Collegian 30 (2023) 828–834

Contents lists available at ScienceDirect

Collegian

journal homepage: www.elsevier.com/locate/colegn

Research paper

Nurse–patient ratios and infection control practices: A cross-sectional study

Monika Tencic [a], Michael Anthony Roche [a,b,c,*]

[a] Synergy Nursing and Midwifery Research Unit, University of Canberra & ACT Government Health Directorate, The Canberra Hospital, Yamba Drive, Garran, Australian Capital Territory 2605, Australia
[b] University of Canberra, School of Nursing, Midwifery and Public Health, Faculty of Health, 11 Kirinari Street, Bruce, Australian Capital Territory 2617, Australia
[c] University of Technology Sydney, School of Nursing and Midwifery, Faculty of Health, 235 Jones Street, Ultimo, New South Wales 2007, Australia

ARTICLE INFO

Article history:
Received 13 April 2023
Received in revised form 22 August 2023
Accepted 21 September 2023

Keywords:
Nurse staffing
Infection control practices
Patient safety
Nurse–patient ratios
Nurse workload
Nursing

ABSTRACT

Background: Substantial research evidence supports the link between nurse staffing and patient outcomes. Low nurse staffing and high workloads have been linked to poor hand hygiene, ineffective equipment cleaning, and incorrect use of personal protective equipment (PPE), with potential outcomes of intravenous cannula infections, wound infections, urinary tract infections, and pneumonia. Research is limited regarding the impact of staffing models on specific infection control practices (ICP) such as wound dressing, oral hygiene, or patient education.
Aim: To describe nurses' perceptions of the impact of nurse–patient ratios on ICP.
Methods: A cross-sectional survey using a questionnaire with items drawn from pertinent research was distributed via QR code. Data were collected from 51 nurses on 12 units in a large tertiary referral hospital where a minimum 1:4 patient ratio had been recently introduced. Analysis was comparative and descriptive.
Findings: Most participants were female registered nurses with less than 10 years' experience in nursing. More than half had experienced a 1:4 ratio on their most recent shift. Nurses in this group indicated that they could complete infection control care in a timely manner, were more likely to provide infection control-related patient education, and had more time to communicate with the treating team about infection control matters. Hand hygiene and the use of PPE were not associated with the 1:4 staffing model.
Discussion: ICP included patient education, effective communication, and support appears to be strengthened by ratio staffing. These actions, together with more timely completion of activities such as oral hygiene and wound dressings, may significantly impact hospital-acquired infections and enhance patient safety.
Conclusion: ICP may be strengthened by staffing consistent with the 1:4 ratio framework. This suggests that ratio-based staffing can have an early and important impact on practice. Findings regarding foundational practices, teamwork, and team support warrant further investigation.

* Corresponding author at: School of Nursing, Midwifery and Public Health, University of Canberra, 11 Kirinari Street, Bruce, Australian Capital Territory 2617, Australia.
E-mail address: michael.roche@canberra.edu.au (M.A. Roche).
@michael_a_roche (M.A. Roche)

https://doi.org/10.1016/j.colegn.2023.09.003

Summary of relevance

Problem or Issue

The nurse–patient ratio staffing framework is one of several methods to manage nursing workload, with the potential to positively impact patient safety. Limited research has been conducted into the impact of ratios on specific infection control practices.

What is already known

The link between nursing workload and patient safety is well-established. High nurse workload has been associated with missed infection control practices and healthcare-acquired infections. Approaches such as nurse–patient ratios provide a mechanism to sustain appropriate staffing and to strengthen infection control practices.

What this paper adds

Nurses perceived that nurse–patient ratios improved their ability to undertake infection control practices in a timely manner. The enhanced capacity for patient education has the potential to bolster safety and improve outcomes. However, some foundational infection control practices such as hand hygiene were not impacted, suggesting these are prioritised activities.

Acknowledgements

This research was supported by a Synergy Research Internship through the Office of the Chief Nurse and Midwife, Australian Capital Territory Health Directorate. The authors would like to acknowledge the participation of nurses who voluntarily gave their time to contribute to this study.

1. Introduction

There has been significant research interest regarding nurse staffing models and their relationship to nursing workload and patient safety. High nursing workload has been linked to nurse turnover and nurses leaving the profession (ICN, 2019), made even more pertinent during the COVID-19 pandemic (Weston, 2022). Employee organisations (unions) have championed nurse–patient ratios as a straightforward approach to facilitate safe nurse staffing and encourage retention, leading to their introduction in many health services. Research following implementation of ratios has found positive change in patient and nurse outcomes (McHugh et al., 2021), including outcomes such as wound infections and hospital-acquired sepsis (Mitchell, Gardner, Stone, Hall, & Pogorzelska-Maziarz, 2018; Oner et al., 2021), but is limited regarding specific infection control practices (ICP). This paper reports a study that sought to describe nurses' perceptions of the impact of the introduction of nurse–patient ratio-based staffing on ICP.

2. Background

Substantial research evidence supports the link between nurse staffing, nursing workloads, skill mix, the quality of patient care, and patient outcomes (Duffield, Twigg, Roche, Williams, & Wise, 2019; McHugh et al., 2021; Twigg, Whitehead, Doleman, & El-Zaemey, 2021). While other factors such as skill mix and the practice environment (Duffield, Roche, Wise, & Debono, 2020; Oner et al., 2021) are also important, sufficient nurse staffing and a manageable workload are foundations upon which nurses can undertake timely and quality patient care, coordinate the care team, provide education for patients and families, and identify and address clinical deterioration (McHugh, Aiken, Windsor, Douglas, & Yates, 2020). Lower nurse staffing has been associated with patient adverse outcomes. Foundational research in the United States found that the addition of one more patient per nurse increased 30-day mortality by 7% (Aiken, Clarke, & Sloane, 2002), and low staffing has been linked to a higher rate of nursing tasks delayed or left undone (Ball, Murrells, Rafferty, Morrow, & Griffiths, 2013; Griffiths et al., 2018). Indeed, some nurses report leaving up to one-quarter of necessary work undone on a low-staffed shift (Assaye, Wiechula, Schultz, & Feo, 2022; Ball et al., 2013, 2018). Similar findings have been made in Australia, with high workload linked to missed nursing care and to patient mortality following an adverse event (Duffield et al., 2011).

Regarding ICP, both systematic reviews by Oner et al. (2021) and Mitchell et al. (2018) noted substantial research linking nurse staffing levels to nosocomial infections. Missed nursing care, specifically missed infection control care, has been connected to healthcare-acquired infections such as intravenous cannula infections, wound infections, urinary tract infections, and pneumonia (Blackman, Riklikiene, Gurkova, Willis, & Henderson, 2022; McCauley, Kirwan, & Matthews, 2021). Similarly, critical care nurses identified workload as a primary influence on their ability to comply with hand hygiene and other ICP (Sadule-Rios & Aguilera, 2017). Infection control nurses note low staffing and high workload as key factors in impeding effective ICP (Henderson, Willis, Roderick, Bail, & Brideson, 2020), while Bail et al. (2021) identified multiple points of failure in these activities related to high workload. These included incorrect hand hygiene practices, not cleaning equipment between patients, partial or no use of personal protective equipment (PPE), inability to monitor or audit outcomes at the ward level, and limited access to senior colleagues. Research undertaken during the COVID-19 pandemic, the period in which this study was conducted, found a substantial increase in staffing, education, and training resources devoted to supporting ICP with greater compliance observed (Curryer et al., 2021; Wynter et al., 2022). However, as resources are withdrawn, the maintenance of these practices may be more significantly impacted by workload (Curryer et al., 2021).

The minimum nurse–patient ratio is one of several staffing methods intended to ensure adequate staffing and appropriate workloads, and to thereby enhance care and reduce adverse events (Griffiths et al., 2020; Twigg et al., 2021). A nurse–patient ratio is a minimum number of nurses allocated to a specific number of patients for whom they provide care. The ratio is set using a framework that may be derived from the ward type (e.g., acute medical, long-term rehabilitation) or information obtained from administrative systems that capture patient acuity and turnover (Griffiths et al., 2020; Twigg & Duffield, 2009). This 'volume-based' approach (Griffiths et al., 2020) provides a straightforward regulatory and monitoring framework. However, volume-based approaches have limited sensitivity to variations in the mix of patients and the potential to devalue professional judgment of staffing needs and impact effective allocation to individual nurses (Duffield et al., 2019, 2020; Griffiths et al., 2020). Nonetheless, nurse–patient ratios have been implemented in many jurisdictions, for example, California (Manojlovich, 2009), Victoria (EBA Victoria, 2007), and Queensland (McHugh et al., 2020).

The jurisdiction of this study introduced nurse–patient ratios in a selected group of inpatient wards from early 2022. In accordance with the industrial agreement, these units were to operate with a minimum one-nurse-to-four-patient ratio plus a nurse team leader on morning and evening shifts, and a one-nurse-to-six-patient ratio with no nurse team leader at night. This ratio included a maximum of 25% enrolled nurses.

The purpose of this study was to describe nurses' perceptions of the impact of ratios on ICP, and to compare the impact of ratios between those who did or did not experience staffing according to the prescribed staffing ratio.

3. Method

The study employed a post-implementation descriptive cross-sectional design.

3.1. Settings and participants

The setting was a large tertiary referral hospital in a metropolitan area of Australia. Twelve units where ratio-based staffing had been introduced from February 2022 participated in the study. Four of these were general medical wards, six were general surgical, and two were acute aged care units. Eligible participants were all licensed (registered or enrolled) nurses providing direct patient care, who had worked on the participating units for more than six months. An a priori sample size calculation was not undertaken for this descriptive study, and it is estimated that approximately 300 nurses met the eligibility criteria.

3.2. Procedure

Participation was entirely voluntary and no ward, shift, or individual identifying information was collected. Briefings were held on each unit to describe the aims of the study, eligibility, voluntariness, anonymity of responses, risks of participation, support mechanisms in place, and details of accessing the survey. Potential respondents were provided with a participant information form before commencing the survey, and given the opportunity to ask questions. A flyer with QR code was posted in communal nursing areas to facilitate access. Electronic distribution of the survey link was not possible as the organisation did not maintain an accessible email list. The online survey was administered using Qualtrics© (Qualtrics LLC, Provo, Utah, United States of America) software and was accessible from computers, tablets, or mobile phones. It remained open for a three-month period commencing late August 2022, during which one reminder visit was made to each of the units.

3.3. Instrument

The 45-item questionnaire was specifically developed for this study to collect data from nurses regarding nurse–patient ratios and ICP. It was based on a format previously used in Australia (Duffield, Roche, Dimitrelis, Homer, & Buchan, 2015; Roche, Glover, Luo, Joyce, & Rossiter, 2021), and asked nurses to respond to a set of items on Likert-type scales. Items were drawn from research that explored workload, missed care, and ICP (Bail et al., 2021; Blackman et al., 2022), together with infection control guidelines from two Australian sources (Clinical Excellence Commission, 2020; NHMRC, 2019). A draft set of 28 items was reviewed by a panel of infection control nurse experts with the wording of 12 items amended to clarify their focus, and the addition of seven items regarding teamwork and the work environment, considered by the panel to be pertinent to infection control. The distributed survey included 35 items on ICP. Two initial items asked nurses for their recent experience of ratios: 'what percentage of shifts within the previous two weeks were staffed according to the nurse–patient ratio for your unit?' and 'how many patients were you directly allocated to care for on your most recent shift?'. The remaining items asked respondents to reflect on their ICP since the implementation of nurse–patient ratios, grouped into five sections: five basic infection control actions (e.g., completion of five moments of hand hygiene) rated on frequency of completion (four points, never to always); eight statements on perceived likelihood of completing ICP-related patient education, discharge planning, and emotional support, rated from strongly disagree to strongly agree (five points); 10 statements on perceived timeliness of actions such as routine observations or giving antibiotics (five points, strongly disagree to strongly agree); three items on the capacity to access policies or to recognise deterioration and escalate care (e.g., to call the Medical Emergency Team) if needed (five points, strongly disagree to strongly agree); and seven items on teamwork and support, rated on whether capacity had increased, stayed the same, or decreased. Gender and work experience (years in nursing, in current area, and in present job) were also captured, and three text boxes provided for detailed answers: 'any other ICP that you believe have been influenced by the introduction of ratios', 'any other issues regarding the impact of ratios on ICP', and 'any other information regarding changes to your work following the introduction of nurse–patient ratios'.

3.4. Analysis

Quantitative survey data were analysed descriptively using SPSS© (IBM Corp., Armonk, New York, United States of America) version 27. Responses regarding the number of patients cared for on the most recent shift were categorised into two groups defined by the mandated ratio staffing of 1:4 up to four patients, or more than four patients. Means were calculated for infection control items. Group comparisons were then made using non-parametric tests (Mann–Whitney U), with significance set at $p < .05$. The Benjamini–Hochberg adjustment was made within each group of items to reduce the likelihood of false discovery (Thissen, Steinberg, & Kuang, 2002), and Cohen's d calculated to provide an estimate of effect size. Missing data were ignored listwise. Open-text responses were grouped into descriptive topic areas.

3.5. Ethics

The study was approved by the Australian Capital Territory Health Human Research Ethics Committee (2022/ETH01281). Participants were provided with full information via the ward briefings and participant information form, as described above. Data were collected anonymously with no individual, shift, or ward data. Data were stored on an encrypted secure server with access only to the researchers, archived for five years in accordance with university policy. The funding organisation, The Office of the Chief Nurse and Midwife, Australian Capital Territory Health Directorate, reviewed the final draft of the manuscript.

4. Findings

The raw return rate was estimated at 20.3% (61 surveys returned from a potential of approximately 300 nurses working on the selected wards). After exclusion of three largely incomplete surveys, a total of 58 surveys remained (19.3% complete return rate). Of these 58 surveys, several had up to 5% unanswered questions (excluding open text), while no individual item had more than 10% missing data. Thirteen surveys included substantive responses to open-text questions. The key comparator variable (number of patients cared for on the most recent shift) was responded to by only 51 participants. In order to ensure consistency between sample description and comparisons, all reporting below includes these 51 cases only.

Nine nurses (17.3%) were male, 38 (73.1%) female, three (5.8%) non-binary, and two (3.8%) preferred to not say (Table 1). Most were registered nurses (n = 45, 84.9%) with eight (15.1%) enrolled nurses. Average experience in nursing was less than a decade (M = 9.5, SD = 7.5), less in the current organisation (M = 6.6, SD = 5.3), and in the current job (M = 5.9, SD = 6.0). More than half of respondents (n = 39, 63.9%) had cared for four or fewer patients on their most recent shift, thereby meeting the 1:4 ratio requirements, with 22 indicating they had cared for five or more. A similar proportion (n = 36, 62.1%) reported most (> 60%) of their shifts over the preceding two weeks were staffed according to the ratio framework.

Table 1
Sample description.

	N (%)
Gender	
Male	9 (17.6%)
Female	36 (70.6%)
Non-binary/third gender	3 (5.9%)
Prefer not to say	3 (5.9%)
Grade	
RN	43 (84.3%)
EN	8 (15.7%)
Percentage of recent shifts staffed at 1:4 ratio	
> 80%	19 (37.3%)
61–80%	12 (23.5%)
41–60%	11 (21.6%)
≤40%	9 (17.6%)
	Mean (SD)
Years of nursing	9 (7.26)
Years of current area	6.3 (5.15)
Years of present job	5.8 (6.02)
Number of patients cared for the most recent shift	4.6 (1.85)

RN: registered nurses; EN: enrolled nurses.

Regarding fundamental ICP (Table 2), there were no *adjusted* statistically significant differences between comparison groups. Those who were allocated four or fewer patients scored more highly on all items, particularly regarding the five moments of hand hygiene, for which the *unadjusted* p-value indicated statistical significance (*unadjusted* $p = 0.02$).

In contrast to fundamental ICP, items referring to infection control-related education, patient support, assessment, and documentation (Table 3), showed significant differences and large effect sizes. Key items reflecting the perceived impact of ratios related to infection control-related education: about good hygiene practice ($p \leq 0.01$, $d = 0.8$), about why patients are in infectious precaution environments ($p \leq 0.01$, $d = 1.0$), and about infectious or multiple-resistant organism status ($p \leq 0.01$, $d = 1.2$), while nurses' capacity to assess skin integrity was also significantly improved ($p \leq 0.01$, $d = 0.9$). There were also differences regarding the provision of emotional support and comfort to patients in infectious precaution rooms ($p = 0.03$, $d = 0.7$) and the capacity to document in accordance with policy ($p = 0.02$, $d = 0.7$), albeit with slightly smaller effect sizes.

Items more directly linked to workload showed a similar pattern (Table 4) to those for education, support, and assessment above. Large effect sizes were observed regarding timely completion of routine observations ($p \leq 0.01$, $d = 1.0$) and oral hygiene ($p \leq 0.01$, $d = 0.9$). Respondents also indicated they were moderately more likely to complete activities of daily living ($p = 0.03$, $d = 0.6$), procedures or invasive care ($p = 0.03$, $d = 0.6$), aseptic technique ($p = 0.03$, $d = 0.6$), or wound dressings ($p = 0.03$, $d = 0.6$).

There was only one significant difference regarding policy and processes (Table 5), with more time available to communicate effectively with the treating team about infection control ($p \leq 0.01$, $d = 1.1$).

There were no statistically significant differences among the team and support items (Table 6), although all but one of the items had higher mean values in the ratio-based staffing group. Items regarding working as an effective nursing team, collaboration with colleagues, and availability of senior staff to discuss patient care were all higher in this group. In contrast, nurses reported increases in the amount of overtime required, the number of interruptions to their work, and healthcare-acquired infections. Support for nurses with a heavy workload was higher for those allocated more than four patients.

As indicated previously, the open-text responses were limited in number and detail. However, they were consistently phrased and amenable to grouping as represented in Fig. 1. Nurses indicated that ratio-based staffing provided them with a greater capacity to comply with infection precautions related to COVID-19, for example, spending more time to support a patient's understanding of PPE and contact precautions. Factors other than ratio-based staffing believed to influence ICP were limited availability of PPE, and COVID-19 procedures that impeded early intervention in infection control and the ability to effectively escalate care when deterioration was detected. Comments on the general impact of ratios were also provided. These suggested that, in order to maintain the 1:4 ratio, there had been an increase in junior staff, with consequent support and

Table 2
Fundamental infection control practices.

	≤4	> 4	Mann–Whitney *U*	p	adj. p[a]	d[b]
Complete the 5 moments of hand hygiene	3.6	3.1	288	0.02	0.14	0.6
Ensure your PPE is worn correctly	3.4	3.3	371	0.63	0.74	0.1
Clean equipment after use/between patients	2.9	2.7	338	0.23	0.32	0.3
Dispose of infectious waste correctly	3.5	3.4	390.5	0.88	0.88	0.1
Setup infectious status rooms	3	2.6	306.5	0.09	0.26	0.5
Call the cleaning staff to address unclean areas	2.9	2.7	315	0.16	0.28	0.3
Obtain pathology results pertaining to infectious status	2.8	2.4	287	0.11	0.26	0.5

Note: mean of scale 1–4 (never to always).
PPE: personal protective equipment.
[a] Benjamini–Hochberg adjustment.
[b] Cohen's d effect size.

Table 3
Education, support, and assessment.

	≤4	> 4	Mann–Whitney *U*	p	adj. p[a]	d[b]
More likely to educate my patients about good hygiene practices	4.1	3.3	189.0	0.00	0.00	0.8
More likely to provide education about why patients are in infectious precautions	4.4	3.5	175.5	0.00	0.00	1.0
More likely to educate patients about MRO status/infectious status	4.2	3.3	157.0	0.00	0.00	1.2
More likely to do early discharge planning for patients	3.5	3.1	313.0	0.32	0.32	0.4
Can provide emotional support and comfort to patients in infectious precaution rooms each shift	3.4	2.6	237.0	0.02	0.03	0.7
Can assess my patients' skin integrity each shift	3.9	3.1	214.5	0.00	0.00	0.9
Can assess my patients' attachments each shift	3.8	3.3	265.0	0.07	0.08	0.5
Have time to document my nursing care in accordance with policy	3.8	3.1	230.5	0.01	0.02	0.7

Note: mean of scale 1–5 (strongly disagree to strongly agree); MRO, Multi-resistant organisms; ADL, Activities of daily living.
[a] Benjamini–Hochberg adjustment.
[b] Cohen's d effect size.

Table 4
Feeling rushed and timeliness of care.

	≤4	> 4	Mann–Whitney *U*	p	adj. p[a]	d[b]
Can complete ADLs for my patients without feeling rushed	3.4	2.6	243.0	0.02	0.03	0.6
Can complete procedures/invasive tasks without feeling rushed	3.4	2.7	248.0	0.02	0.03	0.6
Can practice aseptic technique without feeling rushed	3.7	3.0	245.5	0.02	0.03	0.6
Can complete IV cannulation without feeling rushed	3.1	2.6	265.5	0.05	0.06	0.5
Can complete wound dressings without feeling rushed	3.5	2.8	240.0	0.02	0.03	0.6
Can complete routine observations in a timely manner	4.1	3.1	210.5	0.00	0.00	1.0
Can complete oral hygiene for patients in a timely manner	3.7	2.7	198.0	0.00	0.00	0.9
Can change I/V lines or fluids in a timely manner	4.0	3.5	274.5	0.05	0.06	0.5
Can give antibiotics in a timely manner	4.1	3.7	296.0	0.15	0.15	0.4
Can take pathology/specimens/blood in a timely manner	3.6	3.0	268.5	0.06	0.07	0.6

Note: mean of scale 1–5 (strongly disagree to strongly agree).
[a] Benjamini–Hochberg adjustment.
[b] Cohen's d effect size.

Table 5
Policy and processes.

	≤4	> 4	Mann–Whitney *U*	p	adj. p[a]	d[b]
More likely to look up infection control policies or protocols when I am not sure of something	3.8	3.2	259.5	0.06	0.09	0.6
More likely to escalate patient observations when necessary	4.3	3.9	269.5	0.09	0.09	0.4
More time to communicate effectively with the treating team about infection control matters	4.1	3.1	174.0	0.00	0.00	1.1

Note: mean of scale 1–5 (strongly disagree to strongly agree).
[a] Benjamini–Hochberg adjustment.
[b] Cohen's d effect size.

Table 6
Team and support.

	≤4	> 4	Mann–Whitney *U*	p	adj. p[a]	d[b]
Capacity to work as an effective nursing team	2.4	2.1	247.5	0.13	0.26	0.4
Availability of senior nursing colleagues to discuss patient care	2.2	1.8	249.5	0.15	0.26	0.5
Amount of overtime required	2.3	2.1	286.0	0.46	0.46	0.2
Opportunities for collaboration with colleagues	2.3	2.0	233.5	0.09	0.26	0.5
The number of interruptions each day	2.1	1.8	265.5	0.33	0.39	0.4
The number of healthcare-acquired infections	2.1	1.8	234.5	0.14	0.26	0.4
Support for nursing team members who have a heavy workload	2.0	2.3	245.5	0.22	0.31	-0.4

Note: mean of scale 1–3 (decreased–same–increased).
[a] Benjamini–Hochberg adjustment.
[b] Cohen's d effect size.

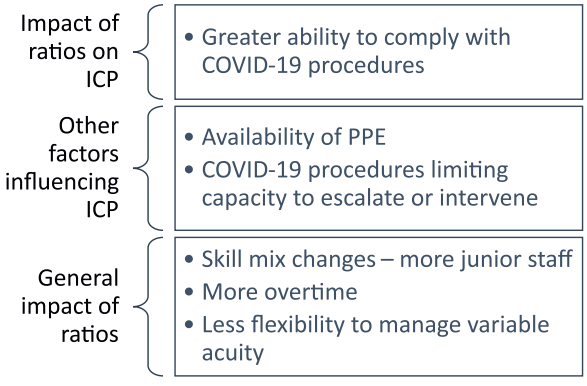

Fig. 1. Summary of open-text responses.

training requirements for more experienced nurses. Other comments indicated that the ratio framework did not provide sufficient flexibility to increase staffing to a higher level when patient acuity required it, so that workload increased regardless of 1:4 staffing. Also, consistent with the survey item in Table 6, comments noted an increase in overtime required.

5. Discussion

This study aimed to explore whether nurse–patient ratio-based staffing influences nurses' self-reported capacity to undertake ICP. It sought to examine a specific implementation of ratios to build evidence on the details of which ICP activities are most impacted, building on the studies and reviews that have demonstrated the relationship between improved staffing and hospital-acquired infections (Cimiotti, Aiken, Sloane, & Wu, 2012; Mitchell et al., 2018). Findings indicate that when ratios were met, nurses ranked their capacity higher for many activities, particularly regarding patient education and timely completion of nursing care. This accords with the literature generally, and specifically with research that indicates that workload and time pressures lead to missed or delayed care (Assaye et al., 2022; Ball et al., 2013, 2018).

Patient education, communication, and support were three key areas where nurses indicated greater capacity to undertake ICP practices. These activities are consistent with person-centred individualised care (Spanakis, Patelarou, & Patelarou, 2020) but may be de-emphasised in busy nursing environments when workload is high. Indeed, the missed care literature indicates that comforting or talking to patients, educating patients, and updating care plans, are often delayed or left undone when workload increases (Bail et al.,

2021; Ball et al., 2013). Particularly in light of the current climate of misinformation exacerbated by the COVID-19 pandemic (Sallam et al., 2020), the support and educational aspects of the nursing role have become even more important. The capacity to spend time with patients to educate effectively and to ensure understanding has the potential to enhance patient safety in both the hospital setting and the community at large.

The additional time afforded by ratio-based staffing was also reflected in nurses' reports of improved timeliness of specific infection control care. These included using aseptic technique, checking patients' skin each shift, oral hygiene, and wound dressings. Timely completion of nursing care and having adequate time to complete care without feeling rushed may therefore conceivably contribute to lower rates of hospital-acquired infections, such as hospital-acquired pneumonia, central line-associated bloodstream infections, and wound infections.

Further detail is required here, as noted by Mitchell et al. (2018) in their systematic review of 54 papers that examined healthcare-associated infections. That is, there is growing evidence of a relationship between staffing and infections, there is considerable variation in the association between nurse staffing and specific infection outcomes. For example, Cimiotti et al. (2012) report that both urinary tract and wound infections are influenced by workload, with the addition of one additional patient per nurse associated with an increase in both of these adverse outcomes. However, they did not identify any relationship between staffing and pneumonia or sepsis. This last finding contrasts with other research (Flanagan, Read, & Shindul-Rothschild, 2020) that found a significant relationship between sepsis and both nursing and medical staffing. This is indicative of the variability in definitions and study design described by Mitchell et al. (2018), and emphasises the need for follow-up studies to explore staffing, specific ICP, and specific outcomes.

In addition, in this study, other activities also expected to be impacted by the introduction of ratios, such as fundamental ICP practices, accessing policy or procedure information, and team support, were not impacted. Regarding these aspects of ICP where no change was observed, it could be suggested that nurses were well-practiced and prioritised actions such as hand hygiene and the use of PPE. This may be a consequence of the COVID-19 pandemic, but the data do not shed any light on this. Interestingly, although not statistically significant, nurses who had a higher patient load than that prescribed by ratios felt more supported than those with a lower number. While the data do not provide an indication as to why this may be the case, one suggestion is that this is reflective of nurses supporting each other through adversity. This is consistent with the collegial support provided to nurses by their nursing colleagues when facing high workload, high patient acuity, or staff turnover, described by Oshodi et al. (2019). Another, related possibility is that the actions of the nurse manager, for example, asking senior staff such as educators or managers to work clinically, demonstrate support. The support of the nursing team and the nurse manager have been identified as significant influences on nurses' perceptions of the environment in which they work (Oshodi et al., 2019). Additionally, as this study took place during the COVID-19 pandemic with the associated impact on workload and staffing, it is feasible that teams were accustomed to 'pull together' to sustain themselves and the quality of nursing care. Indeed, Fernandez et al. (2020) found that professional collegiality is heightened during pandemics, and, during the COVID-19 pandemic, Phillips, Alipio, Hoskins, and Cohen (2023) identified supportive collegial relationships in her phenomenological study of nurses in North America. Finally, the open-text comments suggesting ratios were linked to increased junior staffing and limited flexibility in patient allocation are consistent with other Australian studies (Duffield et al., 2020; Verrall et al., 2015) and warrant further exploration.

5.1. Limitations

The limitations include the small sample size, unequal group sizes for comparisons, response bias, and recollection bias. The sample was impacted by the context in which the study was conducted. This included ongoing COVID-19 restrictions and procedures, related staff shortages, and the pending implementation of a digital health record with associated training requirements that took nurses away from their work for periods of up to two hours and may have distracted from the request to complete a survey. Survey completions did increase after reminder visits and additional visits may have elicited more responses, although this must be balanced against the potential disruption of nurses' activities. Infection control requirements may have varied across the wards, and this may have influenced the findings although the impact of this heterogeneity is unknown. In addition to ward type, shift data were not collected and shift comparisons were therefore not made. The survey depended on participants' recollection of changes related to ratios, an approach acknowledged to be subject to bias. However, resources were not available to adopt a different study design such as longitudinal before and after data collection, and alternative approaches such as retrospective file or data audits would not have addressed the aims. Due to resource constraints, it was not possible to gain access to a comparable group of wards where ratios had not been implemented, so that nurses' views of ICP in non-ratio contexts were not available. Finally, it is important to note that the study design and group comparisons do not imply causation, and that generalisation of the findings presented here should be undertaken with caution.

6. Conclusion

This descriptive study is one of the few internationally, and very few in Australia, to examine the impact of ratio-based staffing. While limited in size and location, it has identified an overall positive impact, and provides insights to the potential impact of ratios on specific nursing practices around infection control. The findings are generally consistent with previous work with some noteworthy findings regarding foundational practices, teamwork, and team support. Future research should expand the sample size, seek to compare with non-ratio-based units, and incorporate additional measures of teamwork and the practice environment. Observational techniques and the potential explanatory power of a mixed-methods approach may illuminate the mechanisms at work, while longitudinal studies will provide information on the sustained impact of ratios in this important domain.

Authorship contribution statement

Monika Tencic: Conceptualization, Methodology, Data collection and curation, Writing – original draft, Writing – review & editing, Project administration. **Michael Anthony Roche:** Conceptualization, Methodology, Data collection and curation, Formal analysis, Writing – original draft, Supervision, Writing – review & editing. Both authors have given final approval of the version to be published and agree to be accountable for all aspects of the work.

Funding

This research was supported by a Synergy Research Internship through the Office of the Chief Nurse and Midwife, Australian Capital Territory Health Directorate.

Ethical statement

This paper reports human research. The authors confirm that the ACT Health Human Research Ethics Committee (Low Risk Sub-Committee) granted approval for this study (2022.LRE.00115), 27 July 2022.

Conflict of interest

This research was supported by a Synergy Research Internship through the Office of the Chief Nurse and Midwife, Australian Capital Territory Health Directorate. The Office of the Chief Nurse and Midwife reviewed the final draft of this paper and made minor typographical changes. The authors declare no conflict of interest.

References

Aiken, L. H., Clarke, S. P., & Sloane, D. M. (2002). Hospital staffing, organization, and quality of care: cross-national findings. *Nurse Outlook, 50*, 187–194. https://doi.org/10.1067/mno.2002.126696

Assaye, A. M., Wiechula, R., Schultz, T. J., & Feo, R. (2022). Missed nursing care, nurse staffing levels and patient safety outcomes in low-income country acute care settings: an observational study. *International Journal of Nursing Practice, 28*, Article e13031. . https://doi.org/10.1111/ijn.13031

Bail, K., Willis, E., Henderson, J., Blackman, I., Verrall, C., & Roderick, A. (2021). Missed infection control care and healthcare associated infections: a qualitative study. *Collegian, 28*, 393–399. https://doi.org/10.1016/j.colegn.2020.11.007

Ball, J. E., Bruyneel, L., Aiken, L. H., Sermeus, W., Sloane, D. M., Rafferty, A. M., et al. (2018). Post-operative mortality, missed care and nurse staffing in nine countries: a cross-sectional study. *International Journal of Nursing Studies, 78*, 10–15. https://doi.org/10.1016/j.ijnurstu.2017.08.004

Ball, J. E., Murrells, T., Rafferty, A. M., Morrow, E., & Griffiths, P. (2013). Care left undone'during nursing shifts: associations with workload and perceived quality of care. *BMJ Quality & Safety, 23*, 116–125. https://doi.org/10.1136/bmjqs-2012-001767

Blackman, I., Riklikiene, O., Gurkova, E., Willis, E., & Henderson, J. (2022). Predictors of missed infection control care: a tri-partite international study. *Journal of Advanced Nursing, 78*, 414–424. https://doi.org/10.1111/jan.14976

Cimiotti, J. P., Aiken, L. H., Sloane, D. M., & Wu, E. S. (2012). Nurse staffing, burnout, and health care–associated infection. *American Journal of Infection Control, 40*, 486–490. https://doi.org/10.1016/j.ajic.2012.02.029

Clinical Excellence Commission. (2020). *Infection prevention and control practice handbook*. Sydney: Clinical Excellence Commission⟨https://www.cec.health.nsw.gov.au/__data/assets/pdf_file/0010/383239/IPC-Practice-Handbook-2020.PDF⟩.

Curryer, C., Russo, P. L., Kiernan, M., Wares, K. D., Smith, K., & Mitchell, B. G. (2021). Environmental hygiene, knowledge and cleaning practice: a phenomenological study of nurses and midwives during COVID-19. *American Journal of Infection Control, 49*, 1123–1128. https://doi.org/10.1016/j.ajic.2021.04.080

Duffield, C., Diers, D., O'Brien-Pallas, L. L., Aisbett, C., Roche, M. A., King, M., et al. (2011). Nursing staffing, nursing workload, the work environment and patient outcomes. *Applied Nursing Research, 24*, 244–255. https://doi.org/10.1016/j.apnr.2009.12.004

Duffield, C., Roche, M. A., Dimitrelis, S., Homer, C., & Buchan, J. (2015). Instability in patient and nurse characteristics, unit complexity, and patient and system outcomes. *Journal of Advanced Nursing, 71*, 1288–1298. https://doi.org/10.1111/jan.12597

Duffield, C., Roche, M. A., Wise, S., & Debono, D. (2020). Harnessing ward level administrative data and expert knowledge to improve staffing decisions: a multi-method case study. *Journal of Advanced Nursing, 76*, 287–296. https://doi.org/10.1111/jan.14207

Duffield, C., Twigg, D., Roche, M. A., Williams, A., & Wise, S. (2019). Uncovering the disconnect between nursing workforce policy intentions, implementation, and outcomes: lessons learned from the addition of a nursing assistant role. *Policy, Politics, & Nursing Practice, 20*, 228–238. https://doi.org/10.1177/1527154419877571

EBA Victoria (2007). *Nurses (Victorian Public Health Sector): Multiple business agreement 2007–2011*. (Agreement ID: AG8040794-2).

Fernandez, R., Lord, H., Halcomb, E., Moxham, L., Middleton, R., Alananzeh, I., et al. (2020). Implications for COVID-19: a systematic review of nurses' experiences of working in acute care hospital settings during a respiratory pandemic. *International Journal of Nursing Studies, 111*, Article 103637. . https://doi.org/10.1016/j.ijnurstu.2020.103637

Flanagan, J. M., Read, C., & Shindul-Rothschild, J. (2020). Factors associated with the rate of sepsis after surgery. *Critical Care Nurse, 40*, e1–e9. https://doi.org/10.4037/ccn2020171

Griffiths, P., Maruotti, A., Saucedo, A. R., Redfern, O. C., Ball, J. E., Briggs, J., et al. (2018). Nurse staffing, nursing assistants and hospital mortality: retrospective longitudinal cohort study. *BMJ Quality & Safety, 28*, 609–617. https://doi.org/10.1136/bmjqs-2018-008043

Griffiths, P., Saville, C., Ball, J., Jones, J., Pattison, N., & Monks, T. (2020). Nursing workload, nurse staffing methodologies and tools: a systematic scoping review and discussion. *International Journal of Nursing Studies, 103*, Article 103487. . https://doi.org/10.1016/j.ijnurstu.2019.103487

Henderson, J., Willis, E., Roderick, A., Bail, K., & Brideson, G. (2020). Why do nurses miss infection control activities? A qualitative study. *Collegian, 27*, 11–17. https://doi.org/10.1016/j.colegn.2019.05.004

ICN (2019). *ICN International Workforce Forum Calls for Urgent Action from Governments to Address Global Nursing Shortage*. ⟨https://www.icn.ch/news/icn-international-workforce-forum-calls-urgent-action-governments-address-global-nursing⟩.

Manojlovich, M. (2009). Seeking staffing solutions. *American Nurse Today, 4*, 1–2. https://www.myamericannurse.com/seeking-staffing-solutions/.

McCauley, L., Kirwan, M., & Matthews, A. (2021). The factors contributing to missed care and non-compliance in infection prevention and control practices of nurses: a scoping review. *International Journal of Nursing Studies Advances, 3*, Article 100039. . https://doi.org/10.1016/j.ijnsa.2021.100039

McHugh, M. D., Aiken, L. H., Sloane, D. M., Windsor, C., Douglas, C., & Yates, P. (2021). Effects of nurse-to-patient ratio legislation on nurse staffing and patient mortality, readmissions, and length of stay: a prospective study in a panel of hospitals. *The Lancet, 397*, 1905–1913. https://doi.org/10.1016/S0140-6736(21)00768-6

McHugh, M. D., Aiken, L. H., Windsor, C., Douglas, C., & Yates, P. (2020). Case for hospital nurse-to-patient ratio legislation in Queensland, Australia, hospitals: an observational study. *BMJ Open, 10*, Article e036264. . https://doi.org/10.1136/bmjopen-2019-036264

Mitchell, B. G., Gardner, A., Stone, P. W., Hall, L., & Pogorzelska-Maziarz, M. (2018). Hospital staffing and health care–associated infections: a systematic review of the literature. *The Joint Commission Journal on Quality and Patient Safety, 44*, 613–622. https://doi.org/10.1016/j.jcjq.2018.02.002

NHMRC (2019). *Australian guidelines for the prevention and control of infection in healthcare.* Canberra: National Health and Medical Research Council⟨https://www.safetyandquality.gov.au/sites/default/files/2022-09/australian_guidelines_for_the_prevention_and_control_of_infection_in_health_care_-_current_version_-_v11.13_19_september_2022.pdf⟩.

Oner, B., Zengul, F. D., Oner, N., Ivankova, N. V., Karadag, A., & Patrician, P. A. (2021). Nursing-sensitive indicators for nursing care: a systematic review (1997–2017). *Nursing open, 8*, 1005–1022. https://doi.org/10.1002/nop2.654

Oshodi, T. O., Bruneau, B., Crockett, R., Kinchington, F., Nayar, S., & West, E. (2019). The nursing work environment and quality of care: content analysis of comments made by registered nurses responding to the Essentials of Magnetism II scale. *Nursing Open, 6*, 878–888. https://doi.org/10.1002/nop2.268

Phillips, J., Alipio, J. K., Hoskins, J. L., & Cohen, M. Z. (2023). The experience of frontline nurses during the COVID-19 pandemic: a phenomenological study. *Western Journal of Nursing Research, 45*, 327–334. https://doi.org/10.1177/01939459221129944

Roche, M. A., Glover, S., Luo, X., Joyce, M., & Rossiter, C. (2021). Extending the role of nursing assistants in mental health inpatient settings: a multi-method study. *International Journal of Mental Health Nursing, 30*, 1070–1079. https://doi.org/10.1111/inm.12859

Sadule-Rios, N., & Aguilera, G. (2017). Nurses' perceptions of reasons for persistent low rates in hand hygiene compliance. *Intensive and Critical Care Nursing, 42*, 17–21. https://doi.org/10.1016/j.iccn.2017.02.005

Sallam, M., Dababseh, D., Yaseen, A., Al-Haidar, A., Taim, D., Eid, H., et al. (2020). COVID-19 misinformation: mere harmless delusions or much more? A knowledge and attitude cross-sectional study among the general public residing in Jordan. *PLoS One, 15*, Article e0243264. . https://doi.org/10.1371/journal.pone.0243264

Spanakis, M., Patelarou, A. E., & Patelarou, E. (2020). Nursing personnel in the era of personalized healthcare in clinical practice. *Journal of Personalized Medicine, 10*, Article 56. . https://doi.org/10.3390/jpm10030056

Thissen, D., Steinberg, L., & Kuang, D. (2002). Quick and easy implementation of the Benjamini-Hochberg procedure for controlling the false positive rate in multiple comparisons. *Journal of Educational and Behavioral Statistics, 27*, 77–83. https://doi.org/10.3102/10769986027001077

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*, 132–140. https://doi.org/10.1016/j.ijnurstu.2008.08.005

Twigg, D., Whitehead, L., Doleman, G., & El-Zaemey, S. (2021). The impact of nurse staffing methodologies on nurse and patient outcomes: a systematic review. *Journal of Advanced Nursing, 77*, 4599–4611. https://doi.org/10.1111/jan.14909

Verrall, C., Abery, E., Harvey, C., Henderson, J., Willis, E., Hamilton, P., et al. (2015). Nurses and midwives perceptions of missed nursing care — a South Australian study. *Collegian, 22*, 413–420. https://doi.org/10.1016/j.colegn.2014.09.001

Weston, M. J. (2022). Strategic planning for a very different nursing workforce. *Nurse Leader, 20*, 152–160. https://doi.org/10.1016/j.mnl.2021.12.021

Wynter, K., Holton, S., Considine, J., Hutchinson, A. M., Munt, R., Williams, R., et al. (2022). The impact of the COVID-19 pandemic on Australian hospital-based nursing and midwifery educators. *Collegian, 29*, 271–280. https://doi.org/10.1016/j.colegn.2021.10.007