

Can nurses' shift work jeopardize the patient safety? A systematic review

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Abstract. – OBJECTIVE: Medication administration accounts for 40% of the nursing clinical activity in hospitals and nurses play a central role in granting the patient safety, as they are directly responsible for the patient care. This review aims at analyzing the correlation between the clinical risk management and the occurrence of medication errors and the effects of the shift work (such as excessive fatigue and sleep deprivation after a shift in hospital) on in-patient nurses.

MATERIALS AND METHODS: This paper adheres to the relevant EQUATOR guidelines. A systematic review was conducted according to the PRISMA statement and pertinent articles were selected based on inclusion criteria and quality assessment factors. Two reviewers searched the bibliographic databases PubMed, Scopus, Cochrane, CINAHL to collect all the available articles in English and Italian issued between 1992 and August 2017.

RESULTS: The reviewers analyzed 19 of the 723 initially extracted references, as they focused on the impact of workload, shifts and sleep deprivation on the probability of making medication errors.

CONCLUSIONS: The main reasons behind medication errors are stress, fatigue, increased workload, night shifts, nurse staffing ratio and workflow interruptions. These factors can have a significant negative impact on the health and the performance of the employees. It is desirable to extend and deepen the research to identify appropriate measures to minimize medication errors.

Key Words:

Medication errors, Nurses' work shift, Patient safety, Fatigued nurses, Hospital settings.

Introduction

The report *To Err is Human – Building a Safer Health System*, issued by the U.S. Institute of Medicine, claims that an estimated 44,000¹ to 98,000 patients die each year from medical errors while receiving medical care; and, in Italy, about 320,000 people are subjected to medication errors in health facilities every year². Patient safety is a priority for healthcare systems worldwide, however, the World Health Organization (WHO) still requests health organizations to take urgent action against medication errors³.

A medication error can be defined as a failure in the treatment process that leads to, or has the potential to lead to, harm to the patient⁴.

Nursing care provision is always organized in shift work to guarantee the healthcare of patients. Medication administration accounts for 40% of the nursing clinical in hospitals and nurses, being directly responsible for the delivery of the patient care, can make the difference to prevent the occurrence of medication errors⁵. In the Intensive Care Units (ICUs) and the Emergency Departments, patients are most vulnerable to being exposed to medication errors related to knowledge, attitude, behaviour and training needs of nurses⁶⁻⁸. However, the negative health effects of the shifts (sleep deprivation, fatigue, and tiredness) can jeopardize the patient safety.

Some studies support the presence of an association between Daylight Saving Time (DST) and a modest increase of acute myocardial infarction (AMI) occurrence⁹, which leads to sleep disturbance and deprivation.

The objective of this study is to analyze the correlation between the clinical risk management and the occurrence of medication errors and the effects of the shift work (such as excessive fatigue and sleep deprivation after a shift in hospital) on inpatient nurses.

Materials and Methods

Study Design

This systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement¹⁰ (a copy is available upon request). The protocol for this systematic review has not been registered or published.

Search Strategy

According to the purpose of this review, the authors drafted a protocol based on the Population, Intervention, Outcome and Setting (PIOS) approach:

P: nursing staff

I: nursing shift work

O: patient safety and medication safety

S: hospital setting

This research aims at answering the following question: What is the correlation between nursing shift work, and the clinical risk management and the risk of medication errors occurrence?

Two reviewers searched the bibliographic databases PubMed, Scopus, Cochrane, CINAHL to collect all the available articles in English and Italian issued between 1992 and August 2017. To obtain an exhaustive string search, the following keywords were combined through Boolean operators AND and OR: *medication error, medication errors, medication errors nursing, medication administration, medication safety, medication management, medication mistake, slip, nurse, shift, shift work, work shift, work schedule.*

Inclusion and Exclusion Criteria of the Study

The reviewers defined the characteristics that made up the eligibility criteria used to rule in or out the collected studies for this research study.

Inclusion criteria:

- Intervention studies, including RCTs, Controlled Clinical Trials (CCTs) and all observational studies (e.g. cohort analytic studies, cross-sectional studies, case-control studies...);
- Papers reporting the administration of medications by registered nurses (RNs);

- Studies performed in hospitals/inpatient settings, including ICUs, emergency departments, medicine and surgical wards;
- Studies focusing on adult and paediatric patient cases;
- Peer-reviewed research articles published in English and Italian.

Exclusion criteria:

- Studies reporting educational interventions;
- Studies reporting the administration of medications by other health professionals and studies reporting the prescription and the dispensation of drugs;
- Studies carried out in outpatient centres, assisted living facilities and nursing homes;
- Grey literature, such as dissertations, conference papers, proceedings, etc.

Study Selection

In the very first phase, the results obtained from the research were imported into Endnote[®] database, then, duplicates were eliminated and only results in English and Italian were considered.

In the second phase, two authors independently reviewed each article loaded in the database. They first screened the records by reading their titles and abstracts, then, according to the eligibility criteria previously set, they excluded the irrelevant articles, while read the full text of the pertinent papers.

Thanks to this in-depth reading, they were able to exclude those studies that did not focus on the correlation between nursing shift work and patient safety.

Data Extraction

The following data were collected for each study: name of the author(s) and year of publication of the study, purpose of the study, study design, study population and summary of findings.

The main information of the relevant articles was organized in a table of data extraction (Table I).

Quality Assessment

The authors assessed the quality of the evidence by using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) method.

They considered the following criteria for each outcome: risk of bias, imprecision, inconsistency, indirectness and other consideration¹¹. The quality assessment of the relevant studies is reported in a table (a copy is available upon request).

Table 1. Table of data extraction.

Authors and years	Aim	Design	Study population	Summary of findings
Al-Kandari et al, 2009	Identify the perceived adverse patient outcomes as related to nurses' workload. It also assessed nurses' perception of variables contributing to the workload and adverse patient outcomes.	Cross-sectional survey	Nurses (n = 780) of medicine and surgery of 5 hospitals in Kuwait.	The positive relationship between workload and adverse effects, with delays or omissions in the administration of drug therapy that occurs in 1.8% of cases.
Holden et al, 2011	Measure each of the three types of workload experienced by nurses at two pediatric hospitals, and to assess whether and which measures of workload were related to three important outcomes: nurses' self-reported job dissatisfaction and burnout, and the perceived likelihood of an error occurring during medication administration. It was expected that some, but not other, types of workload would be associated with each of the outcomes.	Cross-sectional survey	Fulltime nurses (24h/week or more). Six units of two pediatric hospitals. The departments considered are ICU pediatric, hematology oncology and medicine and surgery.	The workload of therapy delivery is associated with the likelihood of making medication errors. This workload has two components: an internal one as mental effort and concentration and an external one related to external requests and therefore directly described to patient safety.
Drachzahavy et al, 2015	To examine the relation between the strategies the nurses employ during handover and the number and types of treatment errors in patient care in the following shift.	Prospective study	Analysis of handover of 5 patients, observing data before, during and after delivery. Specifically, three complex and two simple cases were selected.	The errors during the treatment are mainly 3: dosage discrepancy, orders not executed or executed late, lack of documentation. Writing a summary of notes before making the delivery is very useful for the reduction of medication errors.
Kucuk-Alemandar et al, 2013	Carried out as a descriptive study in order to determine types, causes and prevalence of medical errors made by nurses in Turkey.	Descriptive study	78 nurses	The principal errors that are committed, in order are hospital infections, diagnosis errors, accidental injuries with needles and problems due to the side effects of therapy (10.3%). In the study, 38.5% of nurses reported that the cause of the medical error was highly responsible for fatigue, 36.4% increase in workload and 34.6% for long working hours.
Lockley et al, 2007	Analyze how sleep and work performance in health of health professionals	Web-based survey	2737 health professionals	The reported auto fatigue rate linked to medication errors increases with the increasing number of working hours per shift each month. The probability of having a lack of attention during the shift or educational activities can also be attributed to the number of excessive work shifts. Nurses who work for more than 12.5 h consecutive have an increased risk of making medication errors. 39% of shifts lasting more than 12.5 h are associated with a triple risk of making a mistake.

Continued

Table 1 (continued). Table of data extraction.

Authors and years	Aim	Design	Study population	Summary of findings
Tanaka et al, 2010	Investigated the difference in medical error risk among nurses between the two- and three-shift system, with consideration to potential confounding factors, including psychological stress and work environment characteristics.	Survey	1506 nurses	The 12-hour shifts help to increase leisure time but significantly influence the risk of accidents. Workers doing 12-hour shifts are more likely to make mistakes at the end of the shift than at the beginning of the daytime shifts at night.
Dean et al, 2006	Analyzing the correlation between fatigue and medication errors that nurses of neonatal intensive care units can commit	Case study	6 nurses	Over a 28-day data collection period, neonatal intensive care nurses report three procedural errors and three treatment errors. Although 12-h rounds are widespread among nurses, they may not be appropriate for nurses working in neonatal intensive care as high levels of attention for infants are required.
Gold et al, 1992	Examine the impact of working hours on sleep hours, lack of sleep and the rate of accidents in the Massachusetts women nurses.	Cross-sectional study	878 nurses	From the analysis of the responses, it emerges that 92% of those who work night/day can obtain a "restorative sleep" of 4 hours a month. However, only 6.3% of nurses working at night regularly get restful sleep. About this, the OR measured for the occurrence of medication errors turns out to be double for those working in rotation and night/day on an occasional basis. It, therefore, emerges that sleep deprivation and misalignment of the circadian rhythm lead to frequent decreases in attention, increased reaction times and thus an increased percentage of errors during the performance.
Patrician et al, 2011	Demonstrate the relationship between the organization of nursing staff and the adverse events that may occur during the shiftwork	Longitudinal study	A data set of 115,062 consecutive shifts was generated from 2003 through 2006	Total hours of nursing care per patient per shift were defined as the sum of hours worked by all nursing staff during the shift divided by the number of patients present at the beginning of the shift. Data analysis focused on: patient falls with and without damage and errors from administration and therapy. The covariate analysis of the data leads to the conclusion that more hours of assistance are dedicated to the minor person are the errors due to the administration of the therapy. Also, during the night shift therapy errors are minor, precisely 45% less, as fewer drugs are administered and there are fewer interruptions. Finally, it emerges that adverse events are mainly mismanaged when the nursing staff is fewer.

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Table 1 (continued). Table of data extraction.

Authors and years	Aim	Design	Study population	Summary of findings
Olds et al, 2010	Studying the relationship between working hours and adverse events, accidental punctures, accidents at work, patient falls with damage, nosocomial infections and medication errors.	Survey	11516 nurses	A secondary analysis is performed through bivariate and multivariate regression, using a questionnaire. This tool investigates the characteristics of the work environment, of the work itself and adverse events. The occurrence of adverse events and errors occurs with higher frequency (from 14% to 28%) in all nurses where the average number of working hours per week is > 40 hours. Specifically, in the case of errors from the pharmacological therapy for every hour of work, the probability of the wrong drug or of the wrong dose increases by 2%.
Rogers et al, 2004	Examine hospital nursing job patterns and determine if there is a relationship between the hours worked and the frequency of errors.	Observational study	393 nurses	A collection of 5,317 work shifts shows that hospital nurses work more than is expected on a daily basis, more than 40 hours a week. Although 31% of the programmed shifts work for ≥ 12.5 h, in the real shifts, 39% of nurses work for ≥ 12.5 h. The most extended round lasts 23 hours and 40 minutes. Study participants work an average of 55 minutes per day more than planned. 199 errors are reported and 213 almost errors in the data collection period. More than half of errors and nearly errors are errors of administration. 30% of nurses report having committed at least one mistake and 32% of having committed at least one mistake. A nurse says 8 errors while another 9 near miss.
Scott et al, 2006	Describe the working patterns of ICU nurses, determine whether there is an association between the occurrence of errors and the hours worked by nurses and examine whether such working hours have adverse effects on nurse supervision.	Descriptive study	502 nurses	86% of shiftwork nurses work harder than planned. Although there is provision for 12-hour shifts, as many as 67% work more than 12 hours and 10.8% work more than 16 at least once during the study. The most extended scheduled shift is 17 h while the most extended working shift is 23 h. On average there is at least an hour more work than planned, for those who participate in the study, however, only in 28% of cases, this work is considered extraordinary. 65% of the participants say it is exhausting to stay awake at work and 20% of those declare to fall asleep during the work shift. On average the participating nurses report that they committed one mistake during the study period, for a total of 224 errors and 350 almost errors. These are mainly medication errors.

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Table 1 (continued). Table of data extraction.

Authors and years	Aim	Design	Study population	Summary of findings
Estryn-Behar et al, 2012	The effects of working time on the nursing staff on three parameters (work/family balance, health and safety)	Observational study	25924 nurses	Nurses who work 12-hour shifts a day and night and those who work alternating shifts that include many nights often do not know what should be said to a patient or family, are more concerned with committing medication errors and reporting poor quality of teamwork. Nurses doing 12-hour shifts during the day and those working in alternate shifts report more interruptions and distractions during work, a large amount of requests and a high physical load.
Kunert et al, 2007	Examine the differences in fatigue perception among night and day shift nurses using the BFI tool and evaluate differences in sleep quality, between the two groups, using PSQI.	Descriptive study	196 nurses	From the BFI and the PSQI, respectively, the nurses who do the night shift perceive greater fatigue and have a worse quality of sleep than those doing day shifts. Those who are married or divorced and work in the night shift are more tired than singles.
Hirsch Allen et al, 2014	Evaluate how nursing sleep patterns are influenced by working hours and other factors. Specifically, we hypothesized that nurses in intensive care units get inadequate sleep between 2 consecutive work shifts and that this problem is accentuated between 2 consecutive night shifts. Secondly, we hypothesized that the duration of sleep would be reduced by other factors, such as home responsibilities and time for travel.	Cross-sectional survey	20 nurses	In some health professionals, the resulting cognitive dysfunction caused by fatigue and lack of sleep has potentially influenced patient safety and occupational safety. The error rate increases proportionally to the duration of the shift: 2% shifts of 8.5h are associated with at least 1 reported auto error and 4% of 12.5h shifts are associated with at least 1 error.
Shao et al, 2010	Study of factors affecting sleep quality and quality of life among shift work nurses.	Cross-sectional survey	435 nurses	Data on sleep and life quality were collected using PSQI and WHOQOL-BREF. According to the PSQI nurses working in shifts achieve a score ≥ 5 , which is equivalent to little sleep. The PSQI is negatively related to physical, psychological, environmental and social health. Nurses with better sleep quality and quality of life are better suited to shiftwork.
Johnson et al, 2014	Investigate the relationship between sleep deprivation and occupational and patient care errors among staff nurses who work the night shift.	Cross-sectional survey	289 nurses	Nurses enrolled in the study are observed during the night shift and are observed for a period of 7 months. The study shows that more than half of the sample (56%) claims to have been deprived of sleep. 75% of those who have been deprived of sleep sleeps 4.7 hours less, within 24 hours, which corresponds to about 1.5 hours less than considered adequate for brain functions. then it emerges that those who sleep less are more prone to treatment errors.

Continued

Table 1 (continued). Table of data extraction.

Authors and years	Aim	Design	Study population	Summary of findings
Keshk and Abd El-Moneem, 2012	To examine the effect of nurses' work hours and fatigue on occurrence of medication errors.	Descriptive study	49 nurses	The 32% of nurses identify several factors as a cause of medication errors: reduced personal, a large number of patients assigned to nurses, frequent changes in patient assignment, distractions during treatment preparation, acute cases and lack of patient knowledge. When nurses work more than 12.5 hours they run a doubled risk of making mistakes compared to those who work 8.5h consecutive or less. Because nurses tend to sleep during the day and watch at night, fatigue and sleep increase and with it the possibility of making medication errors that lead to the patient's death increases by 300%.
Surani et al, 2015	Measure sleep quality, drowsiness, fatigue and vigilance of nurses and assess how the work environment and shift work affect	Cross-sectional survey	67 nurses	Study participants have 12 hour work shifts. The questionnaires are completed by PSQI, ESS, FSS, SSS. There is no major difference between ward nurses and intensive care nurses compared to the response of the ESS questionnaire, FSS. Intensive care nurses have a worse quality of sleep. Before daytime nurses showed the pVT test a longer reaction time than nurses on the night shift. Instead there is no difference after the turn, strangely. Daytime intensive care nurses make twice as many mistakes as ward nurses.

Results

Initially, 723 references were identified, then, after the elimination duplicates, authors selected 19 relevant studies (Figure 1).

The results obtained from the research of the scientific literature have been organized into three main interest categories, as explained below.

Shift Work and Errors

According to the studies on the impact of working time on sleep and the risk of making errors, it was highlighted that professionals who work on shifts are exposed to frequent disturbed and interrupted sleep, and they manage to rest only few hours per night and per month. 92% of nurses who work on day/evening regular shifts achieve

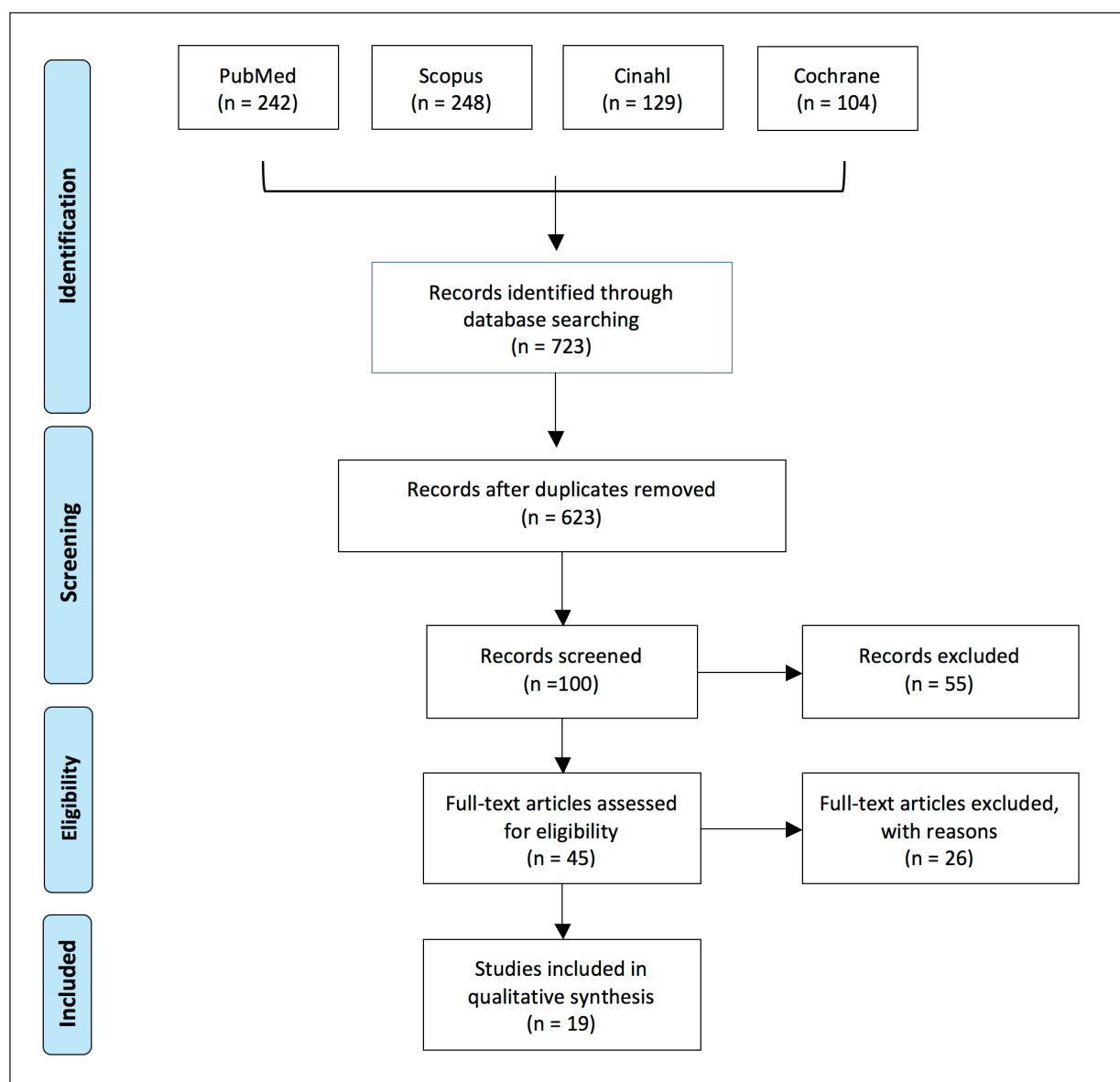


Figure 1. Flowchart (Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009; 6: e1000097.). From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med* 6(7): e1000097. doi:10.1371/journal.pmed1000097. For more information, visit www.prisma-statement.org.

restorative sleep of four hours a night, in a month. The situation is not the same for night workers, as only 6.3% of them manage to sleep for at least four hours. Actually, it was underlined that the quality of sleep is significantly lower for those professionals working in rotating shifts (2.8 OR) and night workers (1.8 OR). From the univariate analysis between shift work and errors related to it, it was observed that medication errors occur more frequently during occasional night shifts and rotating shifts (12.1%)¹².

Patrician et al¹³ used for their study the data collected in some military hospitals and processed with the same database (MilNOD). They observed that the occurrence of adverse events during the shift could be put in relation with the organization of nursing staff. The findings of this study indicated that even in a single shift, if nursing care is provided by a reduced staff, the quality of the assistance is compromised, and the risk of errors increases. The authors¹⁴ affirmed that during the night shift, the availability of a larger number of nursing staff leads to the decrease of medication errors.

Many authors¹⁴⁻¹⁷ instead, studied the relation between the length of nurses' work shifts and the risk of medication errors. The majority of them agree on some data: shifts longer than 12 hours per day and 40 hours per week cause a greater fatigue of the nurses and, therefore, lead to an increased rate of adverse events and medication errors. Olds and Clarke⁶ stated that nurses who work on average more than 40 hours per week are more likely to face adverse events and make errors (from 14 to 28%). For every extra hour of voluntary work (paid) exceeding the 12-hour shift, the probability of administering the wrong drug or the wrong dose increases by 2%.

Comparing the data elaborated by the two authors, they both report in their studies^{14,18} that often the ideal duration of a shift and its effective length do not match. Although 12-hour shifts are scheduled, 67% of participants to the study actually work more than 12 hours per shift and 10.8% of them worked more than 16 hours, at least once during the study period. The longest scheduled shift should last 17 hours, but effectively, it can last up to 23 hours and 30 minutes. Commonly, nurses work at least an hour more than planned during their shift, but only in 28% of cases, this extra work is considered overtime. Nurses participating to the study claimed to have made 1 error on average during the period of the study, for a total of 224 errors and 350 near miss. Mainly, errors (56.5%)

and near miss (28.2%) were medication errors.

Data collected on 5,317 work shifts revealed that nurses employed in hospitals usually work longer than 40 hours per week, exceeding their scheduled daily shift¹⁸. The participants to the study worked, on average, 55 minutes a day longer than planned, and the longest shift lasted 23 hours and 40 minutes. Although 31% of nurses had a scheduled shift of ≥ 12.5 hours, indeed, 39% of them actually work for ≥ 12.5 hours. During data-gathering period, 199 errors and 213 near miss were reported. More than a half of the errors and near miss were medication administration errors. 30% of the nurses reported making at least 1 error, and 32% reported at least 1 near miss. One nurse reported 8 errors, while another one reported 9 near miss.

Too long work shifts expose nurses to major risk factors such as burnout, poor skill work and much concern of causing errors¹⁵. Specifically, nurses working shifts longer than 12 hours or rotating shifts, feel more often tired and experience frequent burnouts; moreover, they are more likely to take short/long leaves. They concerned themselves more with the risk of making errors than with the quality of nursing care they deliver to the patient. Nurses working for more than 12.5 consecutive hours in a shift face a growing risk of making medication errors. In particular 39% of the shifts last more than 12.5 hours and the risk of making a mistake is three times more likely¹⁶. The rate of fatigue related to medication errors increases proportionally to the number of hours worked per month. On the contrary, the reported medication errors, which are not related to the fatigue, do not depend on the extended duration of the shifts. Referring to nurses' self-reported errors, they occur more frequently in a 3-shift system than in a 2-shift system. Tanaka et al¹⁹ confirmed these data through the realization of a bivariate analysis in which they put in relation the 3-shift system and the 2-shift system to nurses' years of work experience and the number of night shifts in a month. The bivariate analysis showed that the frequency of adverse events with the 3-shift system was higher for nurses with 3-6 years of experience.

According to a study carried out in six Neonatal Intensive Care (TIN) in the USA, shifts longer than 12 hours per day resulted in poor quality care delivered by nurses: during the 28-day data-collection period, nurses report 3 procedural errors and 3 medication errors²⁰.

Work Organization and Errors

Some authors investigated the impact that the workload can have on the probability of committing medication errors.

Al-Kandari and Thomas²¹ identifies a positive correlation between the workload and the possible adverse events that nurses face while working. The main adverse events observed are delays and/or omissions in drug therapy administration, which occur in 1.8% of cases. The nurse-patient ratio is the measure of the workload.

Holden et al²² evaluated the correlation between three different dimensions of workload and three outcome variables. One of the results he identified, besides dissatisfaction and work-related burnout, is the occurrence of medication error. He claims that medication errors could be easily predicted if the workload is commensurate with the expertise and the functions of the nurses employed. Therefore, an excessive workload in drugs administration is related to the probability of making medication errors. Holden et al²² identified two kinds of mental workload: the first one is the internal mental workload, which referred to the concentration and the mental effort of the nurse while performing his/her activities; the second one was the external mental workload, which is represented by workflow interruptions, requests, and distractions that the operator has to face while delivering healthcare. The external components of the workload can lead to medication errors, actually, workload accounts for 36.4% of the causes of medication errors and it ranks second in a classification of the factors that can lead to medication errors. Fatigue ranks first, as it was identified as the main reason of therapy errors in 38.5% of cases²³.

The working environment strongly affects the risk of errors. By workplace, the authors not only refer to the working physical structures, but also to the network of relationships and professional partnerships among different professionals who work in synergy.

In 2015, Drach-Zahavy and Hadid²⁴ investigated the relation between the strategies that nurses employ in handover communication and the number and types of medication errors, which occur in the following shift. The handover in the time lag between the end of a shift and the beginning of the next one is a delicate phase and its investigation represents a good opportunity to identify and correct errors. In nearly one-fifth of the handovers, drugs dosage is inaccurate and about half of the documentation is partially

missing. Face-to-face verbal updates between the colleagues, the assessment of the topics faced by the outgoing nurses and those who are starting their work shift, the inclusion of the outgoing personnel on care plans and writing summaries before the handover represent some of the strategies suggested to reduce the occurrence of medication errors. These measures will serve not only to guarantee the patient safety but also the continuity of care.

Sleep Quality and Quantity, Fatigue and Errors

Numerous studies²⁵⁻²⁷ investigated the way that sleep quality affects the quality of life and work in nurses. To measure the sleep quality and the quality of life, various scales were used: Brief Fatigue Inventory (BFI), Fatigue Severity Scale (FSS), WHO Quality of Life Instrument (WHO-QOL-BREF), Epworth Sleepiness Scale (ESS), Stanford Sleepiness Scale (SSS) and Pittsburgh Sleep Quality Index (PSQI).

The BFI showed that night nurses perceive greater fatigue than those involved in day shifts. The ESS findings revealed no significant difference between nurses working in intensive care units and departmental nurses, while, in terms of fatigue, it highlighted an evident difference between the day shift (6.70 ± 3.66) and the night shift (8.58 ± 4.33). This difference was also emphasized by the FSS, as the fatigue borne during the night shift (3.88 ± 1.2) is slightly higher than that of the day shift (3.17 ± 1.25). The score referring to the comparison between nurses working in night shifts and those employed in day shifts does not differ much in the SSS scale. However, the investigation of the reaction time revealed that there is a significant difference between the reaction time in the period immediately before the beginning of a day shift and the one preceding the beginning of a night shift: nurses at the beginning of their night shift are slower in reacting (310.7) than those who start the day shift (278.9). The PSQI scale is meant to measure the sleep quality. This scale is made of 19 items and a score of 0 to 3 can be assigned to each; the final score will be of 0 to 21. A total score of ≥ 5 indicates a poor-quality sleep. The results of the PSQI scale highlighted a significant difference among the scores achieved by nurses working the night shifts and those working the day shifts.

Kunert et al²⁵ indicated an average PSQI score of 7.7 for night-shift nurses and an average score of 5.8 for day-shift nurses. The multivariate anal-

ysis between PSQI and BFI resulted in a significant difference in the duration of sleep and the dysfunctions during the day between nurses employed in night shifts (0.51 and 0.66) and those working during the day (0.23 and 0.39). Also, Surani et al²⁷ recorded a considerable difference in the PSQI scores achieved by night-shift nurses (7.96 ± 3.42) and day-shift nurses (6.29 ± 2.82). The most encouraging scores resulted in Shao et al study²⁶ in which the average PSQI score was of 5.33 ± 2.8 , as 57% of the study participants achieved a score higher than 5.

Many authors^{14,16,28} of the articles considered for the draft of this study focused their attention on the correlation between medication errors and nurse fatigue. In one of these papers¹⁸, it turned out that 65% of the participants affirmed it was exhausting for them to stay awake at work and 20% of them declared to fall asleep during the shift. The rate of fatigue, which nurses self-reported in another study¹⁶ is related to medication errors and increases proportionally to the number of working hours. In fact, long work hours can produce nurses' loss of attention while performing their tasks or during educational activities. Allen et al²⁸ aim in their study at showing how nurses' sleep and rest are influenced by the organization of work shifts. The average sleep duration (5.68 hours) between two shifts at night is shorter than the sleep duration between two day-shifts (6.79 hours). Nurses can benefit from more sleeping hours (8.53 hours) on the days when they do not work and the night (8.93 hours) between a day-shift and a day off. The conclusion of this report is that the cognitive dysfunction generated by fatigue and sleep deprivation potentially affects the patient safety and the work safety. It can be claimed that shift work is the main factor that leads to the risk of medication errors, especially in those cases in which nurses autonomously administer drugs *pro re nata*.

The careful evaluation of the articles examined for this review grounds the assertion that there are strong relations between the sleep deprivation and the occurrence of errors in the therapy delivery.

Another study²⁹ identified a double relation between working hours and physical fatigue, and between medication errors and mental fatigue. Actually, 25% of nurses claimed to make medication errors when they are tired and exhausted. Fatigue has deleterious effects on all types of performance, and it results in loss of attention, vigilance, concentration and judgment.

Johnson et al³⁰ carried out a cross-sectional study by selecting 289 full-time night shifts nurses during a 7-month period. The results revealed that more than half of the sample reported being sleep deprived: more than 75% of the involved nurses slept 4.7 hours or less in a 24-hour period, which is about 1.5 hours less than the recommended hours of sleep for adequate brain function. Sleep-deprived nurses made 25 patient care errors in total.

Discussion

The critical analysis of the studies selected for the draft of this paper highlighted the relevance of some key topics for the study results: shift work, fatigue and workload.

Workload in particular, significantly affects the risk of making medication errors^{21,22,24}. In 36.4% of the analysed cases, it was the second cause of medication error²³.

Many reports provided ample evidence of the inverse relation between nurse staffing and medication errors. Patrician et al¹³ found that medication errors mainly occur during shifts staffed with fewer personnel in general, and, particularly, when only few RNs are at work. Other reasons for medication error occurrences are the increased workload and the night shifts. In fact, the error rate on night shift is consistently higher than the day shift rates^{12,13}. Some researchers emphasized that the number of medication errors increases proportionally to long working hour. Working more than 12 hours per shift or working more than 40-50 hours per week is related to medication errors²³. Some authors found that risks of medication errors increased by 2% for every extra hour of voluntary work. However, the risk of falling into error significantly increases when work shifts are longer than 12 hours¹⁸. In fact, the evidence supports the negative impact on the employee of working more than 12 hours per shift, in terms of fatigue, health, satisfaction, work/family balance and patient safety^{15,23}. Some studies analysed the relation between shift work and its consequences, such as sleepiness and accidents. Sleep deprivation and misalignment of the circadian phase too are linked to slow reaction time, frequent attention lapses and increased error rates on carrying out tasks^{12,16,20}. The most important strategies for nurses to reduce the risk of errors are taking naps, caffeine and exposure to light^{19,20,30}.

Conclusions

The purposes of this research are to analyze the impact of sleep deprivation and excessive fatigue on inpatient nurses by focusing on the possible correlation between the clinical risk management and the occurrence of medication errors, and the effects of the shift work and the workload on sleep quality. Since the 1990s, the literature provided ample evidence on this topic. To create a safety environment in healthcare facilities, simulation based medical education is a key of success³¹, such as the efficacy of the application of critical pathway management to resident doctor's standardized training³².

Although the personal factors (knowledge, attitude and behaviour)³³⁻³⁵ are essential to prevent nursing errors, this research shows that the main reasons for medical errors are: stress, fatigue, increased workload, night shifts, and workflow interruptions³⁶.

Adverse events occur more frequently during reduced staffed shifts (where the number of nursing staff in particular is little)¹³ and when the working hours exceed 12 hours per shift and 40 hours per week^{14,15,17,18}.

These data showed that tiredness and lack of rest play a critical role in increasing the possibility of medication errors.

Nurses working night shifts and rotating shifts struggle more to stay awake during their work activities and they are twice as likely to make errors, compared to nurses working day/evening shifts.

In accord to these results, Ulas et al³⁷ showed a relationship between the effect of day and night shifts on oxidative stress and anxiety symptoms of the nurses. Furthermore, there is an association between the variables linked to work-related stress (WRS) and urinary cortisol levels³⁸. Numerous findings highlighted that extremely long shifts, workflow interruptions and distractions while performing tasks, staff shortage and increasing care needs of patients with chronic comorbidity expose nurses to many risks that lead to adverse events, fatigue, stress and lack of time and concentration. These factors have a significant impact on the fatigue and the health of the employees.

Relevance to clinical practice

It is essential to identify key strategies for nurses to reduce medication errors and improve the patient safety and the quality of nursing care.

A successful strategy to address fatigue and, thus, deliver quality nursing care, is to guarantee

the operator sufficient rest^{20,30} and allocate the work in line with the expertise and the functions of the nurses employed to enhance the management of workload²². Furthermore, longer intervals after night shift may enable longer main sleep and sufficient recovery time, necessary for nurses to cope with stress, which could be linked to reductions in errors during the working hours¹⁹.

It is essential to unburden nurses from excessive tasks, relieve their workload as much as possible and guarantee them adequate rest periods during long shifts for the improvement of their performances and the reduction of errors.

It is desirable to extend and deepen the research to identify appropriate measures to minimize medication errors and improve patient safety.

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Conflict of Interests

The authors declare that they have no conflict of interests and that the article has not been published previously and has not been forwarded to another journal.

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