

Associations of patient safety outcomes with models of nursing care organization at unit level in hospitals

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Abstract

Objective. To examine the associations of four distinct nursing care organizational models with patient safety outcomes.

Design. Cross-sectional correlational study. Using a standardized protocol, patients' records were screened retrospectively to detect occurrences of patient safety-related events. Binary logistic regression was used to assess the associations of those events with four nursing care organizational models.

Setting. Twenty-two medical units in 11 hospitals in Quebec, Canada, were clustered into 4 nursing care organizational models: 2 professional models and 2 functional models.

Participants. Two thousand six hundred and ninety-nine were patients hospitalized for at least 48 h on the selected units.

Main Outcome Measure. Composite of six safety-related events widely-considered sensitive to nursing care: medication administration errors, falls, pneumonia, urinary tract infection, unjustified restraints and pressure ulcers. Events were ultimately sorted into two categories: events 'without major' consequences for patients and events 'with' consequences.

Results. After controlling for patient characteristics, patient risk of experiencing one or more events (of any severity) and of experiencing an event with consequences was significantly lower, by factors of 25–52%, in both professional models than in the functional models. Event rates for both functional models were statistically indistinguishable from each other.

Conclusions. Data suggest that nursing care organizational models characterized by contrasting staffing, work environment and innovation characteristics may be associated with differential risk for hospitalized patients. The two professional models, which draw mainly on registered nurses (RNs) to deliver nursing services and reflect stronger support for nurses' professional practice, were associated with lower risks than are the two functional models.

Keywords: nursing care organization, nursing care models, patient safety, nursing sensitive outcomes, measurement of quality

Introduction

There is growing evidence that how nursing workers are organized and how care is provided are critical factors determining patient outcomes in hospitals [1, 2]. However, reports and studies in recent decades have shown that nurses often practice under suboptimal organizational conditions [3] in terms of staffing, organization of work and the work environment. When making decisions regarding these conditions, health-care leaders assume that care can be organized under different models, but the literature is inconclusive

regarding which approaches maximize nursing services' quality and safety. We target this gap by assessing the associations of four distinct nursing care organization models with patient safety outcomes.

The first step in evaluating different nursing care organization models is to define them operationally. Over the past five decades, typologies of nursing care models in hospitals have focused on allocation of patient care tasks. Four basic models are often identified: functional nursing, total patient care, team nursing and primary nursing. Limitations and inconsistencies in the use of these descriptors have been

documented, and many consider them inadequate for depicting the multiplicity of actual nursing work organization models in practice [4, 5]. We recently developed a taxonomy of nursing care organization models that incorporated a broader range of attributes than found in the literature to date [6, 7]. We propose that a nursing care delivery model consists of five key dimensions: staffing intensity (measured by number of nursing care hours per patient day), skill mix [measured by proportion of care hours provided by registered nurses (RNs) and nurses holding baccalaureate (university) degrees, scope of practice (measured by the ASCOP tool that assesses the extent to which RNs apply their professional preparation in six domains of practice: assessment and planning, teaching, communication, supervision, quality of care and knowledge updating)] [8], nursing practice environment (measured by five subdimensions of the Nursing Work Index: nurse participation in hospital affairs, nursing foundations for quality, nurse manager leadership and support, resource adequacy and nurse–physician relations) [9] and unit-level capacity for innovation (measured on five criteria: expanded RN roles, sharpened focus of care on the patient, attention to patient transitions, leveraging of technologies and performance monitoring and feedback) [10]. Four models derived from this taxonomy are described briefly in the Methods section.

Outcomes used to evaluate care models must be sensitive to nursing inputs and interventions [11]. Although care provision always involves different provider groups, there is increasing evidence that some outcomes, particularly those linked to safety, reflect differences in processes and structural features of nursing services [12–15]. Studies have demonstrated conceptual, clinical and empirical links between nursing factors and specific safety outcomes, including medication administration errors [16], falls [17], pressure ulcers [18], urinary tract infections [19], pneumonia [20] and unjustified restraint use [21]. Based on this evidence, we examined a composite of these safety-related outcomes as the dependent measure in this study.

Methods

Sampling

Hospital units. This study was conducted in 22 acute medicine units in 11 hospitals in Quebec, Canada. Units were selected to generate a stratified sample covering a variety of organizational contexts of nursing care, based on predefined criteria and informed by a survey sent to all Quebec hospitals (50 out of 100 institutions responded). Diversity of institutions was sought on the following criteria: institutional teaching status (university and community), size, location (urban, suburban and rural), nursing workforce profiles (different proportions of nurses holding university degrees) and work reorganization track records (stable structure with no recent modification, recent work reorganization initiatives such as introducing new staff categories and enhancing nurses' roles).

Patients. Patients on the 22 units were selected based on 4 criteria: (i) hospitalizations of at least 48 h, (ii) age 18 years

and older, (iii) admission diagnoses typical of care provided on medicine units and (iv) hospitalizations overlapping with a concurrent nurse survey to characterize nursing care delivery models on the units. The observation period was restricted to the first 30 days of the selected patients' hospitalization, to exclude long-stay patients and increase homogeneity of the patient sample.

Assuming a 3% potential rate of selected events based on the literature, we calculated that a sample of 2600 patients would be required to achieve a 2.5% margin of error in point estimates of risk, based on a 0.05 significance level. The final sample totaled 2699 patients, varying from 117 to 128 per unit.

Nursing care organization model (independent variable)

The independent measure was a four-category variable representing the nursing care organization models. Cluster analysis of data from the 22 units elicited 4 nursing care organization models with considerable face validity (see Fig. 1). The unit types clustered along two axes, one related to overall staffing intensity and the second, to the proportion of more educated nurses and the quality of the professional practice environment. Two models were variations on a professional model and two others, on a functional model (see Table 1 for details).

Professional models of nursing care organization. The two professional models reflect managerial decisions that recognize nursing as a professional discipline. These models employ more nursing workers with higher formal education and have professional governance structures supporting the efforts of these knowledge workers. As such, these models are characterized by a higher proportion of care hours provided by RNs and by nurses' perception of greater support for their professional practice. Table 1 describes the two professional models' distinctive features.

Functional models of nursing care organization. The functional models reflect a view of nursing as a broad set of tasks that can be carried out by a variety of workers, presumably in response to factors such as economic and labour-market constraints. As such, these models draw more on less educated staff, including licensed practical nurses (LPNs) and unregulated assistive staff, to deliver nursing services than do the professional models. They are characterized by a lower proportion of care hours provided by RNs, and by nurses' perception that the practice environment is less supportive of a 'professionalized' approach to RNs' work. Table 1 describes the two functional models' distinctive features. The term 'adaptive' refers to the use of both LPNs and RNs to wider scope of practice relative to other units.

Patient safety outcomes (dependent variables)

Based on the literature, we selected six patient outcomes (medication administration errors, falls, pneumonia, urinary tract infection, unjustified restraints and pressure ulcers) for study. They were identified from abstraction of each patient's

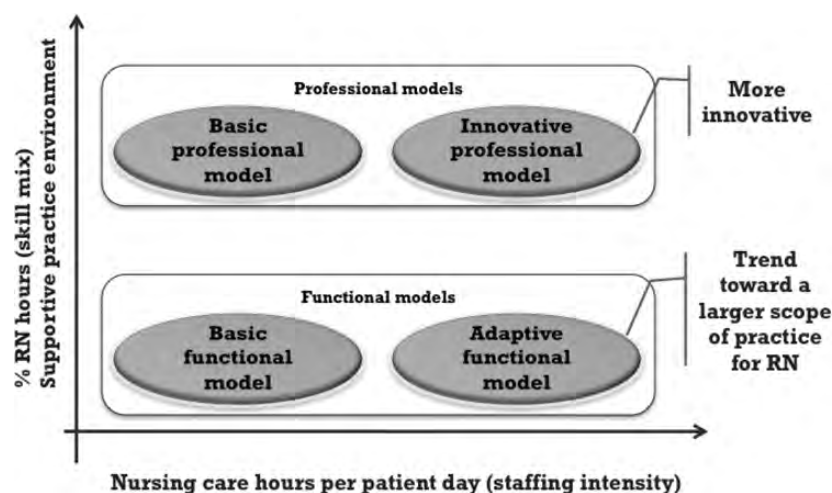


Figure 1 Four nursing care organization models [7]

Table 1 Four nursing care organization models

	Professional models		Functional models	
	Innovative professional model	Basic professional model	Adaptive functional model	Basic functional model
Staffing intensity (care hours per patient day)	High	Low	High	Low
Skill mix				
Proportion of RN hours in total nursing hours	High	High	Low	Low
Proportion of university graduate nurse hours in total nursing hours	High	Low	Low	Low
Practice environment (RNs' perceptions)	More positive	More positive	Lower	Lower
Capacity for innovation (innovation tracers)	High level	Low level	Low level	Very low level
Scope of practice	Moderate level	Moderate level	Trend toward a higher level	Low level

medical record for the stay, using a standardized protocol adapted from earlier work [22]. Each event's severity was rated according to its consequences for the patient, using a standardized algorithm. Events were sorted into those 'without' consequences (which had potential for harm and may or may not have required intervention or follow-up, but did not cause lasting clinically detectable harm) and those 'with' consequences (causing a temporary or permanent change in the patient's condition and requiring an intervention, treatment or extended hospitalization). These categories transcend more restrictive definitions of adverse events, taking into account situations at different points on the safety continuum in terms of impacts on patients.

Patient-level control variables

We used two approaches to address baseline differences in patient risk for events. First, we applied strict inclusion rules to increase homogeneity of the patient pool. Second, we included four indicators as control variables in our regression

model to capture severity of conditions and presumed risk for negative outcomes: age-adjusted Charlson Comorbidity Index [(CCI), in which comorbid conditions are scored, weighted and totaled, with points added for age], number of risk factors (including alcoholism, smoking, drug addiction, obesity, cognitive disorders such as Alzheimer's disease, mental health problems such as depression or schizophrenia and illiteracy), length of stay and number of diagnoses at admission [23, 24].

Data collection

We screened patients' records retrospectively to detect occurrences, after admission, of the six safety-related events. Eligible patients were tracked for outcomes until transfer, hospital discharge, death or the end of a 30-day period. Using a template drawing upon previous studies [22], three experienced nurses screened records post-discharge. Reviewers underwent 4-h training sessions and received a training manual.

The protocol involved a two-stage review. First, each record was screened by one reviewer to check for the occurrence of at least one event by systematically examining incident reports, discharge summaries, medications, lab results, nursing and physician notes or comments. In this first-stage review, data were also collected on patients' demographics (age and sex), conditions (main diagnoses at admission, comorbidities and risk factors) and length of stay. To assess inter-rater reliability, the first seven records of each unit were independently examined by a second reviewer. This quality control was conducted on 6% of records that is in the general range of rates ranging from 1 to 5% in other studies from the literature [25, 26]. The Kappa coefficient for inter-rater agreement for this first stage of the review process was 0.98.

If one or more safety-related events were identified in the first-stage screening, the record was reviewed again, more thoroughly and independently. In that review, assessors also rated each event's severity. The Kappa coefficient for measurement of agreement for the second review was 0.97. In cases of disagreement and discrepancies, the two reviewers reached mutual agreement after discussion.

Statistical analysis

The data were first summarized using descriptive statistics and frequency tables. Prior to logistic regression modeling, bivariate analyses were conducted to examine the associations among the variables, identify potential confounding variables and detect possible problems with multicollinearity (using a *P*-value threshold of 5%).

Two composite outcomes were constructed: a binary variable for each patient indicating occurrence of any of the six events, with or without consequences, and a second indicating whether the patient had experienced any events with consequences. Subsequently, regression modeling was used to assess associations between the four nursing care organization models (independent variables) and both dependent variables. We used binary logistic regression with adjustments for patients' characteristics, including age-adjusted CCI, number of risk factors, number of diagnoses at admission and length of stay. The Hosmer–Lemeshow test and DFBETAS analysis were used to assess goodness-of-fit of the final models [27].

Results

Patient characteristics

Data were collected for 2699 patients on 22 units. Mean age was 71.1 [standard deviation (SD) 15.4; range 18–102] years; 56.4% were female. Average length of stay on the units was 11.4 days (SD 8.7). On average, patients had 1.6 risk factors (SD 1.3; range 0–7), 3.9 comorbidities (SD 2.3; range 0–14) and 1.3 diagnoses at admission (SD 0.6; range 0–4).

Frequency and nature of safety-related adverse events

Table 2 illustrates the distribution of safety-related events in our sample. There were 568 safety-related events observed in 412 (15.3%) patients, of which 32.4% were associated with significant consequences requiring intervention or resulting in harm or complications.

Associations of the four care models with patient safety-related event risk

Event occurrence varied significantly across the four groupings of units by nursing care models. Table 3 presents the unadjusted rates of safety-related events across the four models. The innovative professional model shows the lowest unadjusted rate for occurrence of at least one event of any severity, whereas the basic functional model shows the lowest unadjusted rate for the occurrence of at least one event with consequences.

After controlling for patient characteristics, the logistic regressions presented in Tables 4 and 5 indicate that patients' risk of experiencing one or more events (of any severity), and of experiencing an event with consequences, was significantly lower by factors of 25–52% in both professional models relative to the functional models. Event likelihoods were statistically indistinguishable from each other for the two functional care models. Occurrence of events with consequences in units with the basic functional model was approximately 40% lower than in units with the adaptive functional model.

Discussion

This study found that four distinct unit-level nursing care organizational models characterized by contrasting staffing, professional practice environment and innovation characteristics were associated with different levels of risk of adverse outcomes for patients. Whereas links between nursing-related organizational factors and patient outcomes have emerged in many previous studies, this study's contribution is distinct in several important respects.

First, we examined local conditions and safety outcomes at unit levels. In most earlier studies, analyses were conducted at the hospital level, aggregating structural and outcomes variables across all nursing units. Hospital-level measures reflect an accumulation of local decisions regarding nurses assigned to each unit, their daily practices, their practice environments and the unique characteristics of their patients that vary greatly across hospital units. Data aggregated to the hospital level are at best weak proxies of the organizational conditions under which patients receive care; obtaining more accurate data on these conditions is essential for advancing knowledge on the contribution of nursing care. In our study, we observed fairly clear-cut associations when analyzing carefully linked unit-level organizational and patient outcomes data.

Table 2 Rates of safety-related events of any severity and with consequences ($n=2699$)

Types of safety-related events	Events		Patients			
	Total number of events	Proportion of events with consequences (%)	Patients with at least one event of any severity	Patient-level occurrence rate of at least one event of any severity (%) (95% CI)	Patients with at least one event with consequences	Patient-level occurrence rate of events with consequences (%) (95% CI)
Pressure ulcer	52	80.8	51	1.9 (1.4–2.4)	42	1.6 (1.1–2.0)
Unjustified restraints	24	4.2	23	0.9 (0.5–1.2)	1	0.0 (0.0–0.1)
Falls	230	18.3	160	5.9 (5.0–6.8)	40	1.5 (1.0–1.9)
MAE	169	17.2	149	5.5 (4.7–6.4)	29	1.1 (0.7–1.5)
Pneumonia	23	100.0	23	0.9 (0.5–1.2)	23	0.9 (0.5–1.2)
Urinary tract infections	70	67.1	70	2.6 (2.0–3.2)	47	1.7 (1.2–2.2)
Overall	568	32.4	412	15.3 (13.9–16.6)	167	6.2 (5.3–7.1)

CI, confidence interval; MAE, medication administration error.

Table 3 Patients' distribution among the different models of organization of nursing care

Models of organization of nursing care	Number of units	Number of patients	Unadjusted rate of any safety-related event (%)	Unadjusted rate of any safety-related event with consequences (%)
Basic professional model	6	735	15.5 (12.0–19.0)	6.3 (4.7–7.9)
Innovative professional model	2	234	11.5 (3.0–20.0)	5.1 (1.0–9.2)
Basic functional model	5	618	15.5 (11.3–19.7)	4.7 (3.3–6.1)
Adaptive functional model	9	1112	15.7 (13.4–18.0)	7.2 (6.0–8.4)

Second, this study provides early evidence of predictive validity for a typology or configurational approach for representing nursing care organization models. Nearly, all earlier research examined associations between outcomes and patient assignment patterns, nurse staffing and work environments, separately and often in isolation, with little consideration of organizational context. The configurational approach we used is able to simultaneously assess impacts of a broad range of factors that define nursing care organization and have the potential, in combination, to impact patient outcomes.

The findings support the notion that safety outcomes in hospital care result from multiple factors. The lowest rates of negative outcomes were seen in the innovative professional model characterized by favorable factors, including a richer skill mix, higher staffing intensity and a practice environment more supportive of professional practice and with greater investments in innovation. Similarly, the two professional models' stronger performance in comparison to the functional models may be related to the professional models' richer staff mix and more positive practice environment. These associations are consistent with findings reported for Magnet hospitals, known for the excellence of their conditions for both nurses and patients [28].

Findings that models whose staff mixes include greater proportions of educated personnel were linked to decreased risk of adverse events accord with results of previous studies tying richer skill mix in hospital nurse staffing to lower risks of adverse events [20]. These results support the contention that RNs play key roles in hospitals' systems for early detection of threats to patient safety and for prompt remedial intervention. However, the performance differential between the two professional models suggests that the effectiveness of this surveillance may be influenced by factors other than the simple proportion of RNs, such as level of RNs' education, intensity of other resources (LPNs and assistive staff) available to provide nursing care and support professional nurses' work and capacity for innovation. Although the differences in outcomes between the two professional models were not especially strong, the odds ratios suggest a certain superiority of the innovative professional model with regard to rates of occurrence of events with consequences.

Our findings do not contradict those of previous studies showing that staffing parameters at the lower extremes of distributions are linked with higher rates of adverse outcomes [29]. Such results suggest that employing an adequate number of staff is a necessary condition for safe patient care. However, in our study, highly significant differences between

Table 4 Odds ratios for experiencing at least one event of any severity associated with the four nursing care models

Independent variables	Occurrence of at least one event		
	Adjusted odds ratio ^a	95% CI	P-value
Models of care (reference category—adaptive functional)			
Innovative professional	0.525	0.33–0.84	0.007*
Basic professional	0.752	0.57–0.99	0.04*
Basic functional	1.010	0.76–1.35	0.95
Number of risk factors (reference category—three and higher)			
None	0.589	0.41–0.84	0.004
One	0.593	0.44–0.8	0.001
Two	1.010	0.75–1.36	0.948
CCI (age-adjusted)	1.096	1.06–1.13	< 0.001
Length of stay (days)	1.079	1.07–1.09	< 0.001

^aIn addition to number of risk factors, age-adjusted CCI and length of stay, odds ratios were also adjusted for sex and number of diagnoses at admission, but these two latter variables were not statistically significant. * $P > 0.05$.

Hosmer–Lemeshow statistic = 6.599; 8 df; $P = 0.58$.

CI, confidence interval.

Table 5 Odds ratios for experiencing at least one event with consequences associated with the four nursing care models

Independent variables	Occurrence of at least one event with consequences		
	Adjusted Odds ratio ^a	95% CI	P-value
Models of care (reference category—adaptive functional)			
Innovative Professional	0.477	0.25–0.91	0.026*
Basic Professional	0.623	0.42–0.93	0.020*
Basic Functional	0.601	0.38–0.95	0.029*
CCI (age adjusted) after categorization (reference category—9 and higher)			
0–5	0.383	0.26–0.56	< 0.001
6–9	0.408	0.27–0.61	< 0.001
Length of stay (days)	1.085	1.01–1.07	< 0.001

^aIn addition to age-adjusted CCI and length of stay, odds ratios were also adjusted for sex, number of risk factors and number of diagnoses at admission, but these three latter variables were not statistically significant (* $P > 0.05$)

Hosmer–Lemeshow statistic = 8.905; 8 df; $P = 0.350$

CI, confidence interval.

the innovative professional model and the adaptive functional model strongly suggest that, although staffing intensity matters, it is not sufficient to ensure positive outcomes. Both models were characterized by higher staffing intensity; as such, the performance differentials suggest interplay between staffing intensity and other unit-level factors. The relatively poor performance of the adaptive functional model indicates that, beyond staffing intensity, a combination of factors, including skill mix, support of professional practice, capacity for innovation and nurses' scope of practice, account for differences across various types of nursing organizational structures. The results are also consistent with studies that identified associations between the proportion of RNs and/or baccalaureate prepared nurses in hospitals and patient outcomes [30]. Besides higher staffing intensity, the innovative professional model is characterized by higher proportions of

care hours provided by RNs and by nurses with baccalaureate degrees.

Interpretation of these findings should be informed by certain methodological caveats. First, there are the limitations of cross-sectional analyses in uncovering causal relationships, and the possibility that unmeasured variables at both organizational and unit levels account for some or all of the associations revealed, particularly given the small number of units sampled. Despite the inclusion of risk-adjustment variables in the modeling, we cannot entirely eliminate the possibility that patient characteristics differed across units or organizational models and partially explain the results. Retrospective examination of patients' charts to assess the occurrence of adverse events relies upon consistency of recording that may vary across, or within, hospitals or units. Although every precaution was taken to ensure reviewers' consistency, and

assessed inter-rater reliability was very high, identification and classification of events are subject to biases. Another limitation results from patients' being assigned to a single unit and unit grouping for the analysis. Although the data used to measure both independent and dependent variables were collected within the same temporal bracket, the study was not designed to link patients and their outcomes to the amount and nature of nursing care they received. It is possible that, within the same care model or unit, nursing care received by patients with similar conditions varied.

Despite its limitations, this project makes an important contribution to develop and test a methodological framework that can be used and refined in future research either to measure the impact of nursing care organization models or to establish the sensitivity of specific outcomes to variations in nursing care organization. From a policy-making perspective, this study's findings have important potential implications for resource allocation decisions. The characteristics that define the four nursing care organization models are modifiable factors and levers that could be synergistically mobilized through policy initiatives at the unit, organizational and system levels. At the very least, these factors merit being considered together in workforce planning, management and leadership development, as well as in financial and budgeting decisions at all three levels, to maximize positive outcomes and minimize negative ones for hospitalized patients and the broader health-care system.

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References

- Henneman EA, Gawlinski A. A 'near-miss' model for describing the nurse's role in the recovery of medical errors. *J Prof Nurs* 2004;**20**:196–201.
- Kurtzman ET. The contribution of nursing to high-value in-patient care. *Policy Polit Nurs Pract* 2010;**11**:36–61.
- Institute of Medicine (IOM). *Keeping Patients Safe: Transforming the Work Environment of Nurses*. Washington, DC: National Academy Press, 2003.
- Sjetne IS, Helgeland J, Stavem K. Classifying nursing organization in wards in Norwegian hospitals: self-identification versus observation. *BMC Nurs* 2010;**9**:3.
- Brannon RL. *Intensifying Care: The Hospital Industry, Professionalization, and the Reorganization of the Nursing Labor Process*. Amityville, NY: Baywood Publishing Company, 1994.
- Dubois C-A, D'Amour D, Tchouaket E et al. Nursing care delivery models in acute care units in Quebec. How do they hold their promises? In: Academy of Management Annual Meeting, 7 August 2010, Montreal, Quebec, Canada.
- Dubois C-A, D'Amour D, Tchouaket E et al. A taxonomy of nursing care organization models in hospitals. *BMC Health Serv Res* 2012;**12**:286.
- D'Amour D, Dubois C-A, Déry J et al. Measuring actual scope of hospital nursing practice: a new tool for nurse managers and researchers. *J Nurs Adm* 2012;**42**:248–55.
- Lake ET. Development of the practice environment scale of the Nursing Work Index. *Res Nurs Health* 2002;**25**:176–88.
- Kimball B, Joynt J, Cherner D et al. The quest for new innovative care delivery models. *J Nurs Adm* 2007;**37**:392–8.
- Doran DM. *Nursing-Sensitive Outcomes. State of the Science*. Sudbury: Jones and Bartlett, 2003.
- Needleman J, Buerhaus P, Mattke S et al. Nurse-staffing levels and the quality of care in hospitals. *N Engl J Med* 2002;**346**:1715–22.
- Needleman J, Buerhaus PI, Stewart M et al. Nurse staffing in hospitals: is there a business case for quality? *Health Affairs* 2006;**25**:204–11.
- Riehle AI, Hanold LS, Sprenger SL et al. Specifying and standardizing performance measures for use at a national level: implications for nursing-sensitive care performance measures. *Med Care Res Rev* 2007;**64**:S4S–S81.
- Clarke S, Donaldson NE. Nurse staffing and patient care quality and safety. In: Hughes RG (ed). *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. Rockville, MD: Agency for Healthcare Research and Quality, 2008, 111.
- Rogers AE, Dean GE, Hwang WT et al. Role of registered nurses in error prevention, discovery and correction. *Qual Saf Health Care* 2008;**17**:117–21.
- Manojlovich M, Sidani S, Covell CL et al. Nurse dose: linking staffing variables to adverse patient outcomes. *Nurs Res* 2011;**60**:214–20.
- Flynn L, Liang Y, Dickson GL et al. Effects of nursing practice environments on quality outcomes in nursing homes. *J Am Geriatr Soc* 2010;**58**:2401–6.
- Kendall-Gallagher D, Blegen MA. Competence and certification of registered nurses and safety of patients in intensive care units. *J Nurs Adm* 2010;**40**:S68–77.
- Kane RL, Shamliyan TA, Mueller C et al. The association of registered nurse staffing levels and patient outcomes: systematic review and meta-analysis. *Med Care* 2007;**45**:1195–204.
- Gerolamo AM. The conceptualization of physical restraint as a nursing-sensitive adverse outcome in acute care psychiatric treatment settings. *Arch Psychiatr Nurs* 2006;**20**:175–85.
- Baker GR, Norton PG, Flintoft V et al. The Canadian Adverse Events Study: the incidence of adverse events among hospital patients in Canada. *CMAJ* 2004;**170**:1678–86.
- Iezzoni LI. Dimensions of risk. In: Iezzoni LI (ed). *Risk Adjustment for Measuring Healthcare Outcomes*. 2nd edn. Chicago: Health Administration Press, 1997, 43–167.
- Melfi C, Holleman E, Arthur D et al. Selecting a patient characteristics index for the prediction of medical outcomes using administrative claims data. *J Clin Epidemiol* 1995;**48**:917–26.

25. Zegers M, de Bruijne MC, Wagner C *et al.* Design of a retrospective patient record study on the occurrence of adverse events among patients in Dutch hospitals. *BMC Health Serv Res* 2007;**7**:27.
26. Brennan TA, Leape LL, Laird NM *et al.* Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *N Engl J Med* 1991;**324**:370–6.
27. Kleinbaum DG, Klein M. *Logistic Regression: A Self-Learning Text*. 3rd edn. New York: Springer, 2010.
28. Lake ET, Shang J, Klaus S *et al.* Patient falls: association with hospital Magnet status and nursing unit staffing. *Res Nurs Health* 2010;**33**:413–25.
29. Aiken LH, Clarke SP, Sloane DM *et al.* Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *JAMA* 2002;**288**:1987–93.
30. Aiken LH, Clarke SP, Cheung RB *et al.* Educational levels of hospital nurses and surgical patient mortality. *JAMA* 2003;**290**:1617–23.