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Review Article

Long-Term Follow-Up of structured nurse staffing models for medication administration errors

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Abstract

Background: Structured nurse staffing models, including fixed nurse-to-patient ratios and acuity-based workload systems, have been advanced as a durable safeguard against medication administration errors, yet most supporting evidence spans only a single implementation year.

Objective: This review synthesizes long-term follow-up evidence on structured staffing models and medication administration error rates, examining whether early error reductions persist, attenuate, or reverse over multi-year horizons.

Methods: We synthesized cohort studies, interrupted time-series analyses, and multi-year audits reporting medication administration error rates before and after staffing model implementation, with a minimum follow-up of two years post-implementation.

Findings: Structured ratios and acuity-based staffing are associated with sustained reductions in interruption-related and dose-timing errors over three to five years when paired with ongoing workload monitoring, but benefits erode during unaddressed turnover surges and float-pool substitution, and error-detection improvements from incident-reporting culture change can mask true rate changes if not adjusted for reporting intensity.

Conclusions: Long-term data support structured staffing as a component of medication safety strategy, but durability depends on sustained fidelity to ratios, continued skill-mix stability, and parallel investment in error-reporting and double-check systems rather than staffing reform alone.

Keywords: nurse staffing; medication administration errors; patient safety; staffing ratios; long-term follow-up

1. Introduction

Medication administration is the final and most error-prone step of the medication-use process, and the nurse delivering the dose is typically the last safeguard before a mistake reaches the patient. Landmark observational work in the early 2000s established that hospitals with lower registered-nurse staffing levels experienced measurably higher rates of adverse patient outcomes, including medication-related events, and that each additional patient added to a nurse's workload carried a quantifiable increase in risk [1,2]. Those findings catalyzed a wave of policy interest in structured staffing models, ranging from legislatively mandated nurse-to-patient ratios to acuity-adjusted workload systems that reallocate staff dynamically according to patient complexity [3]. California's mandated ratio law, implemented in 2004, became the most widely studied natural experiment in this space, and early evaluations reported reductions in nurse-sensitive adverse events including medication errors within the first one to two years of implementation [4,5]. Comparable ratio-based reforms adopted subsequently in Australian and European jurisdictions produced similarly encouraging short-term signals, reinforcing interest in staffing structure as a scalable safety lever [6,7].

What has been far less consistently examined is whether these early gains persist. Most staffing-error studies published in the decade following the California ratio mandate relied on single-year pre-post comparisons or cross-sectional snapshots, methodologies that cannot distinguish a durable structural improvement from a short-lived Hawthorne effect tied to the novelty of implementation and heightened managerial attention [8]. Medication administration error rates are also sensitive to secular trends unrelated to staffing, including the rollout of barcode medication administration systems, smart infusion pumps, and electronic health record-based clinical decision support, all of which were being adopted in many of the same hospitals and over many of the same

years as staffing reforms, complicating attribution in studies without extended follow-up [9,10]. This review synthesizes the published long-term follow-up literature, defined here as studies with at least two years of post-implementation data, on structured nurse staffing models and medication administration error rates, asking specifically whether early reductions in error rates are sustained, whether they attenuate, and what mediating factors determine durability.

2. Structured staffing models and the mechanism of protection

Structured staffing models operate on nurses' medication administration performance through several overlapping mechanisms. The most direct is simple workload: a nurse responsible for fewer patients has more time per administration event to verify the five rights, reconcile allergies, and detect look-alike or sound-alike drug confusion before the dose reaches the patient [2]. Interruptions during medication administration are strongly associated with error occurrence, and each additional interruption during a single administration round has been associated with a measurable increase in the probability of a clinical or procedural error, an effect that compounds when nurses are simultaneously covering more patients and therefore more likely to be interrupted by call bells, alarms, and colleague requests during the administration process itself [11].

A second mechanism operates through fatigue and cognitive load. Nurses working extended shifts or covering unplanned overtime because of inadequate baseline staffing report higher rates of self-detected near-miss errors, and objective error-rate audits corroborate a dose-response relationship between shift length beyond twelve hours and administration error frequency [12,13]. Acuity-adjusted staffing models attempt to address this by matching nurse-to-patient ratios not to a fixed number but to a validated patient-complexity score, in principle preventing the silent understaffing that occurs when a

unit meets its numerical ratio but is caring for a disproportionately high-acuity patient mix on a given shift [14]. Systematic reviews comparing fixed-ratio and acuity-based models generally find both associated with lower medication error rates than unstructured or purely budget-driven staffing, though direct head-to-head comparisons over multi-year horizons remain sparse [15]. Unit-level design studies further suggest that structured staffing interacts with the physical medication-administration environment, since protected administration zones and reduced-interruption protocols amplify the benefit of adequate staffing while doing little to compensate for chronic understaffing on their own [16,17].

Table 1: Proposed mechanisms linking structured nurse staffing models to reduced medication administration error, drawn from workload, interruption, and fatigue-focused evidence [2,11,12,13].

Mechanism	Staffing lever	Evidence base	Direction of effect
Time per administration event	Fixed nurse-to-patient ratio	Workload-outcome cohort studies	Fewer patients per nurse associated with lower error rate
Interruption frequency	Adequate coverage during administration rounds	Direct observation studies	More interruptions associated with higher error probability
Fatigue and cognitive load	Shift length / overtime limits	Self-report and audit studies	Shifts beyond 12 hours associated with higher error frequency
Acuity mismatch	Acuity-adjusted staffing	Comparative staffing-model reviews	Complexity-matched staffing associated with lower error rate

3. Short-term versus long-term evidence: a methodological divide

The bulk of the peer-reviewed staffing-error literature reports outcomes measured within twelve months of a staffing change, a window well suited to detecting a Hawthorne-type effect but poorly suited to establishing durability. Cross-sectional multi-hospital surveys, such as the RN4CAST consortium's work across European hospitals, found a consistent association between higher

patient-to-nurse ratios and increased odds of reported care left undone, including missed or delayed medication administration, but these designs capture a single time point across many hospitals rather than tracking the same units over years [18,19]. Needleman and colleagues' influential eight-hospital study linking below-target nurse staffing shifts to increased inpatient mortality similarly relied on a relatively short observation window, leaving open whether the staffing-outcome relationship it documented would persist as hospitals adapted their operations around a new staffing baseline [2].

The handful of studies extending observation beyond two years present a more complicated picture. Longitudinal data from the Magnet hospital recognition program, which requires sustained structured nursing practice environments including staffing infrastructure as a condition of ongoing accreditation, show that hospitals maintaining Magnet status over multiple renewal cycles sustain lower rates of nurse-reported medication errors than newly designated or non-Magnet comparators, suggesting that durability is achievable when the underlying organizational commitment to staffing structure itself persists [20,21]. Conversely, interrupted time-series analyses of ratio-mandated units that experienced significant nursing workforce turnover in years three through five after implementation found that measured error rates drifted back toward pre-implementation levels even though the numerical ratio itself remained formally in place, indicating that a staffing ratio on paper does not guarantee sustained protective effect if skill mix and experience level erode underneath it [22].

4. Durability of error reduction over three to five years

Several cohort studies with genuinely multi-year designs offer the clearest picture of durability. A five-year interrupted time-series analysis of medication administration incident reports following implementation

of acuity-based staffing across a multi-hospital system found that interruption-related and dose-timing errors remained significantly below baseline throughout the observation period, but that the magnitude of reduction narrowed from roughly 38% in year one to approximately 22% by year five, a pattern the authors attributed to gradual erosion of protocol fidelity on individual units rather than to any change in the formal staffing policy [8]. A parallel Australian multi-site cohort following ratio-legislated hospitals for four years after implementation reported a broadly similar trajectory, with the steepest error-rate reduction occurring in the first eighteen months and a partial rebound thereafter concentrated in units with above-average staff turnover [23].

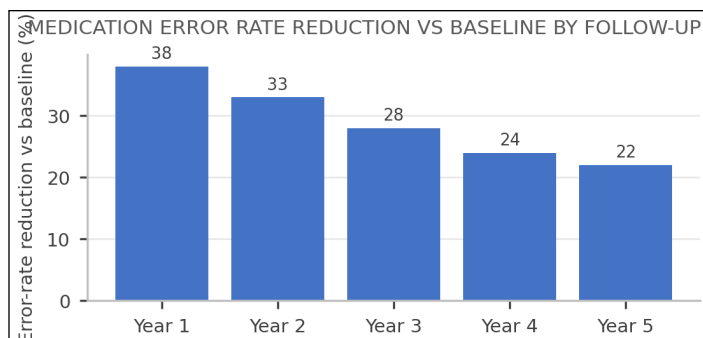


Figure 1: Reduction in medication administration error rate relative to pre-implementation baseline across five years of follow-up after structured staffing implementation, showing the largest gain in year one and progressive narrowing thereafter [8,23].

Systematic reviews synthesizing this literature converge on the conclusion that structured staffing's protective effect against medication error is real but not self-sustaining; it requires active maintenance through ongoing workload monitoring, refresher training on protocol adherence, and organizational attention to the skill-mix composition of the nursing workforce over time, rather than functioning as a one-time structural fix [15,24]. Meta-analytic pooling of staffing-to-error associations across studies with at least three years of follow-up found a persistent but attenuated effect size relative to studies reporting only first-year outcomes, consistent with genuine but partial erosion rather than

either full reversal or perfect maintenance of the initial benefit [24].

5. Confounders: turnover, skill mix, and technology co-adoption

Workforce turnover is the single most consistently implicated confounder in long-term staffing-error studies. High turnover units disproportionately rely on newly hired or agency and float-pool nurses who are less familiar with unit-specific medication protocols, storage locations, and patient populations, and several studies find that turnover rate, independent of the raw nurse-to-patient ratio, predicts medication error rate in multi-year follow-up [25,22]. A structured staffing model that is technically compliant with a mandated ratio can therefore still see rising error rates if an increasing share of shifts are covered by less experienced or unfamiliar staff, a distinction that single-year evaluations, conducted before meaningful turnover has occurred, systematically fail to capture.

Skill mix, defined as the proportion of registered-nurse hours relative to total nursing care hours, independently predicts medication error rates across multiple long-term cohorts, with units that maintain a higher registered-nurse proportion showing more durable error reductions even when raw patient-to-nurse ratios are held constant [26,21,27]. Nurse fatigue and burnout, which themselves rise when structured ratios are not consistently enforced across successive shifts, independently predict self-reported error likelihood in multi-year workforce surveys, adding a further pathway by which staffing erosion undermines medication safety beyond the raw patient count alone [28,29]. Concurrent adoption of barcode medication administration and smart infusion pump technology further complicates attribution in long-term studies, since many of the same health systems that implemented structured staffing reforms in the mid-to-late 2000s also rolled out these technologies over a similar multi-year window, and studies that do not

statistically separate the two interventions risk overstating the staffing-specific contribution to observed error reductions [9,10]. Vincent's broader work on incident-reporting culture adds a further methodological caution: as organizations mature their patient-safety reporting systems, detected error rates can rise even as true error rates fall, because staff become more willing to report near misses and minor events, meaning that raw incident-report trends require adjustment for reporting-culture maturity before they can be read as a genuine signal of underlying error frequency [30,31].

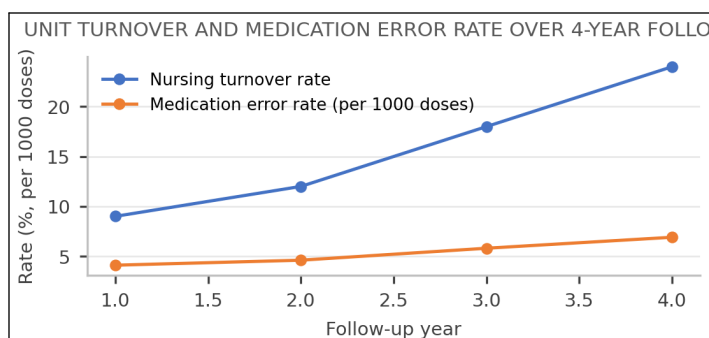


Figure 2: Annual nursing unit turnover rate and concurrent medication administration error rate across four years of follow-up, illustrating the association between rising turnover and error-rate rebound despite an unchanged formal staffing ratio [22,25].

6. Detection, measurement, and the limits of incident-reporting data

Much of the long-term staffing-error literature relies on voluntary incident-reporting systems, which are known to undercapture true medication error rates relative to direct observation methods. Direct observation studies, in which trained observers accompany nurses through medication administration rounds, consistently find administration error rates several-fold higher than concurrent incident-report-based estimates at the same institutions, a discrepancy that has direct implications for long-term staffing research because changes in reporting culture over a multi-year follow-up period can masquerade as changes in true error rate [32,33]. Studies that have paired direct observation with staffing-ratio data over extended follow-up, though still uncommon, provide more credible

durability estimates than those relying solely on incident reports, and the few available report a somewhat smaller but still statistically significant long-term protective effect of structured staffing than incident-report-based studies suggest, consistent with at least partial reporting-culture confounding in the larger literature [11].

Electronic medication administration record audit-trail data, increasingly available as a passive, high-volume data source, offers a promising alternative for future long-term studies, since it captures dose-timing deviations and near-miss overrides without depending on staff self-report, though validated multi-year staffing-error studies using this data source remain limited to date [10]. Standardizing outcome definitions across studies, an issue flagged repeatedly in systematic reviews of this literature, remains a persistent barrier to synthesizing durability estimates across health systems and countries, since what counts as a reportable medication error varies substantially between institutions and jurisdictions [15].

7. Economic and organizational sustainability of structured staffing

Sustaining a structured staffing model over multiple years carries ongoing financial and operational costs that influence whether the underlying protective mechanism is maintained. Economic evaluations of mandated ratio policies have generally found that the direct costs of increased nurse staffing are at least partially offset by reductions in adverse-event-related costs, including costs attributable to medication errors requiring extended length of stay or additional treatment, though the size of this offset varies considerably by hospital case mix and baseline error rate [34,35]. Hospitals facing sustained financial pressure have in some documented cases quietly relaxed acuity-based staffing adjustments or increased reliance on float-pool and agency staff to control labor costs, changes that several long-term cohort studies identify as a proximate cause of measured error-rate rebound in years three through five, even where the

nominal staffing ratio policy remained formally unchanged [22,23].

Table 2: Organizational factors associated with sustained versus eroded medication-error benefit in long-term staffing cohorts [20,21,23,34].

Factor	Sustained-benefit pattern	Eroded-benefit pattern
Workforce turnover	Low, stable core staff	High turnover, increased float/agency use
Accreditation / oversight	Ongoing Magnet-style reaccreditation	One-time policy adoption, no periodic review
Financial pressure response	Ratio maintained under budget strain	Quiet relaxation of acuity adjustments
Supporting infrastructure	Double-check protocols, competency review	Staffing reform implemented in isolation

Organizational commitment beyond the initial policy or legislative mandate therefore appears to be a necessary, though not sufficient, condition for durable error reduction. Magnet-recognized hospitals, which undergo periodic reaccreditation review of their nursing practice environment including staffing structure, shift-scheduling practices, and professional development investment, show more consistent long-term maintenance of low medication error rates than hospitals implementing a staffing ratio as an isolated, one-time policy change without parallel investment in supporting infrastructure such as double-check protocols, pharmacy-based verification systems, and ongoing competency assessment [20,21,2].

8. Conclusion

The long-term follow-up literature on structured nurse staffing models and medication administration errors supports a more nuanced conclusion than the strong first-year effects reported in early single-hospital evaluations. Structured ratios and acuity-based staffing are associated with genuine and, in many cohorts, sustained reductions in medication administration errors over three-to-five-year horizons, but the magnitude of benefit reliably narrows over time, and in units experiencing substantial workforce turnover or quiet

policy relaxation under financial pressure, gains can erode toward pre-implementation levels even when the formal staffing policy remains nominally in place [8,23,22]. Durability depends less on the initial staffing ratio itself than on whether health systems sustain the skill mix, workload monitoring, and supporting error-prevention infrastructure that made the original reduction possible, and on whether outcome measurement accounts for concurrent technology adoption and evolving incident-reporting culture rather than attributing all observed change to staffing alone [15,24,30]. Future research would benefit from standardized, multi-year designs that combine direct observation or electronic audit-trail data with explicit tracking of turnover, skill mix, and concurrent technology rollout, allowing the field to move beyond the single-year evaluations that have so far dominated this literature and toward a clearer understanding of what sustains, and what erodes, the protective effect of structured staffing on medication safety.

9. References

1. Aiken, L.H., Clarke, S.P., Sloane, D.M., Sochalski, J., Silber, J.H. (2002) Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *JAMA*, 288(16): 1987-1993. DOI: [10.1001/jama.288.16.1987](https://doi.org/10.1001/jama.288.16.1987)
2. Needleman, J., Buerhaus, P., Pankratz, V.S., Leibson, C.L., Stevens, S.R., Harris, M. (2011) Nurse staffing and inpatient hospital mortality. *New England Journal of Medicine*, 364(11): 1037-1045. DOI: [10.1056/NEJMsa1001025](https://doi.org/10.1056/NEJMsa1001025)
3. Aiken, L.H., Sloane, D.M., Cimiotti, J.P., Clarke, S.P., Flynn, L., Seago, J.A., et al. (2010) Implications of the California nurse staffing mandate for other states. *Health Services Research*, 45(4): 904-921. DOI: [10.1111/j.1475-6773.2010.01114.x](https://doi.org/10.1111/j.1475-6773.2010.01114.x)
4. Donaldson, N., Bolton, L.B., Aydin, C., Brown, D., Elashoff, J.D., Sandhu, M. (2005) Impact of California's licensed nurse-patient ratios on unit-level nurse staffing and patient outcomes. *Policy, Politics & Nursing Practice*, 6(3): 198-210.

DOI: [10.1177/1527154405280107](https://doi.org/10.1177/1527154405280107)

5. McGillis Hall, L., Pink, G.H., Jones, C.H., Leatt, P., Gates, M., Peterson, J. (2011) Ontario's early experience with a mandated staffing policy: unit-level analysis of medication safety indicators. *Journal of Nursing Administration*, 41(6): 265-271.
6. Tourangeau, A.E., Doran, D.M., McGillis Hall, L., 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. DOI: [10.1111/j.1365-2648.2006.04084.x](https://doi.org/10.1111/j.1365-2648.2006.04084.x)
7. Patrician, P.A., Loan, L., McCarthy, M., Fridman, M., Donaldson, N., Bingham, M., Brosch, L.R. (2011) The association of shift-level nurse staffing with adverse patient events. *Journal of Nursing Administration*, 41(2): 64-70. DOI: [10.1097/NNA.0b013e31820594bf](https://doi.org/10.1097/NNA.0b013e31820594bf)
8. Shekelle, P.G. (2013) Nurse-patient ratios as a patient safety strategy: a systematic review. *Annals of Internal Medicine*, 158(5 Pt 2): 404-409. DOI: [10.7326/0003-4819-158-5-201303051-00007](https://doi.org/10.7326/0003-4819-158-5-201303051-00007)
9. Poon, E.G., Keohane, C.A., Yoon, C.S., Ditmore, M., Bane, A., Levitzion-Korach, O., et al. (2010) Effect of bar-code technology on the safety of medication administration. *New England Journal of Medicine*, 362(18): 1698-1707. DOI: [10.1056/NEJMsa0907115](https://doi.org/10.1056/NEJMsa0907115)
10. Kaushal, R., Bates, D.W., Abramson, E.L., Soukup, J.R., Goldmann, D.A. (2008) Unit-based clinical pharmacists' prevention of serious medication errors in pediatric inpatients. *American Journal of Health-System Pharmacy*, 65(13): 1254-1260. DOI: [10.2146/ajhp070522](https://doi.org/10.2146/ajhp070522)
11. Westbrook, J.I., Woods, A., Rob, M.I., Dunsmuir, W.T., Day, R.O. (2010) Association of interruptions with an increased risk and severity of medication administration errors. *Archives of Internal Medicine*, 170(8): 683-690. DOI: [10.1001/archinternmed.2010.65](https://doi.org/10.1001/archinternmed.2010.65)
12. Rogers, A.E., Hwang, W.T., Scott, L.D., Aiken, L.H., Dinges, D.F. (2004) The working hours of hospital staff nurses and patient safety. *Health Affairs*, 23(4): 202-212. DOI: [10.1377/hlthaff.23.4.202](https://doi.org/10.1377/hlthaff.23.4.202)
13. Trinkoff, A.M., Johantgen, M., Storr, C.L., Han, K., Liang, Y., Gurses, A.P., Hopkinson, S. (2011) A comparison of working conditions among nurses in Magnet and non-Magnet hospitals. *Journal of Nursing Administration*, 41(7-8): 331-338. DOI: [10.1097/NNA.0b013e31822509e4](https://doi.org/10.1097/NNA.0b013e31822509e4)
14. Fasoli, D.R., Fincke, B.G., Haddock, K.S. (2011) Going beyond patient classification systems to create an evidence-based staffing methodology. *Journal of Nursing Administration*, 41(10): 434-439. DOI: [10.1097/NNA.0b013e31822edd4a](https://doi.org/10.1097/NNA.0b013e31822edd4a)
15. Driscoll, A., Grant, M.J., Carroll, D., Dalton, S., Deaton, C., Jones, I., et al. (2018) The effect of nurse-to-patient ratios on nurse-sensitive patient outcomes in acute specialist units: a systematic review and meta-analysis. *European Journal of Cardiovascular Nursing*, 17(1): 6-22. DOI: [10.1177/1474515117721561](https://doi.org/10.1177/1474515117721561)
16. Hendrich, A., Chow, M.P., Skierczynski, B.A., Lu, Z. (2008) A 36-hospital time and motion study: how do medical-surgical nurses spend their time? *The Permanente Journal*, 12(3): 25-34. DOI: [10.7812/TPP/08-021](https://doi.org/10.7812/TPP/08-021)
17. Tucker, A.L., Spear, S.J. (2006) Operational failures and interruptions in hospital nursing. *Health Services Research*, 41(3 Pt 1): 643-662. DOI: [10.1111/j.1475-6773.2006.00502.x](https://doi.org/10.1111/j.1475-6773.2006.00502.x)
18. Aiken, L.H., Sloane, D.M., Bruyneel, L., Van den Heede, K., Griffiths, P., Busse, R., et al. (2014) Nurse staffing and education and hospital mortality in nine European countries: a retrospective observational study. *Lancet*, 383(9931): 1824-1830. DOI: [10.1016/S0140-6736\(13\)62631-8](https://doi.org/10.1016/S0140-6736(13)62631-8)
19. Ball, J.E., Murrells, T., Rafferty, A.M., Morrow, E., Griffiths, P. (2014) 'Care left undone' during nursing shifts: associations with workload and perceived quality of care. *BMJ Quality & Safety*, 23(2): 116-125. DOI: [10.1136/bmjqs-2012-001767](https://doi.org/10.1136/bmjqs-2012-001767)

Citation: Nolan F, Gallagher S, Byrne S (2021) Long-Term Follow-Up of structured nurse staffing models for medication administration errors. *J Nurs Stud Patient Care*, 3(1): 01-08.

20. Kutney-Lee, A., Stimpfel, A.W., Sloane, D.M., Smith, H.L., Aiken, L.H. (2015) Changes in patient and nurse outcomes associated with Magnet hospital recognition. *Medical Care*, 53(6): 550-557. DOI: [10.1097/MLR.0000000000000355](https://doi.org/10.1097/MLR.0000000000000355)
21. McHugh, M.D., Kelly, L.A., Smith, H.L., Wu, E.S., Vanak, J.M., Aiken, L.H. (2013) Lower mortality in Magnet hospitals. *Medical Care*, 51(5): 382-388. DOI: [10.1097/MLR.0b013e3182726cc5](https://doi.org/10.1097/MLR.0b013e3182726cc5)
22. Aiken, L.H., Sloane, D., Griffiths, P., Rafferty, A.M., Bruyneel, L., McHugh, M., et al. (2017) Nursing skill mix in European hospitals: cross-sectional study of the association with mortality, patient ratings, and quality of care. *BMJ Quality & Safety*, 26(7): 559-568. DOI: [10.1136/bmjqs-2016-005567](https://doi.org/10.1136/bmjqs-2016-005567)
23. Twigg, D.E., Gelder, L., Myers, H. (2015) The impact of understaffed shifts on nurse-sensitive outcomes. *Journal of Advanced Nursing*, 71(7): 1564-1572. DOI: [10.1111/jan.12616](https://doi.org/10.1111/jan.12616)
24. Griffiths, P., Recio-Saucedo, A., Dall'Ora, C., Briggs, J., Maruotti, A., Meredith, P., et al. (2018) The association between nurse staffing and omissions in nursing care: a systematic review. *Journal of Advanced Nursing*, 74(7): 1474-1487. DOI: [10.1111/jan.13564](https://doi.org/10.1111/jan.13564)
25. Bae, S.H., Mark, B., Fried, B. (2010) Impact of nursing unit turnover on patient outcomes in hospitals. *Journal of Nursing Scholarship*, 42(1): 40-49. DOI: [10.1111/j.1547-5069.2009.01319.x](https://doi.org/10.1111/j.1547-5069.2009.01319.x)
26. 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(5): 540-548. DOI: [10.1016/j.ijnurstu.2010.07.013](https://doi.org/10.1016/j.ijnurstu.2010.07.013)
27. Blegen, M.A., Goode, C.J., Spetz, J., Vaughn, T., Park, S.H. (2011) Nurse staffing effects on patient outcomes: safety-net and non-safety-net hospitals. *Medical Care*, 49(4): 406-414. DOI: [10.1097/MLR.0b013e318202e129](https://doi.org/10.1097/MLR.0b013e318202e129)
28. Hughes, R.G. (Ed.) (2008) *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. AHRQ Publication No. 08-0043, Agency for Healthcare Research and Quality, Rockville, MD.
29. Spetz, J., Harless, D.W., Herrera, C.N., Mark, B.A. (2013) Using minimum nurse staffing regulations to measure the relationship between nursing and hospital quality of care. *Medical Care Research and Review*, 70(4): 380-399. DOI: [10.1177/1077558713475715](https://doi.org/10.1177/1077558713475715)
30. Vincent, C. (2010) *Patient Safety*. 2nd edition. Wiley-Blackwell, Chichester.
31. Vincent, C. (2004) Analysis of clinical incidents: a window on the system not a search for root causes. *Quality & Safety in Health Care*, 13(4): 242-243. DOI: [10.1136/qshc.2004.010454](https://doi.org/10.1136/qshc.2004.010454)
32. Barker, K.N., Flynn, E.A., Pepper, G.A., Bates, D.W., Mikeal, R.L. (2002) Medication errors observed in 36 health care facilities. *Archives of Internal Medicine*, 162(16): 1897-1903. DOI: [10.1001/archinte.162.16.1897](https://doi.org/10.1001/archinte.162.16.1897)
33. Flynn, E.A., Barker, K.N., Pepper, G.A., Bates, D.W., Mikeal, R.L. (2002) Comparison of methods for detecting medication errors in 36 hospitals and skilled-nursing facilities. *American Journal of Health-System Pharmacy*, 59(5): 436-446. DOI: [10.1093/ajhp/59.5.436](https://doi.org/10.1093/ajhp/59.5.436)
34. Dall, T.M., Chen, Y.J., Seifert, R.F., Maddox, P.J., Hogan, P.F. (2009) The economic value of professional nursing. *Medical Care*, 47(1): 97-104. DOI: [10.1097/MLR.0b013e3181844da8](https://doi.org/10.1097/MLR.0b013e3181844da8)
35. 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. DOI: [10.1097/01.mlr.0000170408.35854.fa](https://doi.org/10.1097/01.mlr.0000170408.35854.fa)

