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REVIEW

Fatigue in nurses and medication administration errors: A scoping review

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Abstract

Background: Medication administration errors (MAEs) cause preventable patient harm and cost billions of dollars from already-strained healthcare budgets. An emerging factor contributing to these errors is nurse fatigue. Given medication administration is the most frequent clinical task nurses undertake; it is vital to understand how fatigue impacts MAEs.

Objective: Examine the evidence on the effect of fatigue on MAEs and near misses by registered nurses working in hospital settings.

Method: Arksey and O'Malley's scoping review framework was used to guide this review and PAGER framework for data extraction and analysis. The PRISMA checklist was completed. Four electronic databases were searched: CINAHL, PubMed, Scopus and PsycINFO. Eligibility criteria included primary peer review papers published in English Language with no date/time limiters applied. The search was completed in August 2021 and focussed on articles that included: (a) registered nurses in hospital settings, (b) MAEs, (c) measures of sleep, hours of work, or fatigue.

Results: Thirty-eight studies were included in the review. 82% of the studies identified fatigue to be a contributing factor in MAEs and near misses (NMs). Fatigue is associated with reduced cognitive performance and lack of attention and vigilance. It is associated with poor nursing performance and decreased patient safety. Components of shift work, such as disruption to the circadian rhythm and overtime work, were identified as contributing factors. However, there was marked heterogeneity in strategies for measuring fatigue within the included studies.

Relevance to clinical practice: Fatigue is a multidimensional concept that has the capacity to impact nurses' performance when engaged in medication administration. Nurses are susceptible to fatigue due to work characteristics such as nightwork, overtime and the requirement to perform cognitively demanding tasks. The mixed results found within this review indicate that larger scale studies are needed with particular emphasis on the impact of overtime work. Policy around safe working hours need to

be re-evaluated and fatigue management systems put in place to ensure delivery of safe and quality patient care.

KEYWORDS
fatigue, medication administration errors, near misses, nurse, shift work, sleep, sleep deprivation, sleep disorders

1 | INTRODUCTION

Patient safety is a global healthcare concern (The Health Foundation, 2013; World Health Organisation [WHO], 2004). One of the most frequent causes of preventable patient morbidity and mortality in hospitals is medication administration errors (MAEs) (Adams & Koch, 2010; Cousins et al., 2011). The term MAE typically refers to any preventable event (e.g. calculation errors, labelling errors) that causes inappropriate medication use for a patient (Billstein-Leber et al., 2018). The consequences of MAEs can be catastrophic to patients, causing illness, injury and death (Mayo & Duncan, 2004). MAEs may also increase the length of a patient's hospital stay and exhaust valuable healthcare resources unnecessarily (WHO, 2017a). The WHO recognises MAEs as the leading global cause of healthcare acquired injury, costing USD$42 billion annually (WHO, 2017b). In Australia, the cost of MAEs in 2017 was estimated to be AU$1.2 billion (Australian Commission on Safety and Quality in Health Care, 2017).

Whilst evidence suggests there are many contributing factors to MAEs, fatigue in registered nurses (RN) has been identified as an emerging contributor (Keers et al., 2013; Parry et al., 2014; Schroers et al., 2021). Many RNs perform shift work in hospital settings across 24-h rotating rosters to meet patient needs. Shift work often involves working long, irregular and extended hours (Harrington, 2001). There is a significant body of evidence indicating that RNs who work these rotating shift patterns experience fatigue (Smith-Miller et al., 2014; Steege et al., 2015). Fatigue is associated with reduced cognitive performance, lack of attention and vigilance (Goel et al., 2009) and is known to be associated with poor nursing performance and decreased patient safety (Cho & Steege, 2021). Whilst there is research linking fatigue to impaired performance (Al-Mugheed et al., 2022), the extent to which fatigue contributes to MAEs and near misses (NMs) is unclear.

Globally there is a shortage of RNs, which is placing significant strain on healthcare systems (WHO, 2020). This shortage has put pressure on RNs to work longer and/or work additional shifts (International Council of Nurses [ICN], 2021) and has been exacerbated by the COVID-19 pandemic (ICN, 2020; Maben & Bridges, 2020). The International Council of Nurses (2021) state that nearly 90% of national nurses' associations globally report being somewhat or extremely concerned about insufficient staffing levels, burnout and stress because of the pandemic which, in turn, is causing RNs to leave the profession early (ICN, 2020; Maben & Bridges, 2020). Fewer RNs in the workforce will inevitably put further strain on those remaining, with increasing expectations to cover staffing short falls, thereby increasing workload and fatigue (Lopez et al., 2022). Given nurses spend a significant proportion of their time administering medications, it is important to gain an understanding of the effects of RN fatigue on MAEs.

What does this paper contribute to the wider global clinical community?

- Fatigue may contribute to medication administration errors as a result of circadian disruption, extended hours of work and sleep restriction.
- There is inconsistency in the evidence linking fatigue with medication administration errors.
- There is marked heterogeneity in how fatigue is measured within healthcare literature.

2 | METHODS

A scoping review was undertaken to examine the extent, nature and range of available literature on the effects of RN fatigue on MAEs. Scoping reviews are becoming increasingly popular for providing a rigorous and transparent method of synthesising evidence (Levac et al., 2010). Scoping reviews have been found to be particularly useful when the topic is complex or heterogeneous in nature as with MAEs (Mays et al., 2001). The framework set out by Arksey and O'Malley (2005) was used to guide this scoping review. This framework involves six steps which guide researchers to identify themes to collate and summarise results (Arksey & O'Malley, 2005). Refer to Table 1. This review was not registered. The PRISMA 2020 checklist was completed to ensure all critical components were included in this review (Page et al., 2021).

The Population/Intervention/Comparison/Outcome (PICO) framework was used to formulate the review question 'What is the impact of RN fatigue on the incidence of MAEs and NMs?' Refer to Table 2.

Four electronic databases were searched, including: CINAHL, PubMed, Scopus and PsycINFO. Relevant MESH terms and keywords were used to ensure all relevant inclusions were identified. The Boolean operators 'AND'/'OR' was applied between search terms. The following keywords were used:

> nurs* AND hospital* OR 'acute care facilit* OR health care facilit* OR healthcare facilit* AND fatigue* OR sleep OR "sleep deprivation" OR "shift work" OR overtime

TABLE 1 Arksey and O'Malley (2005) scoping review framework

Framework stage		Framework as applied to scoping review
Step 1	Identify the research question—The researcher is guided to develop a research question which is broad enough to allow for identification of the relevant literature for inclusion in the study.	'What is the impact of RN fatigue on the incidence of MEs and NMs?'
Step 2	Identify relevant studies—This involves the identification of where to search and the terms to be used in order to identify the relevant studies which will aid in answering the research question	• four database searches • key words and MESH terms used as applicable • searches saved • librarian consulted • forwards and backwards citation tracking • grey literature searched
Step 3	Study selection—This involves similar steps to a systematic review; however, there is greater flexibility with inclusion and exclusion criteria. Search terms may be refined as the researcher becomes more familiar with the data.	• Level 1 screening of title and abstract • Level 2 screening of full text article against inclusion–exclusion criteria as detailed in Table 3 (p.7) • Reasons for exclusion of studies recorded and presented in Figure 1 (p.9)
Step 4	'Charting' the data—reflects the data extraction phase of a systematic review, whilst has a broader approach. Employs a narrative descriptive-analytical framework method, yet does not attempt to apply 'value' to the methodological quality of evidence gleaned	Develop a data extraction table with: • author • publication year • country • speciality • method • definition of MAE, • measure of fatigue used, • participants • key findings See Appendix A (p.46)
Step 5	Collating, summarising and reporting the results—using a framework approach	See Section 4.5 (p.10)
Step 6	Consultation—This stage is optional; however, incorporation adds to methodological rigour	During the consultation phase of this review, the researcher consulted with the supervisors of the proposed study. Their participation provided assistance in the identifying, charting, collating and reporting stages of the review

TABLE 2 PICO protocol for review question

PICO protocol	Review question components
Population	Registered nurse
Intervention	Fatigued
Comparison	Not fatigued
Outcome	Medication administration error or near miss* *Near misses can provide valuable evidence on the root causes of errors.

OR tired* AND medication error* OR "drug error*" OR "medication administration error' OR "near miss"

Included study's reference lists were then hand searched to ensure all relevant studies were included. All searches were undertaken in August 2021.

2.1 | Inclusion/exclusion criteria

The search had no date/time limiters applied with the search completed in August 2021. Language was limited to availability in English. Table 3 presents the inclusion/exclusion criteria applied.

2.2 | Screening process

A total of 310 studies were identified after duplicates were removed. Identified studies were uploaded onto RAYYAN (Ouzzani et al., 2016), an internet-based software program that allows collaboration with reviewers during the screening process. A blinded screening of the title and abstract was completed (level one) by four reviewers (TB, AS, TF, and MS). Any conflicts arising through the independent screening process were resolved by consensus. Studies that were included at level one (n = 131) then progressed to full text screening (level two). Based on level two screening, 38 studies were included in the review. The reasons for exclusion are detailed in Figure 1.

TABLE 3 Inclusion/exclusion criteria

Inclusion criteria	Exclusion criteria
Population includes RNs	Data reports on healthcare professionals as a whole and does not report on RN data separately
Setting is a hospital or acute care facility (short-term hospital that has facilities, medical staff and all necessary personal to provide diagnosis, care and treatment of a wide range of acute conditions, including injuries).	Data on hospitals or acute care facilities are not clearly reported
Reports on rates of MAEs on NMs	Focus is on adverse events in general without clearly separated data on MAEs or NMs
Includes a measure of sleep OR details of hours worked OR use of a fatigue measurement tool	Focus is on the reporting of MAEs or NMs by RNs to supervisors and/or as part of incident management systems
	Full text not available
	Not in English

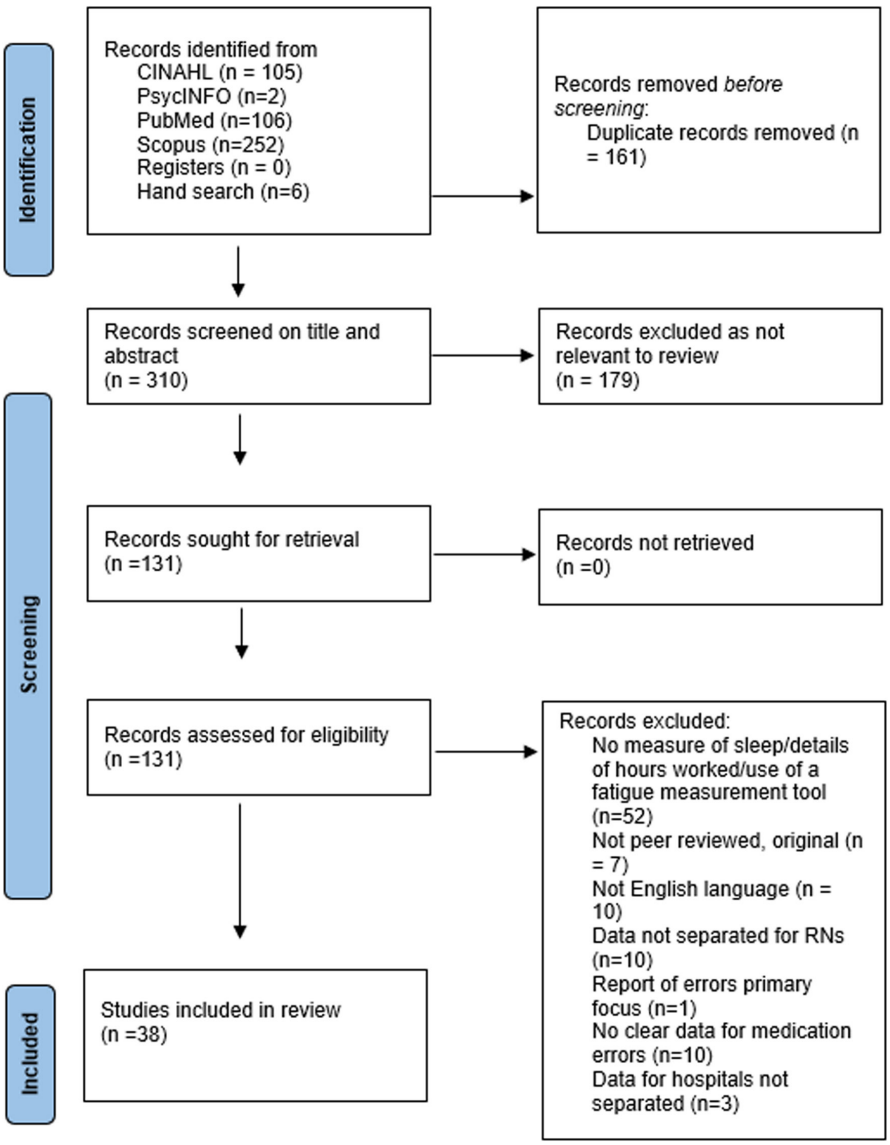

FIGURE 1 From 'The PRISMA 2020 statement: An updated guideline for reporting systematic reviews,' by M.J. Page et al., *BMJ*, 372: pp.71 [Colour figure can be viewed at wileyonlinelibrary.com]

Data extracted from the 38 studies included: (a) demographics of study (authors, year of publication, location, study design), (b) definition of MAEs, (c) population characteristics (sample size, ward/unit where RNs work) (d) data collection tools used for fatigue, hours of work and measure of sleep (e) data collection tools used for MAEs and NMs (f) main findings. Refer to Table 4. Data were then organised and presented as descriptive and narrative synthesis. The PAGER (Patterns, Advances, Gaps, Evidence for practice

and Research recommendations) framework was used to help in the analysis and reporting of the key messages from the review (Refer to Table 5) (Bradbury-Jones et al., 2022).

3 | RESULTS

3.1 | Characteristics of included studies

Of the 38 studies, 33 reported quantitative data, three reported qualitative data and two included both quantitative and qualitative components. Tools used to collect quantitative data included once off questionnaires ($n = 29$), retrospective data ($n = 3$), observation ($n = 1$) and logbook ($n = 1$). Multiple studies were conducted in Iran ($n = 11$), USA ($n = 9$), Japan ($n = 3$), Canada ($n = 2$) and Finland ($n = 2$). Single studies were completed in Australia, Egypt, UK, Nigeria, Taiwan, Turkey, Iraq, Korea, Malaysia, Italy and Jordan. Sample sizes for qualitative studies ranged from 18 (Sessions et al., 2019) to 41 participants (Groves et al., 2020) and for quantitative 12 (Zadeh et al., 2014) to 11, 516 participants (OIds & Clarke, 2010).

3.2 | Definition of MAE

Of the included studies, 11 gave a definition of MAEs (refer to Table 6) (Ali et al., 2020; Baghaei et al., 2015; Fathi et al., 2017; Hassan et al., 2009; Jassim & Ebrahim, 2020; Karadeniz & Cakmakci, 2002; Mayo & Duncan, 2004; Oshikoya et al., 2013; Saleh et al., 2014; Sessions et al., 2019; Zarea et al., 2018). In these 11 studies, a total of seven different definitions were given with one article explicitly providing a doctor's definition and a nurse's definition (Oshikoya et al., 2013). Five studies (Ali et al., 2020; Baghaei et al., 2015; Fathi et al., 2017; Hassan et al., 2009; Jassim & Ebrahim, 2020) used the definition from the National Coordinating Council for Medication Error Reporting and Prevention (2021). Table 6 provides details of the definitions used.

Heterogeneity was found in the ways that fatigue was measured. Twelve studies used a measure of prior sleep (sleep in the last 24 or 48 h), such as a sleep record or self-reported sleep. Hours of work, such as length of shift or hours worked per week, were reported by eight studies (Ali et al., 2020; Campbell et al., 2021; Jassim & Ebrahim, 2020; Kiymaz & Koç, 2018; Oshikoya et al., 2013; Roseman & Booker, 1995; Westley et al., 2020; Wilkins & Shields, 2008). A measure of fatigue was used by 26 studies; of these 15 relied on self-reporting of fatigue levels. More than one measure was used in 11 of the studies. See Tables 7–9 for further details.

3.3 | Fatigue and MAEs

Fatigue was found to be a contributing factor in MAEs and NMs in 31 of the included studies, including in populations of RNs working in emergency service units (Ehsani et al., 2013; Kiymaz & Koç, 2018;), paediatric units (Murphy & While, 2012), oncology units (Saleh et al., 2014) and medical units (Rafat et al., 2015). There were mixed results on the association of fatigue; however, nine of the 31 studies found that fatigue was the most important contributor to MAEs. One of these nine studies was a mixed methods study (Baghaei et al., 2015), with the remainder using quantitative methodologies (Gorgich et al., 2016; Hassan et al., 2009; Fathi et al., 2017; Jassim & Ebrahim, 2020; Karadeniz & Cakmakci, 2002; Piroozi et al., 2019; Shohani & Tavan, 2018; Zarea et al., 2018). All the eight quantitative studies report fatigue as being the most important contributing factor in MAEs based on RNs recall of MAE incidents and rating of the factors they believed contributed to the errors. Furthermore, self-reported measures of fatigue were used in each of these studies. Conversely, seven studies found that fatigue did not contribute to MAEs and NMs (Aghaei et al., 2020; Asaoka et al., 2012; Bolandianbafghi et al., 2017; Campbell et al., 2021; Groves et al., 2020; Hong et al., 2021; Seki & Yamazaki, 2006). Of these studies, one was qualitative (Groves et al., 2020), and only one of the remaining seven quantitative studies (Aghaei et al., 2020) relied on self-reported fatigue. Asaoka et al. (2012) found that RNs with excessive daytime sleepiness did not report a significantly different number of MAEs ($\chi^2 = 2.79$, n.s). Similarly, Bolandianbafghi et al. (2017) found that fatigue measured with a validated fatigue measurement tool (Cronbach's alpha 0.92) was not significantly associated with MAEs ($p = 0.711$). In addition, hours of work were found to not be significantly associated with MAEs by Campbell et al. (2021) ($p = 0.4707$). This study by Campbell et al. (2021) used historical data on hours of work and barcode medication administration systems removing any necessity for RNs to recall events. Findings from Campbell's study are supported by Hong et al. (2021) who reported that RNs working 12-h shifts experienced less chronic fatigue ($p = 0.018$), but there was no significant correlation with MAE rates ($p = 0.146$). The study by Seki and Yamazaki (2006) found that NMs were significantly more frequent on day shifts when perceived level of fatigue were lower (OR = 0.976, 95% CI: 1.490–42.883). Seki and Yamazaki (2006) asked the RN participants to measure their fatigue levels using a visual analogue scale (Philip et al., 2003), immediately before work and near misses were recorded at the end of shift, thus minimising the risk of recall bias. They also reported that on evening shifts NMs occur significantly more frequently when prior sleep duration was longer (OR-1.241, 95% CI: 1.049–1.470).

From the findings of the review, two main themes were identified as being potential factors in RNs fatigue and the incidence of MAEs: (i) shift work and the effect on sleep cycle and (ii) the RNs hours of work.

3.3.1 | Shift schedules

Working rotating shifts is a common aspect of RNs work. This pattern of work generally requires RNs to start and finish work at different times of the day, work at night and have short breaks between shifts (Westley et al., 2020). Rotating shifts can lead to

TABLE 4 Distribution of studies

Authors + year	Country	Hospital ward area	Method	Definition of MAE	Measure of sleep	Details of hours worked	Fatigue measurement tool	Sample (nurses)	Main findings
Aghaei et al. (2020)	Iran	No details	Quantitative	No	No	No	Yes	211	Fatigue ranked lowest of variables on safety performance (mean 2.43 ± 1.14)
Ali et al. (2020)	Jordan	No details	Qualitative	Yes	No	Yes	No	24	Nurses who have a second job or are studying are noted by colleagues to be tired and more error prone
Asaoka et al. (2012)	Japan	No details	Quantitative	No	Yes	Yes	Yes	1202	Nurses reporting difficulties sleeping or excessive daytime sleepiness did not report a significantly different number of MAEs ($\chi = 2.79$, n.s)
Baghaei et al. (2015)	Iran	Variety of ward areas	Mixed methods	Yes	No	No	Yes	102	Self-reported fatigue rated as the most common cause of MAE
Bolandianbafghi et al. (2017)	Iran	Variety of ward areas	Quantitative	No	No	No	Yes	170	Fatigue not significantly associated with MAEs ($p = 0.711$)
Campbell et al. (2021)	USA	Medical-surgical unit	Quantitative	No	No	Yes	No	23	Hours of work not significantly associated with MAEs ($p = 0.4707$)
Deans (2005)	Australia	Surgical, medical and palliative care	Quantitative	No	Yes	No	Yes	154	Self-reported fatigue/lack of sleep reported by 16.5% ($n = 13$) of nurses as being a cause of MAEs
Di Simone et al. (2020)	Italy	No details	Quantitative	No	No	No	Yes	446	Risk of MAEs was correlated with poor quality sleep ($p = <0.01$)
Ehsani et al. (2013)	Iran	Emergency department	Quantitative	No	No	No	Yes	94	19% ($n = 9$) of nurses self-reported fatigue as affecting the incidence of MAEs
Fathi et al. (2017)	Iran	No details	Quantitative	Yes	No	Yes	Yes	500	Fatigue caused by excessive work hours (mean 3.94 ± 1.02) and type of shift work (mean 3.74 ± 1.05) rated as the two main causes of MAEs
Gold et al. (1992)	USA	No details	Quantitative	No	Yes	No	No	687	Nurses working rotating shifts reported less and poorer quality sleep. Working rotating shift significantly associated with MAEs (OR 1.83, 95% CI: 1.86–3.91) and NMs (OR 1.93, 95% CI: 0.99–3.74). Working at night significantly associated with NMs (OR 2.10, 95% CI: 0.95–4.68)
Gorgich et al. 2016	Iran	Internal, surgical, emergency department, gynaecology, ICU, paediatarics	Quantitative	No	No	No	Yes	327	Self-reported fatigue most common cause of MAEs reported by 97.8% ($n = 320$) of nurses.
Groves et al. (2020)	USA	Inpatient and critical care units	Qualitative	No	Yes	Yes	Yes	41	No differences found in fatigue management amongst nurses involved in MAEs and those not

TABLE 4 (Continued)

Authors + year	Country	Hospital ward area	Method	Definition of MAE	Measure of sleep	Details of hours worked	Fatigue measurement tool	Sample (nurses)	Main findings
Harkanen et al. (2017)	Finland	No details	Mixed methods	No	Yes	No	Yes	1012	Nurse was tired reported as contributing to MAE ($n = 9$). Night shift reported ($n = 11$)
Hassan et al. (2009)	Malaysia	Surgical and medical wards ($n = 5$)	Quantitative	Yes	No	No	Yes	92	Self-reported tiredness and exhaustion reported by 73% ($n = 68$) of nurses as causing MAEs.
Hong et al. (2021)	South Korea	General wards ($n = 38$), ICU ($n = 11$)	Quantitative	No	No	No	Yes	227	Nurse working 12-hour shifts experienced less chronic fatigue ($p = 0.018$), but there was no significant difference in MAEs between 8 h and 12 h shifts ($p = 0.146$) and NMs ($p = 0.437$)
Jassima & Ebrahim (2020)	Iraq	Various departments	Quantitative	Yes	No	Yes	Yes	100	Self-reported tiredness ranked as the highest nurse related factor by 56%. Errors mostly occurring at night reported by 44%
Karadeniz & Cakmakc (2002)	Turkey	Internal medicine and surgery	Quantitative	Yes	No	No	Yes	27	Self-reported tiredness and exhaustion reported by 33% ($n = 14$) of nurses. Main cause reported by nurses
Kiymaz & Koç (2018)	Turkey	Emergency service units ($n = 18$)	Quantitative	No	No	Yes	No	284	Fatigue/exhaustion/burnout reported by 75% ($n = 86$). Long duration of work reported by 48% ($n = 55$). Excessive number of monthly shifts reported by 46% ($n = 53$).
Liu et al. (2012)	Taiwan	No details	Quantitative	No	Yes	No	No	1358	Overtime work positively associated with NMs ($p = 0.00$) but not MAEs ($p = 0.659$)
Mayo and Duncan (2004)	USA	No details	Quantitative	Yes	No	No	Yes	983	MAEs occur when nurses are tired and exhausted ranked third as a cause (mean 4.30 ± 2.82)
Murphy & White (2012)	UK	Paediatric hospital	Quantitative	No	Yes	No	Yes	140	Fatigue/lack of sleep reported by 61% or nurses as causing MAEs.
Olds and Clarke (2010)	USA	Various	Quantitative	No	No	Yes	No	11,516	Working >40 hours/week and voluntary overtime significantly positively related to MAEs ($p < 0.01$)
Oshikoya et al. (2013)	Nigeria	Paediatric services	Quantitative	Yes	No	Yes	No	50	Working long hours reported by two nurses (4%) as being a risk factor in MAE
Piroozi et al. (2019)	Kurdistan	No detail	Quantitative	No	Yes	Yes	No	503	MAE positively correlated with having a second job ($p = 0.003$), number of night shifts ($p = 0.001$). Long and unconventional shifts listed at the main causes by nurses (mean 3.89 ± 1.28)
Rafat et al. (2015)	Iran	No detail	Quantitative	No	No	No	Yes	100	Tired and exhausted listed as 6th ranked cause of MAEs out of 10 options (mean 5.48 ± 3.16)

(Continues)

TABLE 4 (Continued)

Authors + year	Country	Hospital ward area	Method	Definition of MAE	Measure of sleep	Details of hours worked	Fatigue measurement tool	Sample (nurses)	Main findings
Sears et al. (2013)	Canada	Paediatric	Quantitative	No	No	Yes	Yes	372 reports	Descriptive statistics identified rationale for the occurrence of paediatric MAEs 1–5 fatigue 1.81, OT 1.29 ($p = 0.083$)
Roseman and Booker (1995)	USA	No detail	Quantitative	No	No	Yes	No	Not given	Overtime negatively associated with MAEs in permanent staff ($p < 0.05$, $t = -2.96$)
Seki and Yamazaki (2006)	Japan	Nephrology, cardiovascular medicine, neurosurgery & haematology	Quantitative	No	Yes	No	Yes	88	NMs studied. NMs significantly more frequent on day shifts when perceived level of fatigue is lower (OR = 0.976, 95% CI: 1.490–42.883). On evening shift, NMs occur significantly more frequently when sleep duration was longer (OR-1.241, 95% CI: 1.049–1.470). No differences on night shifts
Sessions et al., (2019)	USA	CCU, ICU, telemetry, ED, oncology, medical & surgical	Qualitative	No	No	No	Yes	18	Nurses report fatigue and loss of focus as a barrier to safe administration of HAMs
Shahrokhi et al. (2013)	Iran	No details	Quantitative	Yes	No	Yes	Yes	150	Tiredness due to excessive OT reported by 62% (n-94) of nurses as a factor in MAEs. Night shift reported as a factor by 22% ($n = 33$).
Shohani and Tavan (2018)	Iran	No details	Quantitative	No	No	No	Yes	128	Fatigue reported as high importance by 58% ($n = 70$) of nurses. Highest ranked.
Suzuki et al.	Japan	No details	Quantitative	No	Yes	No	No	4279	Statistically significant association between excessive daytime sleepiness and MAEs ($p = <0.0001$)
Saleh et al. (2014)	Egypt	Oncology	Quantitative	No	Yes	No	Yes	52	Significant negative correlation between hours of sleep and MAEs. Frequency of MAEs ^ during irregular shift work and irregular night work
Westley et al. (2020)	USA	No details	Quantitative	No	No	Yes	No	5372	Nurses who worked extended hours (>60 h/7 days) reported significantly more near miss alerts ($p < 0.001$)
Wilkins and Shields (2008)	Canada	No details	Quantitative	No	No	Yes	No	4379	MAEs significantly related to 'usually working overtime' (OR 1.4, 95% CI: 1.0–1.8). 12-h shifts significantly lower rate of MAEs (OR 0.7, 95% CI: 0.5–0.9). No relationship between working >40 h/week (OR 1.0) and shifts other than days found (OR 1.0).
Zadeh et al. (2014)	USA	Acute nursing unit	Quantitative	No	No	No	Yes	12	Working in an environment with windows significantly reduced sleepiness ($p = 0.023$), but this did not significantly affect MAEs ($p = 0.14$)
Zarea et al. (2018)	Iran	No details	Quantitative	No	No	No	Yes	225	Fatigue reported by 40% ($n = 91$) of nurses as being a factor in MAEs, highest ranking cause.

TABLE 5 PAGER framework

Pattern	Advances	Gaps	Evidence for practice	Research recommendations
RN fatigue has an effect on the incidence of MAEs and NMs	There is some evidence that RNs and nurse managers acknowledge that fatigue has a consequence for patient safety and should be addressed	Inconsistent evidence on how impactful fatigue is in the incidence of MAEs and NMs	Policy and procedures should be put in place to manage RN fatigue. RNs should be given the information and skills to recognise when their practice is affected by fatigue	The use of subjective and validated objective methods of measuring fatigue are required. Fatigue levels can then be correlated with the incidence of MAEs and NMs
Shift work impacts the incidence of MAEs and NMs	Globally the use of 12-h shifts has become popular. There is some evidence that their use reduces fatigue in RNs as they allow RNs more time to recover from shift work	Recall is often used in reporting of fatigue levels and the incidence of MAEs and NMs. This may affect the validity of findings	Roster development should allow for adequate rest and recovery between shifts	The use of subjective and validated objective methods of measuring fatigue are required. Fatigue levels can then be correlated with the incidence of MAEs and NMs
Time of day impacts the incidence of MAEs and NMs	Quality and amount of prior sleep is known to be a predeterminant of fatigue	Inconsistent evidence of the effect of time of day on the incidence of MAEs and NMs	Medication should be prescribed with the effect of time of day on MAEs in mind. Medications at night should be avoided where possible. Roster development should be mindful of the number of night shifts allocated per month	The use of subjective and validate objective methods of measuring fatigue are required. Fatigue levels can then be correlated with the incidence of MAEs and NMs. To carry out quantitative research measuring fatigue levels with validated tools through shifts to identify when high levels of fatigue are experienced and how this affects MAEs and NMs
Hours of work impacts the incidence of MAEs and NMs	The use of 12-h shifts has been questioned as long working days may increase RN fatigue. Unplanned overtime has been reported as being the greatest risk.	Inconsistent evidence on the impact of 8- and 12-h shifts and overtime work on MAEs. Fatigue is implied in some studies, due to long working hours.	Unplanned overtime should be avoided. Where this is not possible RNs should not undertake medication administration. Maximum hours of work should be mandated.	To carry out quantitative research measuring fatigue levels with validated tools through shifts to identify when high levels of fatigue are experienced and how this affects MAEs and NMs

TABLE 6 Definitions of MAEs used

Reference	Definition	Studies using
National Coordinating Council for Medication Error Reporting and Prevention, (2021)	A medication errors is an event which is preventable. The error may cause medication to be used in an appropriate manner or cause patient harm whilst a healthcare professional, patient or consumer is in control of said medication	Ali et al., (2020); Baghaei et al., (2015); Fathi et al., (2017); Hassan et al., (2009); Jassima & Ebrahim, (2020)
Cesur, (1988); Becker et al., (1978); Osbourne et al., (1999)	A medication error is defined as (i) incorrect drug dose administered, (ii) drug administered to the wrong patient, (iii) drug administered at the wrong time, (iv) duplicate doses being administered to the same patient, (v) wrong drug administered, (vi) drug not administered, (vii) drug administered without an order	Karadeniz and Cakmakci (2002)
Mayo & Duncan, (2004)	A deviation from the order of a physician	Mayo & Duncan, (2004)
(i) Headford et al., (2001) (ii) Wolf, (1989)	(i) MAE defined by medical doctors as any medication dose which deviates from a physician's medication order which is written in the patient's chart. (ii) Nurses define MAEs as mistakes which are associated with both medication and intravenous solutions which occur during any of the phases of medication preparation and distribution; prescribing, transcribing, dispensing and administration	Oshikoya et al., (2013)
PSNet Patient Safety Network, (2017)	A medication error occurs when process which are put in place to protect patients are not followed. They can occur anytime from when the medication is ordered until the medication is given to the patient. Medication error may and may not result in harm to the patient	Sessions et al., (2019)
Zhang et al. (2002)	A medication error occurs when the method of care chosen by the healthcare provider is inappropriate or when the correct method of care has been chosen but it is not executed correctly	Saleh et al., (2013)
Zarea et al., (2018)	A medication errors is an avoidable event which may lead to medicines being used in an inappropriate was and can cause adverse events for the patient	Zarea et al., (2018)

desynchronisation of RNs internal circadian clock relative to their sleep–wake pattern, making it difficult to obtain sufficient sleep between shifts (Asaoka et al., 2012; Zadeh et al., 2014). Furthermore, short breaks between shifts may restrict the opportunity for sleep, resulting in the nurses feeling fatigued (Deans, 2005; Di Simone et al., 2020; Suzuki et al., 2005). One study found that MAEs increased frequency when RNs worked irregular shifts with additional unplanned overtime (Saleh et al., 2014). The Saleh study concluded that irregular sleep patterns were a result of RNs working rotating shifts with additional overtime work significantly contributing to MAEs ($p = 0.000$). Similarly, Asaoka et al. (2012) found that symptoms of fatigue, which were subjectively relevant to their shift work schedule, were experienced by 24.4% of participants ($n = 242$). The RNs with fatigue symptoms were significantly more likely to report a NM and MAE compared to those without symptoms ($p < .001$). However, there was no significant difference in the reporting of actual MAEs between the RNs with fatigue symptoms and those without ($\chi^2 = 2.79$, n.s).

Registered nurses have reported that the time of day they work their shift is a contributing factor to their physical and mental fatigue, with the most fatigue reported during night shifts (Groves et al., 2020; Piroozi et al., 2019; Saleh et al., 2014; Shohani & Tavan, 2018). The number of night shifts RNs' worked in the past month was positively correlated with the number of MAEs and NMs they are involved in (Piroozi et al., 2019). Quality and duration of sleep when working night shifts was significantly poorer as compared with day shifts (Gold

TABLE 7 Measure of sleep used

Study	Measure of sleep
Asaoka et al. (2012)	Questionnaire as part of nurses' sleep health project
Deans, (2005)	Self-reported 'lack of sleep'
Di Simone et al., (2020)	Pittsburgh sleep Quality Index–Italian version (Curcio et al., 2012)
Gold et al., (1992)	Self-reported wake and sleep times for 1 week and quality of sleep
Groves et al. (2020)	SSI question asking about sleep habits
Harkanen et al. (2017)	Retrospective incident reports with free text descriptions of contributing factors to MAE
Liu et al. (2012)	Validated logbook (Cronbach's alpha 0.96)
Murphy & White (2012)	Self-reported 'lack of sleep'
Piroozi et al. (2019)	Self-constructed questionnaire (Cronbach's alpha 0.81)
Seki and Yamazaki, (2006)	Unvalidated self-constructed questionnaire
Suzuki et al., (2005)	Pittsburgh sleep Quality Index–Japanese version (Doi et al., 1998)
Saleh et al., (2014)	American Academy of Sleep Medicine 2-week sleep diary

TABLE 8 Measure of details of work used

Study	Details of work measure
Ali et al. (2020)	Self-reported second jobs or study commitments
Asaoka et al. (2012)	Questionnaire as part of nurses' sleep health project
Campbell et al. (2021)	Retrospective hospital records of hours worked in previous 7 days
Fathi et al. (2017)	Self-constructed questionnaire (Cronbach's alpha 0.81)
Groves et al. (2020)	SSI question asking about typical workday
Jassima & Ebrahim (2020)	Unvalidated questionnaire
Kiymaz & Koç (2018)	Unvalidated questionnaire
Olds and Clarke (2010)	Self-reported hours of work and overtime in the past year
Oshikoya et al. (2013)	Unvalidated questionnaire
Piroozi et al. (2019)	Self-constructed questionnaire (Cronbach's alpha 0.81)
Sears et al. (2013)	The paediatric medication administration error survey tool
Roseman and Booker (1995)	Retrospective hospital records of overtime worked in previous month
Shahrokhi et al. (2013)	Self-constructed questionnaire (Cronbach's alpha 0.86)
Westley et al. (2020)	Retrospective hospital records of hours worked in previous 7 days
Wilkins and Shields (2008)	National Survey of the Work and Health of Nurses, Canada

et al., 1992), impacting both RN recovery and their ability to carry out their duties safely on subsequent shifts (Piroozi et al., 2019). A link between misalignment of circadian phase when working at night and/or rotating shifts and increased error rate on performance tasks was found in several studies (Asaoka et al., 2012; Piroozi et al., 2019; Shohani & Tavan, 2018). However, these studies relied on RNs recall of MAEs or NMs, some for as long as the past 12 months. In contrast, a study undertaken in Japan found that no significant difference in the occurrence of NMs between shift types (i.e. day, afternoon and night shifts) (Seki & Yamazaki, 2006). Seki and Yamazaki (2006) used objectives measures of fatigue, and the RNs were asked about the occurrence of NMs daily, thus reducing recall bias. Wilkins and Shields (2008) also reported that time of shift had no correlation to MAEs with RNs recall on the occurrence of MAEs being used.

3.3.2 | Shift length

Six studies in this review reported RNs working long hours as being a factor impacting MAEs (Fathi et al., 2017; Kiymaz & Koç, 2018; Lui et al., 2012; Olds & Clarke, 2010; Piroozi et al., 2019; Sears et al., 2013). Piroozi et al. (2019) reported it as being the most important cause of MAEs to their respondents (n = 366). Piroozi et al.'s (2019) study asked RNs to rate 10 statements regarding the causes of MAEs using a visual analogue scale. A score of one indicated the RN believed fatigue had little to no importance to MAEs and a score of five as strong importance. Long and unconventional shifts scored a mean of 3.89 ± 1.28, though no definition was given for unconventional shifts. Similarly, in a Turkey, long working hours was thought to be a reason for MAE by 72% (n = 36) of RNs (Kiymaz & Koç, 2018). Again, these RNs were given a list of causes and asked to pick those that they thought had contributed to MAEs they had made. Conversely, a Canadian study with a sample of 18, 676 RNs found that those who worked 12-h shifts reported the likelihood of a self-recalled MAE in the past 12 months as significantly less than those working eight-hour shifts (Wilkins & Shields, 2008). The shifts worked in this study were planned 12-hour shifts, and the RNs were not working overtime. Additionally, Campbell et al. (2021) found that the number of additional 2-h time periods worked during a one-week timeframe did not statistically predict the occurrence of a NMs (p = 0.7001). A study of 252 RNs in South Korea found no significant statistical difference in MAE rates between those working 12-h shifts and those working 8-h shifts (Hong et al., 2021). These 12-h shifts were planned and did not involve the RNs working any overtime. The Hong et al. (2021) study used a validated tool to measure fatigue levels in RNs, finding the rates of chronic fatigue were lower for those working 12-h than those working 8 h, with no statistical difference in acute fatigue levels. Whilst we found mixed results on the associations of shift length with MAEs, all the studies mentioning hours of work stated working long hours or overtime as predictive of high levels of fatigue. Despite this, fatigue levels were not actually subjectively or objectively measured.

3.3.3 | Overtime work

Overtime work was also associated with MAEs. A study by Liu et al. (2012) found a strong association between RNs working overtime and NMs (p = 0.00). This study used a logbook to record hours of work and NMs over a period of 3 months. Similarly, a linear trend was found by Olds and Clarke (2010) between voluntary overtime and MAEs. Regular overtime was linked to a 30% increased risk of

TABLE 9 Measure of fatigue used

Study	Measure of fatigue
Aghaei et al. (2020)	Occupational safety climate questionnaire (Zarei et al., 2016)
Asaoka et al. (2012)	Questionnaire as part of nurses' sleep health project
Baghaei et al. (2015)	Self-constructed questionnaire (Cronbach's alpha 0.78)
Bolandianbafghi et al. (2017)	Herzberg's job satisfaction and fatigue questionnaire (Herzberg, 1966)
Deans (2005)	Self-reported 'fatigue'
Ehsani et al., (2013)	Self-constructed questionnaire (Cronbach's alpha 0.91)
Fathi et al. (2017)	Self-constructed questionnaire (Cronbach's alpha 0.81)
Gorgich et al. (2016)	Self-constructed questionnaire (Cronbach's alpha 0.89)
Groves et al. (2020)	SSI question asking about fatigue levels
Harkanen et al. (2017)	Retrospective incident reports with free text descriptions of contributing factors to MAE
Hassan et al. (2009)	Questionnaire adopted from Mayo and modified Gladstone (Mayo & Duncan, 2004)
Hong et al. (2021)	Occupational Fatigue Exhaustion Recovery Scale Korean version (Winwood et al., 2005)
Jassim & Ebrahim, 2020	Unvalidated self-constructed questionnaire
Karadeniz and Cakmakci (2002)	Unvalidated questionnaire
Mayo and Duncan (2004)	Modified Gladstone survey (Gladstone, 1995)
Murphy and While (2012)	Self-reported 'fatigue'
Rafat et al. (2015)	Self-constructed questionnaire (Cronbach's alpha 0.84)
Sears et al. (2013)	Self-constructed survey tool (No Cronbach's alpha given, states received face, content and construct validity)
Seki and Yamazaki (2006)	Unvalidated self-constructed questionnaire
Sessions et al. (2019)	SSI question regarding factors that interfere with the safe administration of medications
Shahrokhi et al. (2013)	Self-constructed questionnaire (Cronbach's alpha 0.86)
Saleh et al. (2014)	Modified fatigue severity scale (Chalder et al., 1993)
Zadeh et al. (2014)	Observation of subsidiary behaviours related to sleepiness (e.g. yawning, eye rubbing, etc.) and visual ecological assessment (Stone & Shiffman, 1994)
Zarea et al. (2018)	Self-constructed questionnaire (Cronbach's alpha 0.8)

reporting MAEs. This study also reported that RNs working more than 40 h per week were 28% more likely to report occasional or frequent MAEs than those working less than 40 h per week, and this increased by 2% for every additional hour of voluntary overtime worked. Similarly, Wilkins and Shields (2008) found that RNs who worked overtime, 22% recalled being involved in a MAE in the past 12 months, as opposed to 14% of those who did not work overtime ($p < 0.05$) and had made a MAE. Moreover, in Iran, RNs ranked tiredness due to 'excessive overtime work' as a contributing factor to MAEs by 62.6% of the participants ($n = 94$) (Shahrokhi et al., 2013). RNs were asked to rank factors from a preprepared list, and no definition of 'excessive overtime' was given. A qualitative study by Ali et al. (2020) reported RNs feeling that their colleagues who are working a second job or are studying arrived to work tired and therefore were more prone to errors. However, Roseman and Booker (1995) found that working overtime does not affect or even reduces the likelihood of MAEs. Data for this study was retrospective, extracted from a medical centre's database for a five-year period. The frequency of MAEs appeared to differ based on how MAEs were defined and reported by RNs.

3.3.4 | Sleep restriction

Several studies found that short sleep duration was associated with an increased likelihood of MAEs. Murphy and While (2012) report that 61% ($n = 140$) of RNs said a lack of sleep was the cause of MAEs; however, their data collection methods relied on RNs recall of MAEs that occurred under these conditions. A significant negative correlation between average sleep hours and MAEs ($p = 0.35$) was found by Saleh et al. (2014). Method of data collection for this study was through a sleep diary kept by nurses for over 2 weeks to record hours of sleep. Conversely, lack of sleep was reported by only 16.5% ($n = 13$; $N = 154$) of RNs as contributing to MAEs based on error recall in the last 4 weeks (Deans, 2005). Interestingly, a study carried out in Japan which asked participants about their sleep behaviour over the last month found that RNs who reported sleep issues such as insomnia were at no greater risk of involvement in MAEs (Asaoka et al., 2012). RNs who were in fact experiencing symptoms of fatigue may not have met these sleep criteria, such as those suffering from acute fatigue, and this may have affected these findings.

4 | DISCUSSION

This scoping review set out to examine the effect of fatigue on MAEs and NMs by registered nurses working in hospital settings. Thirty-eight studies were ultimately included as they reported on findings related to the effect of RNs fatigue on the incidence of MAEs and NMs in hospitals. Of the 38 included studies, 31 of them found fatigue to be a contributing factor in MAEs and NMs. Many studies did not provide a definition of MAEs, and there was inconsistency in the definitions of those that did. A common definition of MAE would have been helpful in the comparison of findings. It was surprising to find that a large number (n = 11) of the studies were conducted in Iran. This finding may be based on the reporting of higher rates of MAEs than in other parts of the world which may have prompted these studies (Vaziri et al., 2019). Working a 24-h rotating roster can lead to problems with sleep, which this review found increased the incidence of MAEs. However, there was some inconsistency in this finding with two studies not finding sleep to significantly impact MAEs or NMs (Asaoka et al., 2012; Deans, 2005). Hours of work were also found to impact MAE rates, but again, there was inconsistency across the findings. These inconsistencies are supported by another study that report a direct relationship of shift length associated with quality of care, but not with medical errors (Jarrar et al., 2018). Of interest, authors from the same study (Jarrar et al., 2019) found that shift length indirectly affects nurses' *perceived* medication error. Planned longer shifts, such as 12-h shifts, appear to have less significance on the incidence of MAEs than unplanned overtime (Hong et al., 2021; Liu et al., 2012, Olds & Clarke, 2010; Wilkins & Shields, 2008). This has implications for nurse managers when developing rosters, as RNs working overtime is a factor which can be prevented and warrants further study.

Whilst not all studies collected data on NMs, there appears to be some differences in the findings for MAEs and the finding for NMs in some of those that did. Two studies (Asaoka et al., 2012; Liu et al., 2012) found that NM rates were positively correlated with fatigue but the rates of actual MAEs were not significantly higher. This would suggest that fatigue may contribute to RNs initially making errors; however, they were able to detect these errors prior to proceeding to administer the medication to the patient. This may be due to the systems and processes in place, such as double checking of medications, working to prevent these errors. Nonetheless, following the layers of the Swiss cheese model, errors not detected early could easily contribute to a MAE.

Fatigue is a multifaceted concept (Billones et al., 2021). This review found that many of the studies used only one measure to indicate fatigue. The use of one measure may affect the validity of the findings in these studies as there may have been other factors contributing to the fatigue levels of the RNs which were not measured or controlled for. For example, the use of hours of work does not consider the quantity and quality of sleep in the previous 24 h. In general, this review found that data were collected on hours of work, quantity and quality of sleep and fatigue levels. The heterogeneity of the data collected to indicate fatigue may explain the inconsistency in the findings reported in this review. Further research using multiple methods to collect data on the many factors which may contribute to fatigue is indicated. This will allow for more reliable and valid reporting of the effect of RNs' fatigue on the incidence of MAEs and consequent implications for education and practice.

This review found that many of the studies relied on subjective data alone, both on fatigue and on the incidence of MAEs. RNs were asked to recall when they were involved in MAEs and what factors they felt contributed to the error. This method of data collection is subject to both recall bias as RNs may not accurately remember previous events (Coughlin, 1990) and social desirability bias as RNs may not want to admit their mistakes (Wu & Marks, 2013). The study conducted by Di Simone et al. (2020) demonstrated the lack of reliability found in the use of subjective measures. This study found that of 446 RNs surveyed, 60.1% (n = 268) reported self-perceived sleep quality as good to excellent; however, when these same RNs undertook a validated measure of sleep, the Pittsburgh Sleep Quality Index, their scores indicated poor sleep quality. The use of objective measures, such as activity monitors to measure sleep duration, along with subjective measures will add validity to study findings. Furthermore, given the diverse methods and findings of the included studies, it is critical that future large-scale studies address MAE incidence and factors that contribute to MAEs using validated and/or objective measures.

5 | CONCLUSION

The evidence on the impact of RNs fatigue on the incidence of MAEs and NMs is inconsistent. This review found that some studies reported fatigue as being highly significant, whilst others report minimal or no contribution. Heterogeneity was found in the methods of measuring fatigue, and this may account for the mixed results that were reported. Future studies need to consider mediation or moderation factors to explain these inconsistencies. Further larger-scale studies are needed to comprehensively understand and measure the impact of fatigue on MAEs. Additionally, a more globally recognised and clearer definitions of MAEs and NMs is warranted.

6 | RELEVANCE FOR CLINICAL PRACTICE

Table 6 reports on the patterns, advances, gaps, evidence for practice and research recommendations (PAGER) arising from this review.

Whilst the introduction of electronic medical records has shown some reduction in the incidence of MAEs (Westbrook et al., 2020), there is still much room for improvement in systems and practices of medication administration (World Health Organisation, 2017a, 2017b). It is imperative that there is a good understanding of the factors which contribute to MAEs. Effective initiatives need to be put in place to reduce MAE rates. If fatigue is found to be contributing to MAEs, the nursing profession needs to begin implementing fatigue management systems like those which are currently being

used in aviation and long-distance truck driving so that patients can be protected and delivered safe and quality care.

Fatigue in nurses has been exacerbated during COVID-19 and is impacting staff retention. Studies have reported that RNs intention to leave the profession has been directly affected by the COVID-19 pandemic with nurses globally reporting that they will leave the workforce (International Council of Nurses, 2020; Maben & Bridges, 2020). High levels of attrition due to Covid-19 coupled with natural attrition will add extra pressure on RNs to work extended hours and additional shifts to meet the shortfalls in staffing (International Council of Nurses, 2021). The loss of experienced RNs will place huge pressure on newly graduated RNs joining the workforce, which can only add to their feelings of fatigue (Raso et al., 2021). Therefore, understanding how RNs fatigue impacts MAEs is of vital importance for the profession. Moreover, the use of overtime should be limited where possible to reduce MAEs. Importantly, policies around safe working hours need to be re-evaluated and fatigue management systems put in place to ensure delivery of safe and quality patient care.

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CONFLICT OF INTEREST

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DATA AVAILABILITY STATEMENT

Data available on request from the authors.

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