian Institute for Health and Welfare (2008) Nursing and midwifery labour force 2005. In *National health labour force series no 39 Cat. n. HWL 40*AIHW, Canberra.

Australian Institute for Health and Welfare (2010) Hospital performance: cost per casemix-adjusted separation. Vol. 2011 Australian Institute for Health and Welfare,, Canberra.

Australian Nursing Federation (2009) Ensuring quality, safety and positive patient outcomes: Why investing in nursing makes $ence. Australian Nursing Federation, Melbourne.

Basile, T. (2012) Personal Communication. Perth.

Brameld, K.J., Thomas, M.A., Holman, C.D., Bass, A.J. & Rouse, I.L. (1999) Validation of linked administrative data on end-stage renal failure: application of record linkage to a 'clinical base population. *Australian and New Zealand Journal of Public Health,* **23** (5), 464-467.

Clarke, S.P. & Aiken, L.H. (2006) More nursing, fewer deaths. *Quality and Safety in Health Care,* **15**, 2-3.

Dall, T.M., Chen, Y.J., Seifert, R.F., Maddox, P.L. & Hogan, P.F. (2009) The economic value of professional nursing. *Medical Care,* **47**(1), 97-103.

Donaldson, N. & Shapiro, S. (2010) Impact of California mandated acute care hospital nurse staffing ratios: A literature synthesis. *Policy Politics, & Nursing Practice,* **11**(3), 184-201.

Duffield, C., Diers, D., O'Brien Pallas, L., Aisbett, C., Roche, M., King, M. & Aisbett, K. (2011) Nursing staffing, nursing workload, the work environment and patient outcomes. *Applied Nursing Research,* **24**, 244-255.

Ehsani, J.P., Jackson, T. & Duckett, S. (2006) The incidence and cost of adverse events in Victorian hospitals 2003-2004. *Medical Journal of Australia,* **184**(11), 551-555.

Eichler, H.G., Kong, S.X., Gerth, W.C., Mavros, P. & Jönsson, B. (2004) Use of Cost-Effectiveness Analysis in Health-Care Resource Allocation Decision-Making: How Are Cost-Effectiveness Thresholds Expected to Emerge? *Value in Health,* **7**, 518-528.

Estabrooks, C.A., Midodzi, W.K., Cummings, G.G., Ricker, K.L. & Giovannetti, P. (2005) The impact of hospital nursing characteristics on 30-day mortality. *Nursing Research,* **54**(2), 74-84.

Hair, J.F., Black, W.C., Babin, B.J. & Anderson, R.E. (2010) *Multivariate Data Analysis,* Pearson Upper Saddle River.

Health Reform Committee (2004) A healthy future for Western Australians: Report of the Health Reform Committee. Department of Health, Perth.

Health Workforce Australia (2012) National Training Plan Methodology Paper. Vol. 2012 Health Workforce Australia,, Adelaide.

Index mundi (2011) Australia life expectancy at birth. Index mundi,.

Irvine, D., Sidani, S. & McGillis Hall, L. (1998) Linking outcomes to nurses' roles in health care. *Nursing Economics,* **16**(2), 58-64, 87.

Johnson, M. & Lass, M. (eds.) (1997) *Nursing outcome classification (NOC),* Mosby, St. Louis MO.

Kalisch, B.J. (2006) Missed nursing care: a qualitative study. *Journal of Nursing Care Quality,* **21**(4), 306-315.

Kane, R.L., Shamliyan, T.A., Mueller, C., Duval, S. & Wilt, T.J. (2007) The association of Registered Nurse staffing levels and patient outcomes. *Medical Care,* **45**(12), 1195-1203.

Mass, M., Johnson, M. & Moorhead, S. (1996) Classifying nursing-sensitive patient outcomes. *IMAGE: Journal of Nursing Scholarship,* **28**(4), 259-301.

Needleman, J. & Buerhaus, P. (2003) Nurse staffing and patient safety: current knowledge and implications for action. *International Journal for Quality in Health Care,* **15**(4), 275-277.

Needleman, J., Buerhaus, P., Mattke, S., Stewart, M. & Zelevinsky, K. (2002) Nurse-staffing levels and the quality of care in hospitals. *New England Journal of Medicine,* **346**(22), 1715-22.

Needleman, J., Buerhaus, P., Pankratz, S., Leibson, C.L., Stevens, S.R. & Harris, M. (2011) Nurse staffing and impatient hospital mortality. *The New England Journal of Medicine,* **364** (11), 1037-1045.

Needleman, J., Buerhaus, P.I., Stewart, M., Zelevinsky, K. & Mattke, S. (2006) Nurse staffing in hospitals: Is there a business case for quality? . *Health Affairs (Project Hope),* **25**(1), 204-11.

Newbold, D. (2008) The production economics of nursing: A discussion paper. *International Journal of Nursing Studies,* **45**(1), 120-128.

Page, A. (ed.) (2004) *Keeping patients safe: Transforming the work environment of nurses,* National Academies Press, Washington DC.

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.

Rothberg, M.B., Abraham, I., Lindenauer, P.K. & Rose, D.N. (2005) Improving nurse-to-patient staffing ratios as a cost-effective safety intervention. *Medical Care,* **43**(8), 785-791.

Teng, T.-H.K., Finn, J., Hung, J., Geelhoed, E. & Hobbs, M. (2008) A validation study: how effective is the Hospital Morbidity Data as a surveillance tool for heart failure in Western Australia. *Australian and New Zealand Journal of Public Health,* **32**(5), 405-407.

Thungjaroenkul, P., Cummings, G.G. & Embleton, A. (2007) The impact of nurse staffing on hospital costs and patient length of stay: A systematic review. *Nursing Economics,* **25**(5), 255-265.

Tourangeau, A.E., Doran, D.M., Hall, L.M., O'Brien Pallas, L., Pringle, D., Tu, J.V. & Cranley, L.A. (2007) Impact of hospital nursing care on 30-day mortality for acute medical patients. *Journal of Advanced Nursing,* **57**(1), 32-44.

Tourangeau, A.E. & Tu, J.V. (2003) Developing risk-adjusted 30-day hospital mortality rates. *Research in Nursing & Health*, **26**, 483-496.
Twigg, D. & Duffield, C. (2009) A review of workload measures: A context for a new staffing methodology in Western Australia. *International Journal of Nursing Studies*, **46**, 131-139.
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.
Twigg, D., Duffield, C., Bremner, A., Rapley, P. & Finn, J. (2012) Impact of skill mix variations on patient outcomes following implementation of nursing hours per patient day staffing: a retrospective study. *Journal of Advanced Nursing*, **DOI:10.1111/j.1365-2648.2012.05971.x**.
Weiss, M.E., Yakusheva, O. & Bobay, K.L. (2011) Quality and cost analysis of nurse staffing, discharge preparation and postdischarge utilization. *Health Services Research*, **46**(5), 1473-1494.

Table 1: NSO Multivariable logistic regression - Significant variables in each model

NSO	Season	COB	Referral source	Care type	Indigenous status	MDC	DRG cost weight	Age	Age squared	Gender	Age x Gender
1	0.503	0.889	<0.001	0.261	0.002	<0.001	<0.001	0.054	0.180	<0.001	<0.001
2*	0.176	0.271	<0.001	0.014	0.326	<0.001	<0.001	<0.001	<0.001	0.076	0.067
3*	0.301	0.190	<0.001	0.920	0.121	<0.001	<0.001	0.006	0.186	0.005	0.005
4	0.001	<0.001	<0.001	0.054	<0.001	<0.001	<0.001	<0.001	0.927	<0.001	<0.001
5	0.011	0.005	<0.001	0.003	0.617	<0.001	<0.001	<0.001	0.365	0.932	0.946
6	<0.001	0.002	<0.001	0.004	<0.001	<0.001	<0.001	0.526	<0.001	0.014	<0.001
7	0.570	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.062	0.618
8	0.008	0.204	<0.001	0.439	0.575	<0.001	<0.001	<0.001	<0.001	0.881	0.444
9	0.218	0.004	<0.001	0.650	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
10*	0.037	0.030	<0.001	0.944	0.017	<0.001	<0.001	<0.001	0.043	<0.001	0.001
11	0.243	0.234	<0.001	0.671	0.001	<0.001	<0.001	<0.001	0.003	0.073	0.004
12	0.102	<0.001	<0.001	<0.001	0.087	<0.001	<0.001	<0.001	0.044	0.008	<0.001
13	0.370	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.864	<0.001	<0.001

* Model run on surgical patients only

Table 2 Nursing-sensitive outcomes observed and expected frequencies

Nursing-sensitive outcome	Pre/Post Intervention	n =	Observed number of outcome (frequency)	Expected number of outcome (frequency)	Difference between expected and observed frequencies		P value
1	Pre	107253	497				
CNS complications	Post	108224	489	486	-3	increase	0.923
2*	Pre	42417	909				
Surgical wound infection	Post	43749	857	1002	145	decrease	0.001
3*	Pre	42417	491				
Pulmonary failure	Post	43749	398	571	173	decrease	<0.001
4	Pre	107253	4685				
Urinary tract infection	Post	108224	4906	5039	133	decrease	0.172
5	Pre	107253	709				
Pressure ulcer	Post	108224	885	778	-107	increase	0.008
6	Pre	107253	2686				
Pneumonia	Post	108224	3326	2833	-493	increase	<0.001
7	Pre	107253	606				
Deep vein thrombosis	Post	108224	622	628	6	decrease	0.864
8	Pre	107253	1308				
Ulcer/gastritis/UGI bleed	Post	108224	827	1368	541	decrease	<0.001
9	Pre	107253	994				

Sepsis	Post	108224	1220	1099	-121	increase	0.012
10*	Pre	42417	1245				
Physiologic/metabolic derangement	Post	43749	1319	1344	25	decrease	0.623
11	Pre	107253	623				
Shock/cardiac arrest	Post	108224	303	646	343	decrease	<0.001
12	Pre	107253	3522				
Mortality	Post	108224	3479	3617	138	decrease	0.096
13	Pre	107253	1243				
Failure to rescue	Post	108224	1160	1315	155	decrease	0.002

Pearson Chi-Square tests were used to determine differences between expected and observed frequencies
* Analysis completed on surgical patients only

Table 3 Patient demographics for pre and post intervention

	Gender		Mean Age (Years)	Diagnostic Related Group cost weight
	Male	Female		
Pre intervention	52.7%	47.3%	60.31	2.10
Post intervention	52.5%	47.5%	60.82*	2.16*

*t-test p < 0.001

Table 4 Nursing hours by pre/post intervention in all hospitals

	RN hours	Other hours	Agency hours*	Total hours
Pre	3466811.84	494672.22	464322.82	3961484.00
Post	3876798.96	675253.03	442990.14	4552052.00
Difference	409987.12	180580.81	-21332.68	590568.00

*Agency hours were excluded in the analysis of nursing hours

Table 5 Summary of nursing-sensitive outcomes prevented

Nursing-sensitive outcome	Number of nursing-sensitive outcomes prevented
Surgical wound infection	145
Pulmonary failure	173
Ulcer, gastritis, upper gastrointestinal bleed	541
Shock, cardiac arrest	343
Failure to rescue	155
Total	1357