Work Interruptions and Their Contribution to Medication Administration Errors: An Evidence Review

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ABSTRACT

Background: In many surveys, nurses cite work interruptions as a significant contributor to medication administration errors.

Objectives: To review the evidence on (1) nurses' interruption rates, (2) characteristics of such work interruptions, and (3) contribution of work interruptions to medication administration errors.

Approach: Search strategy: CINHAL (1982–2008), MEDLINE (1980–2008), EMBASE (1980–2008), and PSYCINFO (1980–2008) were searched using a combination of keywords and reference lists. Selection criteria: Original studies published in English using nurses as participants and for which work interruption frequencies are reported. Data collection and analysis: Studies were identified and selected by two reviewers. Once selected, a single reviewer extracted data and assessed quality based on established criteria. Data on nurses' work interruption rates were synthesized to produce a pooled estimate.

Results: Twenty-three studies were considered for analysis. A rate of 6.7 work interruptions per hour was obtained, based on 14 studies that reported both an observation time and work interruption frequency. Work interruptions are mostly initiated by nurses themselves through face-to-face interactions and are of short duration. A lower proportion of interruptions resulted from work system failures such as missing medication. One nonexperimental study documented the contribution of work interruptions to medication administration errors with evidence of a significant association (p = 0.01) when errors related to time of administration are excluded from the analysis. Conceptual shortcomings were noted in a majority of reviewed studies, which included the absence of theoretical underpinnings and a diversity of definitions of work interruptions.

Conclusions: Future studies should demonstrate improved methodological rigor through a precise definition of work interruptions and reliability reporting to document work interruption characteristics and their potential contribution to medication administration errors, considering the limited evidence found. Meanwhile, efforts should be made to reduce the number of work interruptions experienced by nurses.

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BACKGROUND

The worldwide incidence of medication administration errors varies between 6.6% and 44.6% for all doses administered by nurses (Tissot et al. 1999; Barker et al. 2002; van den Bemt et al. 2002; Greengold et al. 2003; Lisby et al. 2005). The proportion of these errors with the potential to harm patients, such as permanent disability and death, is estimated at 7% (Flynn et al. 2002). The importance of addressing this problem is recognized internationally (Kohn et al. 2000; Nicklin et al. 2004; World Health Organization 2004).

Medication errors are found at every stage of the medication use process with one-third of medication errors...
Contribution of Interruptions to Medication Errors

OBJECTIVE
To review the evidence on the rates, characteristics, and potential contribution of work interruptions to medication administration errors.

METHODS
This literature review is based on a systematic approach that includes identification of the studies, their selection, critical appraisal, and data synthesis.
Contribution of Interruptions to Medication Errors

TABLE 1
Yield from each database searched

<table>
<thead>
<tr>
<th>DATABASES</th>
<th>COVERAGE</th>
<th>YIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embase Ovid</td>
<td>1980–2008, week 6</td>
<td>154</td>
</tr>
<tr>
<td>Medline Ovid</td>
<td>1980–2008, week 6</td>
<td>138</td>
</tr>
<tr>
<td>Psychinfo Ovid</td>
<td>1980–2008, week 6</td>
<td>33</td>
</tr>
<tr>
<td>CINHAL Ebsco</td>
<td>1980–2008, week 6</td>
<td>90</td>
</tr>
<tr>
<td>Total yield</td>
<td></td>
<td>415</td>
</tr>
<tr>
<td>All references imported to Endnote® XI.</td>
<td></td>
<td>380</td>
</tr>
<tr>
<td>Duplicates removed.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Study Identification

Four databases were searched for relevant literature on work interruptions (Table 1). The search strategy used a combination of keywords and medical subject headings (MeSH) terms (Table 2). The MeSH terms were slightly adapted to each database to reflect their specificities. Keywords were necessary, since work interruptions are not currently indexed. “Distraction” was also employed as a related term. The search strategy involved combining interruptions and nursing care, interruptions, and medication administration process-related terms. The final step of the search strategy involved limiting the results to the English language. Identified references in each database were then imported into Endnote® XI to remove possible duplicates. The reference lists of articles meeting inclusion and exclusion criteria were also searched for relevant references.

Study Selection

The inclusion criteria were based on study design, participants, variables reported, and year of publication. Accordingly, published original studies that included nurse participants, reported work interruption frequencies, and were published in English between 1980 and 2008 were selected for this review. Conference proceedings were excluded. The study selection was performed by two reviewers in a three-step process (primary author AB and a master-prepared research assistant; Higgins & Green 2008). Titles and abstracts were first reviewed to identify potential studies for inclusion. The complete article was then reviewed to ensure that inclusion and exclusion criteria were met. The third step involved the identification of studies from reference lists of studies included for analysis (see Figure 1).

Data Extraction and Appraisal

A standard data extraction form was developed by the primary author and used to extract data from relevant studies, including author, location, objective, design, sample size...

Figure 1. Yield from the search and selection strategy.
and characteristics, sampling method, variables measured, theoretical background, data sources, reliability, validity, interruption definition, statistical analysis performed, findings, strength, and weaknesses. Data extracted, when possible, were specific to nursing, and the appraisal criteria were based on the Cochrane Effective Practice and Organisation of Care Review Group (2002) data collection for experimental studies, the Agency for Healthcare Research and Quality (AHRQ) criteria for observational research (2002), and Mays and Pope (2000) for qualitative research. Data were extracted by a single reviewer (AB).

Data Synthesis
A pooled estimate of nurses’ work interruption rate was calculated by using nurse-specific data from studies reporting both work interruption frequency and length of observation. Further, each study needed to meet a number of quality criteria to be part of this data synthesis. Only data from studies measuring multiple sources of work interruptions using minimally direct observation were used. These quality criteria ensured maximum homogeneity of the studies from which data synthesis was performed.

RESULTS
The search strategy yielded 415 records. After importation into Endnote® XI, 35 duplicates were removed, leaving 380 records (Table 2). Titles and abstracts reviewed for inclusion and exclusion criteria led to 46 retrieved articles. The main reasons for exclusion based on reviewed titles and abstracts are described in Table 3. The full text of the retrieved articles was reviewed to ascertain inclusion and exclusion criteria, resulting in 20 included articles. Another five were identified from reference lists; three of these five were included, for a total of 23 articles to be critically analyzed (Figure 1). The main reason for exclusion among retrieved articles was the nonreporting of work interruption frequencies (Table 4). The use of the truncated keywords, interrupt* and distraction*, resulted in the identification of interrupted time-series studies and of studies on nurses’ use of distraction as a pain management strategy. The other category (n = 3) consists of methodological articles whose results appear in studies already included in the review.

Study Characteristics
Approximately half of the 23 studies included (n = 12) had been published in the past 3 years. A majority (n = 10) had originated in the United States, followed by the United Kingdom (n = 7) and Australia (n = 4). The studies were typically performed within hospital settings (n = 21) and on different specialty units simultaneously (n = 7). Nonexperimental design studies predominated (n = 14), then quasi-experimental (n = 3), mixed method (n = 3), qualitative (n = 2), and preexperimental (n = 1) designs were comparatively less. Two of the experimental studies specifically targeted “distraction” among nurses during medication administration (Pape 2003; Pape et al. 2005). The first of the remaining two experimental studies documented the impact of a communication intervention designed to meet family information needs in the intensive care unit on the number of incoming calls interrupting nurses’ work (Medland & Ferrans 1998); the second, a change in surgical technology that required less unplanned and unscheduled interventions from operating room nurses (Luketich et al. 2002). Table 5 provides a summary of the main characteristics and findings of reviewed articles.

Quality Assessment
Most reviewed studies adopted a quantitative approach to the study of work interruptions (n = 21). Consequently, this section focuses on quality issues specific to quantitative studies among which samples’ representativeness and nurses’ work interruption measurements are the most recurrent. These limitations should be taken into consideration in the subsequent sections.
TABLE 5
Characteristics and key findings of reviewed studies

<table>
<thead>
<tr>
<th>Author's Country</th>
<th>Setting</th>
<th>Objective</th>
<th>Design</th>
<th>RN Sample Data Collection</th>
<th>Key Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alvarez and Coiera (2005), Australia</td>
<td>ICU</td>
<td>An exploratory study to examine interruptive communication patterns of health care staff within an intensive care unit (ICU) during ward rounds.</td>
<td>Nonexperimental</td>
<td>3 RN Direct structured observation and audio-recording</td>
<td>Rate: 145 WI/8 h 40 min = 16.7 WI/h</td>
</tr>
<tr>
<td>Bennett et al. (2006), Canada</td>
<td>Inpatient</td>
<td>To compare a traditional unit dose medication cart system to a system using a locked medication cupboard in each patient’s room.</td>
<td>Preexperimental</td>
<td>Not reported Direct structured observation</td>
<td>Rate: 14 WI/63 min = 13.3 WI/h</td>
</tr>
<tr>
<td>Coiera et al. (2002), Australia</td>
<td>ED</td>
<td>To measure communication loads on clinical staff in an acute clinical setting, and to describe the pattern of informal and formal communication events.</td>
<td>Nonexperimental</td>
<td>6 RN Direct structured observation and audio-recording</td>
<td>Rate: 185 WI/16 h 37 min = 11.1 WI/h</td>
</tr>
<tr>
<td>Coiera and Tombs (1998), UK</td>
<td>NA</td>
<td>An exploratory study to identify patterns of communication behavior among hospital-based health care workers.</td>
<td>Nonexperimental</td>
<td>2 RN Direct structured observation and audio-recording</td>
<td>Rate: 8 W/5 h 32 min = 1.4 WI/h (pages and telephone calls only)</td>
</tr>
<tr>
<td>Ebright et al. (2003), USA</td>
<td>Mixed²</td>
<td>To increase understanding of RN work complexity in an acute care setting using a human performance framework.</td>
<td>Mixed</td>
<td>8 RN Direct structured observation</td>
<td>Rate: 152 WI/48 h = 3.2 interruptions/h</td>
</tr>
<tr>
<td>Fairbanks et al. (2007), USA</td>
<td>ED</td>
<td>To characterize and describe the communication links and patterns between and within emergency department (ED) practitioner types.</td>
<td>Nonexperimental</td>
<td>4 RN Direct structured observation and audio-recording</td>
<td>Rate: Bedside nurses: 2 WI/4 h 12 min = 0.5 WI/h  Charge nurses: 15 WI/4 h 13 min = 3.6 WI/h</td>
</tr>
<tr>
<td>Hedberg and Larsson (2004), Sweden</td>
<td>Mixed</td>
<td>To explore environmental elements related to the decision-making process in nursing practice.</td>
<td>Qualitative</td>
<td>6 RN Direct unstructured observation</td>
<td>Rate: 85 WI/30 h = 2.8 WI/h Source: Nursing assistant: 27% Family: 25% Primary activity: Medication administration 29%</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>AUTHOR’S COUNTRY</th>
<th>SETTING</th>
<th>OBJECTIVE</th>
<th>DESIGN</th>
<th>DATA COLLECTION</th>
<th>KEY FINDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luketich et al. (2002), USA</td>
<td>OR</td>
<td>To assess the impact of voice recognition technology during a surgical procedure on operating room efficiency and user satisfaction.</td>
<td>Quasi experimental</td>
<td>Not reported 30 OR cases observed Direct structured observation</td>
<td>Results: Average WI to adjust surgical with and without new technology: Control: 15.3 WI per OR case Intervention: 0.33 per OR case Statistically different Rate: 160 WI/1,870 min = 5.1 WI/h Sources: Patient/family 26.4% Local staff 23.6% Interrupted by phone 21.7%</td>
</tr>
<tr>
<td>Lyons Brown et al. (2007), UK</td>
<td>ED</td>
<td>To objectively evaluate the organisation of triage and what issues may affect the effectiveness of the process.</td>
<td>Nonexperimental</td>
<td>15 RN Direct structured observation</td>
<td>Rate: 160 WI/1,870 min = 5.1 WI/h Sources: Patient/family 26.4% Local staff 23.6% Interrupted by phone 21.7%</td>
</tr>
<tr>
<td>Manias et al. (2002), Australia</td>
<td>Surgical</td>
<td>To investigate the effectiveness of the observation method in exploring nurse–patient interactions for pain assessment and management in hospitalized postsurgical patients, and to identify barriers that surround nursing pain management decisions.</td>
<td>Qualitative</td>
<td>12 RN Direct unstructured observation</td>
<td>Rate: 247 WI/24 h = 10.3 WI/h Sources: Seeking items 33.6% Assisting nurses with procedures 13.4% Answering telephone calls 15.0% Interrupting or being interrupted by others 38.1%</td>
</tr>
<tr>
<td>McLean (2006), UK</td>
<td>Medical</td>
<td>To try reduce medication errors through a three-phased approach: (1) reduce interruptions to the round, (2) introduce a system of double-checking, and (3) introduce an additional level of drug expertise than may normally be found on a busy medical ward.</td>
<td>Nonexperimental</td>
<td>RN sample not reported Direct structured observation</td>
<td>Rate: 99 WI/1,261 min = 4.7 WI/h</td>
</tr>
<tr>
<td>Medland and Estwing Ferrans (1998), USA</td>
<td>ICU</td>
<td>To test a structured communication program for family members to determine whether the program would . . . decrease disruption for the ICU nursing staff caused by incoming telephone calls from patient’s family members.</td>
<td>Quasi experimental</td>
<td>30 family members (15 per group) Self-report</td>
<td>Source: Single interruption source: incoming phone calls. Control group: 3.26 phone calls per day. Intervention group: 0.33 phone calls per day. Difference statistically significant t (14) = 5.88, p = &lt; 0.0001</td>
</tr>
<tr>
<td>AUTHOR’S COUNTRY</td>
<td>SETTING</td>
<td>OBJECTIVE</td>
<td>DESIGN</td>
<td>DATA COLLECTION</td>
<td>KEY FINDINGS</td>
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</tbody>
</table>
| Pape (2003), USA | Med-surg | To measure the effect of two targeted interventions based on airline industry measure for decreasing nurses' distraction during medication administration. | Quasi experimental | 24 RN Direct structured observation | Rate:  
Control group: 60.5 distractions per MAC  
Focused protocol: 22.5 distractions per MAC  
Focused protocol + vest: 8 (SD = 4.5) per MAC  
Significant difference among experimental groups $F(2, 23) = 68.229$, $p < 0.0001$.  
Source of interruptions for control group:  
MD 2.9%  
Other person 31.8%  
Phone call 3.8%  
Other patient 4.8%  
Visitor 2.9%  
Missing medication 3.9%  
Wrong dose medication 0.0%  
Emergency situation 1.0%  
External talking 32.0%  
Loud noise 6.2% |
| Pape et al. (2005), USA | Mixed | To measure the effect of an intervention to reduce nurses’ distraction. | Preexperimental | 20 RN Self-report measure developed by author | Less perceived distractions postintervention ($t = -14.33$, $df = 19$, $p < 0.0001$). |
| Paxton et al. (1996), UK | Primary care | Compare rate and perception of interruptions experienced by practice nurses before and after change in physician practice. | Nonexperimental | 34 RN Self-report | Rate =  
Phone: 15.7 WI / 100 consultations  
Person: 32.7 WI / 100 consultations |
| Potter et al. (2005), USA | Mixed | To analyze the nature of nurses’ cognitive work and how environmental factors create disruptions that pose risks for medical errors. | Mixed | 7 RN Direct structured observation | Rate:  
Human factor definition: 261 WI/43 h = 6.1 WI/h  
Nurse researcher definition: 151 WI/43 h = 3.5 WI/h  
Location: Medication room: 22% |
### Table 5 (Continued)

<table>
<thead>
<tr>
<th>Author's Country</th>
<th>Setting</th>
<th>Objective</th>
<th>Design</th>
<th>Data Collection</th>
<th>Key Findings</th>
</tr>
</thead>
</table>
| Scott-Cawiezell et al. (2007), USA | Nursing home | To determine the impact of various levels of credentialing among nursing home staff who deliver medications (RN, LPN, or CMT/A) on medication error. | Nonexperimental | 8 RN 12 LPN Direct structured observation | RN medication administration error rate:  
With wrong time errors: 34.6%  
Without wrong time: 7.4%  
Distraction rate: 2,200 distractions/4,803 min = 27.5 distractions/h⁻¹  
Association between WI and MAE: Increased interruptions are associated with increased medication error rates when wrong time errors are excluded (p = 0.0348).  
Secondary task: Results not specific to nurses  
Irrelevant conversation by team staff 27.0%  
Irrelevant conversation by external staff 17.4%  
Next patient 13.2%  
Other patient/list 9.0%  
Teaching 9.0%  
Equipment/provisions 8.4%  
Irrelevant conversation by attending staff 5.4%  
Phone calls/bleeps 4.8%  
Previous patient 2.4%  
Unclear 3.6%  
Intensity of distraction: Case-irrelevant communications (CIC) related to equipment and provisions are more distracting than irrelevant comments/queries (p < 0.01), more distracting than patient-related CICs (p < 0.05), and more distracting than teaching (p < 0.01). |
<p>| Sevdalis et al. (2007), UK | OR | To describe the content, initiators, and recipients of communications that intrude or interfere with individual surgical cases. Development of a distraction intensity scale. | Nonexperimental | RN sample not reported. Event sampling: 48 general surgical procedures. Direct structured observation |  |</p>
<table>
<thead>
<tr>
<th>AUTHOR’S COUNTRY</th>
<th>SETTING</th>
<th>OBJECTIVE</th>
<th>DESIGN</th>
<th>RN SAMPLE</th>
<th>DATA COLLECTION</th>
<th>KEY FINDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spencer et al. (2003), Australia</td>
<td>ED</td>
<td>To determine whether there are differences in role-related communication patterns in the ED.</td>
<td>Nonexperimental</td>
<td>4 RN</td>
<td>Direct structured observation and audio-recording</td>
<td>Rate: Nurse shift coordinators: 24.9 (95% CI 21.9–27.9) WI/h. Nurses with an allocated patient load: 9.2 (95% CI 6.9–11.4) WI/h. <strong>Secondary task:</strong> Indirect patient management: 36% (most frequent) <strong>Duration:</strong> Average duration: 53 sec <strong>Rate:</strong> 7.5 WI/h <strong>Duration:</strong> Average duration: 45 sec <strong>Reasons:</strong> The need to attend to specific patients (i.e., focused monitoring): 87.2%.</td>
</tr>
<tr>
<td>Tang et al. (2007), USA</td>
<td>ICU</td>
<td>To investigate workflow in intensive care unit remote monitoring.</td>
<td>Nonexperimental</td>
<td>7 RN</td>
<td>Direct structured observation</td>
<td>Rate: 7.5 WI/h <strong>Duration:</strong> Average duration: 45 sec <strong>Reasons:</strong> The need to attend to specific patients (i.e., focused monitoring): 87.2%.</td>
</tr>
<tr>
<td>Tucker and Spear (2006), USA</td>
<td>Mixed</td>
<td>To describe the work environment of hospital nurses with particular focus on the performance of work systems supplying information, materials, and equipment for patient care.</td>
<td>Mixed</td>
<td>11 RN</td>
<td>Direct unstructured observation</td>
<td>Rate: 85 WI/108 h 18 min = 0.8 WI/h <strong>Results:</strong> Significant reduction in WI for nurses with the new reconstitution method: F(2, 29) = 10.54, p = 0.0001 <strong>Rate:</strong> 836 WI/20 h = 41.8 WI/h</td>
</tr>
<tr>
<td>Turner et al. (2003), UK</td>
<td>Surgical</td>
<td>To investigate the feasibility of replacing a standard method of intravenous antibiotic reconstitution.</td>
<td>Quasi experimental</td>
<td>RN sample not reported</td>
<td>Direct structured observation</td>
<td></td>
</tr>
<tr>
<td>Woloshynowycz et al. (2007), UK</td>
<td>ED</td>
<td>To identify the features of the communication load on the nurse in charge of the ED.</td>
<td>Nonexperimental</td>
<td>11 RN (nurse in charge)</td>
<td>Direct structured observation and audio-recording</td>
<td></td>
</tr>
</tbody>
</table>

ICU = intensive care unit; WI = work interruptions; ED = emergency department; MAC = medication administration cycle; CMT/A = certified medication technician/aides.

aMixed involves at least two different type of nursing units.
bSample constituted of RN, LPN, and CMT/A.
Sample Representativeness
Half of the quantitative samples included 10 or fewer nurses. A convenience sampling strategy, when reported, was used in all quantitative studies except one. Only two studies (Manias et al. 2002; Tang et al. 2007) provided information on the recruitment rate to estimate nursing sample representativeness. Six of nine studies that adopted an event sampling strategy (as opposed to a time sampling strategy) did not describe the participants.

Work Interruption Measurement
Another common limitation of the studies reviewed relates to the way work interruptions are measured. Distinct definitions, when present, were used to operationalize work interruptions. Frequently, the selected definition clearly influenced the actual rates of observed interruptions. In one study, observations were performed simultaneously by two researchers using two different definitions; as a result, the two researchers’ interruption rate estimates are different (5.9 per hour compared to 3.4 per hour; Potter et al. 2005). Others used the terms “work interruptions” and “distractions” interchangeably (Pape 2003).

An additional issue related to quantifying nursing work interruptions is the number of interruption sources considered. Some authors examined a single source (Medland & Ferrans 1998), whereas others focused on communication interruptions, which by definition are initiated by another person (Spencer et al. 2004). Certain authors considered the nurses’ patients as a source of interruption (Hedberg & Larsson 2004) while others did not (Pape 2003). As regards the definition selected, the number of sources lessened the ability to compare results among studies.

Once a definition was selected and the sources carefully considered, data should be reliably collected. Most studies relied on direct observation to collect work interruption data. Estimates of observer agreement are reported only by Spencer et al. (2004) and Pape (2003), using percentage agreement. The absence of reported reliability estimates and other preidentified quality issues serves to weaken the inferences that can be drawn from this review. The results presented in the upcoming sections should be considered accordingly.

Interruption Rate
By pooling the data from 14 studies reporting both work interruption frequency and total length of observation, the interruption rate is estimated at 6.7 per hour (range 0.8–41.8). This number is based on a total of 2,622 work interruptions and 402.5 hours of observation. Furthermore, all 14 studies on which this estimate is based measure work interruptions through direct observation along with the multiple interruption sources considered. These quality criteria were selected to maximize the validity of the estimate.

Characteristics of Work Interruptions
Interruptions have been characterized according to interruption source, the channel through which the work interruption is conveyed, the task being performed when interrupted (primary task), the requested task by the interrupting source (secondary task), duration, and location. Interestingly, work interruption characteristics are less studied than nurses’ actual rate of work interruptions. The paucity of evidence on work interruption characteristics precludes data synthesis, therefore, a descriptive approach was used. Unless otherwise specified, the evidence presented applies to nursing work in general and is not specific to medication administration.

Sources
The sources of work interruptions represent the persons or inanimate objects that initiate them. Two broad categories are present among the reviewed studies: individuals (e.g., health care professionals, patients, family members) and technical (e.g., missing equipment, alarms). Some studies focused on the individual, others on the technical; others include both categories.

In the individual category, the most frequent source of interruption is nursing staff (RNs and assistants), accounting for 36.5% of all interruptions experienced by nurses (Hedberg & Larsson 2004). Patients initiated fewer interruptions compared to other nurses, with reported proportions of 24.7% (Hedberg & Larsson 2004) and 26.4% (Lyons et al. 2007), respectively. A considerably lower proportion of 4.7% of work interruptions initiated by patients is also reported (Pape 2003). The latter result is partially explained by the exclusion of patients under nurses’ care as a source of work interruptions.

On the other hand, technical sources of work interruptions include alarms originating from inanimate objects (Hedberg & Larsson 2004) and operational failures, that is, “the inability of the work system to reliably provide information, services, and supplies when, where, and to whom needed” (Tucker & Spear 2006, p. 646). A nurse participant’s inability to find an intravenous (IV) pump to administer total parental nutrition (TPN) to a patient is an example of work interruption due to operational failure (Tucker & Spear 2006). The proportion of all work interruptions with a technical source varies between 4.5% (Tucker & Spear 2006) and 13% (Hedberg & Larsson 2004).

One issue to consider when examining work interruption sources is the erroneous inclusion of the telephone as a source of interruption. The caller and not the telephone...
should be considered the source, since it is the caller who initiates the phone call; the telephone is simply a communications channel. By implication, studies considering the telephone as a source of interruptions have generally underestimated the frequency of work interruptions initiated by other individuals. It is therefore safe to state that a majority of interruptions are initiated by nurses themselves and other members of the nursing team, although a nonnegligible number of interruptions have a technical source.

Channel
The channel is the medium through which work interruptions are conveyed. Face-to-face interactions, telephones, and pagers are examples of the different channels reported when the interruption source is an individual. Technical channels usually refer to inanimate objects like vital signs monitoring devices (Tang et al. 2007). Work interruption channels whose source is an individual have not been explicitly reported among studies included in this review. However, based on the results of four studies, it can be deduced that the most important channel to convey work interruptions is face-to-face interaction (Coiera & Tombs 1998; Coiera et al. 2002; Spencer et al. 2004; Alvarez & Coiera 2005). Work interruptions are, as defined in these four studies, communication events in which a synchronous channel is used. A synchronous channel is “when two parties exchange messages across a communication channel at the same time” (Spencer et al. 2004, p. 270). Face-to-face interactions are the most important synchronous communication channel in these studies, representing at minimum 87% of all communication channels used (Coiera & Tombs 1998, Coiera et al. 2002, Spencer et al. 2004, Alvarez & Coiera 2005).

Primary Task
The primary task characteristics describe the activities that nurses are performing when interrupted. Evidence on primary task characteristics enables a determination of whether some nurses’ activities are more at risk of interruption than others. One study provides evidence on primary task characteristics (Hedberg & Larsson 2004). Most work interruptions occur during direct patient care (62%) as opposed to indirect care (32%) (Hedberg & Larsson 2004). Medication administration is the most interrupted nursing activity, with 29% of all work interruptions occurring during this activity (Hedberg & Larsson 2004). Documentation is the next most frequent interrupted nursing activity, representing 14% of all work interruptions (Hedberg & Larsson 2004). Work interruptions among the remaining nursing care activities were approximately equally divided.

Secondary Task
The secondary task characteristics describe what the nurse is asked to do when interrupted. The secondary task characteristics of interruptions have rarely been quantitatively described, with the exception of Spencer et al. (2004), who report that indirect (36%) and direct patient care (28%) constitute the bulk of secondary tasks for nurses with an allocated patient load (Spencer et al. 2004). In support of these findings, Hedberg and Larsson (2004) provide a qualitative description of the main characteristics of secondary tasks. These include exchange of information, instructions and assistance. They state: “The patient, the relatives of the patient and the staff interrupted the nurses when they wanted information from her or when they wanted to inform the nurse of something they felt was important about treatments, examinations or discharge planning” (Hedberg & Larsson 2004, p. 319). Based on these results, indirect patient management seems to characterize most of the secondary tasks related to interruptions.

Duration
Duration refers to the length of the interruption, usually expressed in minutes or seconds. Whereas Spencer et al. (2004) report a mean work interruption duration of 1 minute and 22 seconds, Tang et al. (2007) report a mean duration of 45 seconds. From these results, the interruption duration appears relatively short.

Nurses’ Locations When Interrupted
Location describes the physical environment in which nurses are located when interrupted. Evidence on nurses’ locations when interrupted is scarce. The most frequent location seems to be the medication room, which accounts for 22% of all interruptions (Potter et al. 2005). Some medication rooms, designed as open spaces where nurses are “at hand,” may promote interruptions (Hedberg & Larsson 2004). The preparation of medication using a wall-mounted cupboard in each patient’s room results in 64% fewer work interruptions compared to a medication cart, supporting the argument that open spaces (medication room, hallway) are more prone to work interruptions (Bennett et al. 2006).

In summary, interruptions are characterized as being initiated mainly by nurses themselves and other members of the nursing team, conveyed through face-to-face interactions, occurring for patient management purposes, and are of short duration. There is some evidence that medication administration is the most interrupted nursing activity, especially in the room where medications are prepared. A summary table presents studies containing evidence on the characteristics of interruptions applicable to nurses (Table 6). This table makes explicit that frequency and
TABLE 6
Studies reporting characteristics of interruptions

<table>
<thead>
<tr>
<th>STUDY</th>
<th>FREQUENCY</th>
<th>SOURCE</th>
<th>CHANNEL</th>
<th>PRIMARY TASK</th>
<th>SECONDARY TASK</th>
<th>DURATION</th>
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<td>Alvarez et al. (2005)</td>
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<td>Bennett et al. (2006)</td>
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<td>Coiera et al. (2002)</td>
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<td>Ebright et al. (2003)</td>
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<td>Fairbanks et al. (2007)</td>
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<td>Hedberg et al. (2004)</td>
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<td>Lyons et al. (2007)</td>
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<td>Manias et al. (2002)</td>
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<td>McLean (2006)</td>
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<td>Pape (2003)</td>
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<td>Tang et al. (2007)</td>
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<td>Tucker and Spear (2006)</td>
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Interruptions as a Contributing Factor to Medication Administration Errors

Among the literature reviewed, one nonexperimental quantitative study specifically addresses interruptions as a contributing factor to medication administration errors (Scott-Cawiezell et al. 2007). The overall aim of the study was to determine the impact of various levels of educational preparation on medication error. Based on a sample of 39 participants (12 RNs, 8 LPNs, and 19 certified medication technician/aides) and using direct observation to collect data on both work interruptions and the rate of medication administration errors, a significant positive association between interruptions and rate of medication errors is present when the wrong time category is excluded (\( p = 0.01 \)). The relationship is also present and significant (\( p = 0.04 \)) between work interruptions and the rate of medication errors when wrong time medication errors are included but the relationship is inverse.

Scott-Cawiezell and colleagues (2007) are among the first to show quantitative evidence showing interruptions as a contributing factor to medication administration errors. The fact that data were collected using direct observation both for work interruptions and the medication administration errors increased the validity and reliability of the results. Previous attempts to examine contributors of medication administration errors have been almost exclusively based on secondary data analysis of administrative databases; this constitutes an important limitation (White & McGillis Hall 2003). Error underreporting partially explains this situation (Wakefield et al. 1999; Flynn et al. 2002). On the other hand, information supporting sample representativeness and reliability estimates for interruptions and medication administration errors measures are absent in most studies included in this review. Moreover, no other contributing factors except for educational background were considered. The study was not specifically designed to examine the relationship between work interruptions and medication administration errors that could potentially explain the absence of other contributing factors.

DISCUSSION

The main objective of this review was to identify evidence on work interruptions, their rate of frequency, characteristics, and contribution to medication administration errors, which goes beyond data obtained through surveys. The results of this review are discussed around three main themes: the quality of the reviewed studies, the contribution of interruptions to medication administration errors, and possible avenues for interventions aimed at reducing work interruptions in nursing practice.

Quality of the Reviewed Studies

Shortcomings are present at conceptual and methodological levels among the reviewed studies. From a conceptual perspective, the results of this review indicate two main problems: the diversity of definitions of work
interruptions, and the absence of a theoretical framework on work interruptions and how they potentially contribute to medication administration errors.

Efforts need to be made to better define interruptions. This is a prerequisite to further knowledge development. In this review, two main conceptualizations of interruptions are present. One is task oriented and defined by its adherents as “an activity that stops the RN from performing an immediate task” (Potter et al. 2005, p. 332). The alternate conceptualization is communication oriented and defines interruptions as “a communication event in which the subject did not initiate the conversation and in which a synchronous channel was used” (Spencer et al. 2004, p. 270). The choice of either conceptualization is dependent, in part, on the objective being pursued.

One could argue that a task-oriented conceptualization of interruptions might be preferable for two reasons. A task-based perspective considers all sources of interruptions present in the work environment. A communication-oriented conceptualization only considers communication events initiated by another individual, leaving aside technical sources of work interruptions such as system glitches and alarms, which are nonnegligible factors of interruptions (Hedberg & Larsson 2004). In addition, a task-based orientation takes into account the duration of not only the communication event (e.g., “Could you please take a blood sample?”), but also the time required to accomplish the secondary task (taking the sample). Together with the work interruption frequency, the duration of the secondary task has been hypothesized to have a negative impact on task performance (Gillie & Broadbent 1989).

Efforts also need to be made to improve the methodological quality of studies on interruptions. Sample size and representativeness as well as how work interruptions are measured are recurrent issues among quantitative observational studies reviewed, and need to be addressed to move research forward. Sample size could be increased to promote the external validity of the results and greater attention to sample size determination through power analysis would help address this. Participation rates and the characteristics of the sample should be provided in addition to sample size justification. Observational studies are vulnerable to selection bias. Providing information on sample and, when possible, population characteristics helps in an evaluation of the extent to which the risk of bias might be present (Higgins & Green 2008).

Direct structured observation should be the privileged data collection method for interruptions over unstructured observation and self-report. Unstructured observation is less reliable when the objective is to determine nurses’ work interruption frequencies (Bakeman 2000). Self-report, on the other hand, could be considered unsuitable due to work interruption pervasiveness and frequency, rendering nurses’ capacity to recollect their occurrences limited (Marsch et al. 2005). Reliability estimation is absent in most studies despite interobserver agreement being considered a sine qua non condition to observation-based research (Bakeman 2000). Interobserver agreement helps to evaluate inconsistencies in findings from different observers who collect basically the same information (Shoukri et al. 2004).

Interobserver agreement is mainly estimated using either percentage agreement or the kappa statistic. Percentage agreement is the ratio of the number of occasions both observers agree the behavior occurred to the sum of those occasions plus occasions on which they disagreed (Birkimer & Brown 1979). Pape (2003) claimed to have achieved above 90% reliability, but this result was obtained based on the total frequency of distractions and not by determining agreement for each distraction occurrences (Baer et al. 2005). Percentage agreement is certainly one positive step toward better reliability reporting, but percentage agreement tends to overestimate agreement because it does not account for agreement that would be expected purely by chance (Sim & Wright 2005). For this reason, the Kappa statistic should be preferred (Landis & Koch 1977) because a chance-corrected index of agreement indicates the proportion of agreement beyond that expected by chance.

**Contribution of Interruptions to Medication Administration Errors**

Limited empirical evidence exists on the contribution of interruptions to medication administration errors. One nonexperimental study examines the potential contribution of interruptions to medication administration errors and its results are supportive of such contribution (Scott-Cawiezell et al. 2007). Here, the dearth of evidence is similar to other published reviews on the contributing factors to medication administration errors (Carlton & Blegen 2006), which reiterates the need for research in this area. This is particularly important, since the evidence reviewed indicates that medication administration could be at particular risk from work interruptions. The production of new research evidence will require more robust methods to adequately inform future directions in practice, research, and policy.

Reality is complex; interruptions do not take place in a vacuum, but are situated in a context (Briey et al. 2007). Interruptions are one of the potential contributors to medication administration errors. Safety culture (Aspden 2007), nursing leadership (Wong & Cummings 2007), the number of hours worked by nurses (Rogers et al. 2004), their workload (Tissot et al. 2003), and medication
administration complexity (Scott-Cawiezell et al. 2007) have also been identified as potential contributory factors. The inclusion of these emerging contributing factors in future studies would enable an estimate of the relative contribution of interruptions compared to other contributors through multivariate statistical analysis. This will facilitate the prioritization of efforts toward reducing the number of medication administration errors by prioritizing the greatest contributors. Furthermore, the inclusion of other potential contributors will offer evidence on the contextual factors under which interruptions are most detrimental.

Another potential means of limiting the detrimental effect of interruptions on medication administration is by reducing their frequency. This requires a better understanding of their characteristics, and thus the need for descriptive research on interruptions. Evidence on secondary task characteristics that examines the reasons for interruptions is especially needed. Such evidence will help determine the work interruptions that are avoidable. Another strategy to minimize the potential detrimental effect of interruptions is to examine how nurses manage them. Different options are available to the interrupted nurse: he or she can execute the secondary task immediately, negotiate it, or mediate it through another individual with a filtering function (McFarlane & Latorella 2002). No studies to date report quantitative evidence on the strategies employed by nurses to manage work interruptions. Manias et al. (2002) and Hedberg and Larsson (2004) both identify the tendency for nurses to immediately respond to work interruptions; a tendency that might not be the most effective way to minimize the detrimental effects of these interruptions. Evidence on interruption management strategies to maximize medication administration safety is especially needed, as some work interruptions will remain despite efforts to reduce them.

Intervening on Work Interruptions

Work interruptions are frequent. This review identified evidence that nurses are, on average, interrupted every 9 minutes, with some evidence supporting a detrimental effect on medication administration practices leading to errors. Efforts to reduce work interruptions due to work system failures could certainly be deployed, since they are theoretically avoidable (Tucker & Spear 2006). An example of work system failures applied to medication administration is missing medication, a recurrent problem faced by nurses (Hurley et al. 2007). When a medication is missing, the nurse has to interrupt her medication administration to locate or to communicate with the pharmacy, and remember to administer it at a later time.

Some work interruptions initiated by another person can also be reduced. The intervention described by Pape (2003) is an example that directly targets distraction during medication administration. One of these interventions was for nurses to wear a red vest with the inscription, “Medsafe Nurse, Do Not Disturb,” while administering medications. Proactive communication strategies to meet information needs of family members in ICU and thus reduce the number of incoming calls are another example of how work interruptions can be minimized. Interventions should target work interruptions more than distractions, since the detrimental effect of the former would appear to be greater than the latter.

Despite any interventions implemented, work interruptions will remain a part of nursing work, due to its very nature. Patients’ conditions are constantly changing and adjustments to treatments are consequently required. Members of interprofessional teams need to communicate information about patient management, making a certain number of work interruptions unavoidable. This situation results in error-producing conditions, as described by Reason’s Human Error Model (Reason 1990), leading to errors that could conceivably affect the patient if not intercepted by a defence barrier. Defence barriers as safeguards (e.g., double-checks) occupy a key role in a system perspective on error prevention. Consequently, it becomes important to implement these defence barriers to maximize patient safety considering that the work interruptions will likely remain despite efforts aimed at reducing their occurrences.

LIMITATIONS

This literature review has some limitations. First, the search strategy relied on keywords to identify articles that address interruptions, since there are currently no subject headings that apply to this concept in the databases searched. Keywords used were “interruptions” and “distractions.” It is possible that some papers may have been missed due to the decision to retain only these keywords. However, the identification of 415 articles for review, along with the search of reference lists of the included articles, makes it less probable that any major studies on nursing interruptions were missed. Second, data were extracted by a single reviewer. This data extraction process might lead to bias, although results have been discussed extensively among the authors.

IMPLICATIONS

The following implications for research and practice are formulated based on this review of the evidence regarding the rate of work interruptions in nursing practice, their
characteristics, and their contribution to medication administration errors.

Further research is needed to better document the contribution of work interruptions to medication administration errors, considering the limited evidence found. Full consideration should be given to how work interruptions are embedded in a cluster of factors that best predict medication administration errors. Future research should demonstrate improved methodological rigor that includes a precise definition of the concept of work interruptions, which translates into a clear operationalization of what is to be reliably measured. Concurrently, descriptive studies are also needed to better understand work interruption characteristics such as their sources, interrupted primary task, secondary task, duration, and work interruption strategies employed by nurses.

A better understanding of work interruption characteristics will inform frontline nurses and administrators to develop effective interventions to reduce the number of work interruptions experienced by nurses. Meanwhile, two avenues have already been identified from this review. Work interruptions resulting from work system failures (e.g., missing medications) represent a prime target of intervention because they are theoretically avoidable. Another avenue is the implementation of defence barriers (e.g., double-checks) that are critical for the prevention of medication administration errors from reaching patients, considering that certain work interruptions may be unavoidable.

**CONCLUSIONS**

Evidence so far shows that nurses’ work environment is characterized by frequent work interruptions that are initiated mostly by members of the nursing team, that consist mainly of face-to-face interactions, that are mainly for patient management purposes, and that are of short duration. Limited evidence exists on whether these work interruptions actually contribute to medication administration errors. This observation calls for further studies that will require a comprehensive approach through the inclusion of other emerging, key contributing factors to medication administration errors. Such evidence is urgently needed to develop effective prevention strategies.

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Contribution of Interruptions to Medication Errors

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