Interruptions during hospital nurses' medication administration rounds

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Abstract

Medication administration errors are common, costly and the cause of adverse events in clinical practice. Interruptions during medication administration rounds are thought to be a prominent causative factor of these medication errors. In this observational study, data were collected on the number and duration of several different sources of verbal and non-verbal interruptions using unobtrusive structured observations on 32 medication administration rounds. Interruptions occurred very often (6.9 times per nurse each hour), differed in frequency among the medication administration rounds and were from a variety of sources. The most frequent interruptions were caused by nursing colleagues (43%) and non-verbal interruptions from the ward environment (25%), such as noises from pagers, conversations in the vicinity of the nurse, the work of cleaners, or stock management by pharmacy staff. The longest durations of interruptions were from nursing colleagues' verbal interruptions. When comparing the medication rounds, more and longer interruptions were observed during the morning rounds than those at noon. A comparison between surgical and non-surgical units showed that interruptions occurred more often and lasted longer in non-surgical units than those in surgical units. But the observed differences were not statistically significant. In conclusion, interruptions during medication administration rounds are frequent and originated from different human and environmental sources. Interventions should target not only interruptions by colleagues, but should also consider ways to reduce self-initiated interruptions and those arising from the immediate ward environment.

Introduction

The most common type of errors and pre-

ventable cause of adverse events is medication errors (MEs).¹ An ME is defined as *any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient or consumer*.² MEs are found at every stage of the medication process, with one-third of them being associated to medication preparation and administration procedures.³⁻⁵ On top of these alarming numbers, it is also known that only 2% of the MEs have been reported.^{4,6,7}

Medication administration is predominately the responsibility of the nursing staff and can be considered a nursing activity at high risk of errors. Many different factors contribute to MEs, including nurse's workload, time of duty shift, years of nursing experience, and system deficiencies.^{8,9} When nurses are surveyed, interruptions during medication administration appear to be one of the prominent causative factors of MEs.¹⁰⁻¹³

In the landmark report *To err is human*, the Institute of Medicine was among the first to suggest that interruptions could contribute to medical errors.¹⁴ In general, interruptions are recognized as conditions that reduce efficiency and productivity and contribute to errors in clinical practice.¹⁵ Westbrook and colleagues found that each interruption was associated with a 12.1% increase in procedural failures and a 12.7% increase in clinical errors.¹⁶ In a mixed methods study of the effect of interruptions on nurses' cognitive performance, medication preparation and administration procedures took up 16% of the nurses' working time. Furthermore, they also found that a high percentage of interruptions (22%) occurred in medication rooms during preparation.¹⁷ These findings suggest that interventions are needed to eliminate or reduce interruptions that occur during the medication preparation and administration process. However, insights into the sources and characteristics of interruptions are needed before any intervention is designed. A systematic review by Biron and colleagues on the contribution of interruptions to medication administration errors found that studies should have demonstrated more methodological rigor through a more precise definition of interruptions and reliability reporting.¹⁸ Furthermore, most studies on interruptions are not specific to medication administration rounds (MARs), but are only applied to nurses' work in general or performed in intensive care units. Therefore, the evidence available so far on the characteristics of interruptions is limited to their frequencies from some important sources and is not specific to MARs in general nursing units.¹⁸ A better understanding of the characteristics and sources of interruptions during MARs would make it possible to tailor possible interventions in such a way that they most likely will

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have a significant impact on reducing interruptions and promote safe medication administration.

The aims of this study are: i) to examine the frequency and duration of interruptions and distractions during the daytime MARs (from medication preparation to administration) in the nursing units of an academic hospital; ii) to identify the causes of the interruptions and distractions; and iii) to compare any differences in the interruptions between surgical and non-surgical units.

Materials and Methods

Setting

The Academic Medical Center (AMC) is an 1024-bed tertiary care university teaching hospital in Amsterdam, The Netherlands. Medications at the study units were stored in a single medica-

tion preparation room that was usually centrally located within the unit. Based on the physicians' prescriptions, nurses would prepare medications for their assigned patients either in medication rooms or in the corridor at standard or routine times (mainly at 8 a.m., 12 a.m., 6 p.m., and 10 p.m.). Preparation could involve collecting the medications from stock in the unit, checking them appropriately against the prescription sheets and mixing them for intravenous administration. After preparation, nurses would distribute and administer the medications to their assigned patients one by one.

Study design

Unobtrusive, structured observations of the MARs were used to obtain data on frequency and duration of the interruptions in the study units.^{19,20} The observed nurses were not aware of the actual specific aim of the observations in order not to influence their behavior and thus create performance bias. During the study briefing, the researchers stated that the medication administration process would be observed but gave no indication that the observations would be focused on interruptions. The nursing managers were informed of the purposes of the study and agreed to participate. Therefore, this study used unobtrusive observation of the behaviors of the nurses and their actions with their surrounding people and events during the MARs.^{21,22}

Sample and data collection procedure

Since day shifts in clinical units are the most hectic and are most likely to be subject to interruptions and distractions, the decision was made to observe the MARs in the morning (8 a.m.) and at noon (12 a.m.). Based on similar sample sizes of the morning and noon MARs of two previous studies, we decided that the observation of 32 MARs would be sufficient for our study purposes.^{23,24} To be able to estimate inter-observer agreement during the study period, 2 observers measured the same MAR every two days. This added an extra seven observations for a total of 39. The data collected for the purpose of inter-observer agreement could only be used once for the primary end points. One observation was randomly chosen by blinded draw for inclusion in the analysis. In each MAR, the duration of measurement was 60 min to ensure homogeneous results for better comparability between all observed MARs. Observations were performed on weekdays in a 2-week period by 2 senior baccalaureate nursing students. The medication trolley was used as the site of measurement and as a consequence of this the observations were made in the medication room, as well as in the corridor. Whenever a nurse would enter a patient room with the medication, the observer would not follow but remain at the location of the medication trolley.

Definitions and evaluation criteria

An interruption or a distraction was defined as both an event initiated by another professional(s) or something else, and when a nurse interrupted him- or herself. In this review, the term interruption will be used for distractions as well as for interruptions. In addition, the kind of interruptions nurses experience was of interest. Again, based on the same previously published studies, data were collected on eight different categories of interruptions.^{23,24} These categories of interruptions were grouped into either verbal or non-verbal interruptions, resulting in the following categories: verbal or non-verbal interaction with a colleague, verbal or non-verbal interaction with a patient, verbal or non-verbal interaction with another person, non-verbal interaction with the environment, non-verbal logistical events. Table 1 shows how each category is defined. A paper-based data collection form was developed to record interruption characteristics: source of the interruption, duration of the interruption in seconds, location of the interruption (medication room or corridor), and category of the interruption. Other collected data were: morning or noon round, surgical or non-surgical unit. Data concerning the gender and level of training of the nursing staff (registered nurse, RN) were also collected. The data collection form was validated by a nested inter-observer agreement study of the 2 observers. The inter-class correlation coefficient (ICC) was used to determine inter-observer agreement. Inter-observer agreement concerns whether or not an interruption occurs at a certain time and how long it lasts. A two-way fixed model was used to determine the inter-class correlation for each category of interruption. For the number of interruptions for each of the eight categories, six categories scored an ICC higher than 0.9, one category scored 0.5 (non-verbal colleague), and one category scored 0.8 (verbal patient). For the dura-

tion of the interruptions, all eight categories scored an ICC higher than 0.9. Therefore it was concluded that there was high inter-observer agreement.

Data analysis

Data were entered into an MS-Excel spreadsheet by 2 observers (ED and FO) and cross-checked. The spreadsheet data were checked with the original data formed the third time by a third researcher (MS) using SPSS 16.0 software (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to calculate the number and duration of the interruptions. Due to a skewed distribution of the data, the medians and interquartile ranges (IQR) were used to describe the spread of the data set. The IQR represented the difference between the first and third quartile of each set of data. Non-parametric Mann-Whitney U tests were used to compare the interruptions between the surgical and non-surgical units, and between the morning and noon MARs.

Ethical approval

Ethical approval was not considered necessary by The Institutional Review Board of the Academic Medical Centre at the University of Amsterdam, according to the Dutch Medical Ethics Law (*i.e.*, a letter of exemption had been received from the Review Board could be requested from the authors).

Results

A total of 39 medication rounds were observed over a 2-week period during which 32 observations were included for analysis (16 morning and 16 noon rounds, 15 non-surgical and 17 surgical MARs). Ten different nursing

Table 1. Categories of interruptions.

Category	Description
Verbal colleague	Colleague initiates a dialog with nurse preparing/administrating
Verbal person	Nurse preparing/administrating initiates a dialog
Verbal patient	Patient initiates a dialog with nurse preparing/administrating
Non-verbal colleague	Colleagues initiates a non-verbal interruption, <i>e.g.</i> getting supplies in the vicinity of the nurse who is preparing/administrating
Non-verbal person	Nurse preparing/administrating initiates an interruption, <i>e.g.</i> by helping a colleague or responding to a pager
Non-verbal patient	Patient initiates non-verbal interruption, <i>e.g.</i> by coming into the vicinity of the nurse preparing/administrating
Non-verbal surrounding	Surrounding environment of the nurse initiates interruption, <i>e.g.</i> noises from pagers, conversations in the vicinity of the nurse, cleaners or stock management by pharmacy staff
Non-verbal logistics	Missing supplies for preparing the medications initiate an interruption in the activities of the nurse preparing/administrating

units were observed (Table 2) for a total of 172 nurses. Participants were mostly female ($n=144$) and two-thirds of the nurses were RN level four or five ($n=118$). In most of the cases medication was prepared in the medication room, resulting in 19 observations in that setting, in four cases medications were prepared in the corridor, and a combination of preparing in the corridor and in the medication room was observed nine times.

Interruption rate

In total, nurses were interrupted 1180 times during the observation period, for a rate of 6.9 interruptions per nurse per hour. This was divided in a total of 578 verbal interruptions (3.4 per nurse per hour) and a total of 602 non-verbal interruptions (3.5 per nurse per hour). Table 3 shows the basic interruption findings, classified by type of source. Most of the interruptions were caused by colleagues with a mean frequency of 9.0 (IQR 6.0-14.0) verbal interruptions and 5.0 (IQR 2.0-8.5) non-verbal interruptions, and noises from the surrounding environment with a mean frequency of 7.5 (IQR 4.0-12.8). Remarkably, only 3% of the interruptions were caused by patients (verbal 2% and non-verbal 1%).

Duration of interruptions

The total duration of the interruptions was 553.8 min (Table 3), a rate of 17.3 min per hour. This was divided in a total duration of 209.1 min for verbal interruptions and 344.7 min for the non-verbal interruptions. The longest interruptions are the verbal interruptions by colleagues with a median duration of 3.2 min (IQR 1.5-4.9). Non-verbal interruptions by colleagues have a median duration of 1.9 min (IQR 0.7-5.0). The second longest interruptions were caused by the non-verbal surrounding environment with a median duration of 2.9 min (IQR 0.8-5.0).

Comparison of interruptions between surgical and non-surgical units

A comparison between the units with surgical patients and the units with non-surgical patients (Table 4) reveals that more interruptions occurred in the non-surgical units (median 39.0; IQR 20.0-54.0) compared to the surgical units (median 29.0; IQR 23.0-42.5). Verbal interruptions occurred more often in surgical units and non-verbal interruptions in non-surgical units. The Mann-Whitney U test showed no statistically significant differences between the surgical and non-surgical units (Table 4).

Comparison of interruptions between morning and noon medication administration rounds

Comparing the morning MAR to the noon MAR showed that more interruptions were observed during the morning round (median 46.0; IQR 27.3-53.8) than during the noon round (median 28.0; IQR 17.0-37.5) (Table 5). The difference proved statistically significant for the verbal interruptions ($P=0.047$), the non-verbal interruptions ($P=0.035$), and for the total of the interruptions ($P=0.005$). The durations of the interruptions were longer during the morning rounds with a median duration of 21.5 min (IQR 12.8-27.9), compared with a median duration of 12.5 min (IQR 9.0-18.0) during the noon rounds. The difference was statistically significant for the non-verbal interruptions ($P=0.029$), as well as for the total duration ($P=0.032$).

Discussion

Emerging research demonstrates that interruptions are a risk for errors in medication

administration.^{16,25} Therefore, we set out to gain a broad understanding of the possible causes for interruptions. The data obtained varied from direct interruptions leading to nurses having to perform other tasks to indirect peripheral distractions in the surrounding environment. Nurses are frequently disturbed during the MAR in their day shifts, which is consistent with other literature. The interruption rate of 6.9 interruptions per nurse each hour is similar to that reported in two studies by Biron *et al.* (6.3 and 6.7 interruptions per hour, respectively).^{18,26} Approximately one-third of the observed time is spent dealing with interruptions, indicating that it is a significant issue in nursing practice. The data also suggest that there may be a relationship between time of day and the number and duration of interruptions, with more and longer interruptions in the morning MAR. This is also consistent with other studies.^{18,24} This may be due to the general commotion of starting the day, as well as a desire to share events of one's per-

Table 2. Number of observations per nursing unit.

Unit	Observations
Surgical	
General surgery	4
General surgery and maxillary surgery	4
Cardiothoracic surgery	2
Orthopedics	4
Gynecology	3
Non-surgical	
Cardiology	3
Infectious diseases	2
Internal medicine and kidney diseases	3
Gastroenterology and rheumatology	4
Acute renal dialysis	3
Total	32

Table 3. Basic interruption data: number and duration of interruptions.

	No. of interruptions ($n=32$)		Duration of interruptions ($n=32$)	
	Frequency (%)	Median (IQR)	Duration* (%)	Median (IQR)
Verbal	578 (49)	17.0 (11.0-23.3)	209.1 (38)	6.4 (3.6-8.1)
Verbal colleague	336 (28)	9.0 (6.0-14.0)	112.7 (20)	3.2 (1.5-4.9)
Verbal patient	21 (2)	0.0 (0.0-1.0)	13.7 (3)	0.0 (0.0-0.3)
Verbal person	221 (19)	5.0 (3.3-8.8)	82.7 (15)	1.9 (1.0-3.5)
Non-verbal	602 (51)	15.0 (11.0-26.5)	344.7 (62)	10.0 (5.1-16.1)
Non-verbal colleague	181 (15)	5.0 (2.0-8.5)	100.8 (18)	1.9 (0.7-5.0)
Non-verbal patient	11 (1)	0.0 (0.0-1.0)	11.0 (2)	0.0 (0.0-0.1)
Non-verbal person	35 (3)	1.0 (0.0-2.0)	38.2 (7)	0.5 (0.0-1.7)
Non-verbal surrounding environment	289 (25)	7.5 (4.0-12.8)	106.8 (19)	2.9 (0.8-5.0)
Non-verbal logistics	86 (7)	2.0 (1.0-4.0)	87.9 (16)	0.6 (0.1-2.5)
Total	1180 (100)	34.0 (21.5-51.5)	553.8 (100)	14.0 (9.6-25.2)

IQR, interquartile ranges. *In minutes.

sonal life on arriving at work. The data suggest that interruptions seemed to occur more often and lasted longer in units with non-surgical patients compared to units with surgical patients. However, the observed difference was not statistically significant. Another study by McGillis *et al.* also compared interruptions between surgical and non-surgical units and had similar findings.²⁷ In addition, our study was limited in time and measurements, and did not reveal any specific clues regarding the causes of medication errors. Possibly differences in the culture of the nursing unit, the type of patients cared for, or differences in the way nursing tasks were organized in these units might be the reason for this.

Verbal and non-verbal interruptions caused by colleagues appear to be a significant issue. Almost half of the observed causes of interruptions are verbal and non-verbal interruptions from colleagues. Other studies also confirm

colleagues to be the main source of interruptions.^{18,23,24} Targeting interruptions by colleagues seems an obvious way to improve medication safety. In recent years, several interventions have been introduced to reduce the interruptions of medication administration, varying from visible reminders such as *do-not-disturb* tabards and signs to remind others of *no interruption during MARs*, to dedicated quiet zones, protocols and educational strategies.^{15,25,28-32} Results are promising, with most of these quality improvement studies reporting positive effects on the number of interruptions. However, implementing such interventions may be difficult. Nurses may find it difficult to call each other to account when they are in the middle of an important task. Also wearing *do-not-disturb* tabards, which is currently a popular intervention to target interruptions, may meet with resistance (M Smeulers, unpublished data, 2012). To address this,

behavioral or cultural interventions targeting the way nurses interact or perceive each other may also be needed.^{33,34}

This study also revealed that interruptions from the surrounding environment are an important factor to target when designing interventions that aim to reduce interruptions.²⁸ Changing procedures in the medication room, such as cleaning and re-stocking times, or adapting the lay-out may be possible measures to take.³⁵

Since interruptions originate from a variety of many different sources, a multi-faceted approach that targets not only a decrease in interruptions by colleagues but also considers ways to decrease interruptions from the surrounding environment seems appropriate. Furthermore, increasing the awareness of the nurses about being disturbed might be useful to lower self-initiated interruptions and conversations on subjects other than patient care

Table 4. Comparison of number and duration of interruptions in surgical and non-surgical units.

Interruptions	Surgical (n=17)				Non-surgical (n=15)				Mann-Whitney U Test	
	Frequency (%)	Median (IQR)	Duration* (%)	Median (IQR)	Frequency (%)	Median (IQR)	Duration* (%)	Median (IQR)	Frequency (P-value)	Duration (P-value)
Verbal	296 (52)	17.0 (12.0-20.5)	100.6 (34)	5.6 (3.8-7.3)	282 (46)	13.0 (6.0-27.0)	108.6 (38)	7.1 (3.0-8.9)	0.794	0.576
Verbal colleague	181 (61)	9.0 (7.0-13.5)	54.7 (54)	3.1 (1.6-4.2)	155 (55)	9.0 (3.0-15.0)	58.1 (53)	3.6 (1.5-5.9)	0.823	0.602
Verbal patient	19 (6)	0.0 (0.0-2.0)	9.6 (10)	0.0 (0.0-1.1)	2 (1)	0.0 (0.0-0.0)	4.1 (4)	0.0 (0.0-0.0)	0.132	0.176
Verbal person	96 (33)	5.0 (3.5-8.0)	36.3 (36)	1.9 (1.1-2.5)	125 (44)	4.0 (3.0-13.0)	46.4 (43)	3.0 (1.0-4.2)	0.628	0.433
Non-verbal	274 (52)	13.0 (9.0-22.5)	168.5 (57)	7.3 (4.6-16.0)	328 (54)	16.0 (13.0-30.0)	176.2 (62)	10.6 (5.0-18.4)	0.097	0.628
Non-verbal colleague	90 (30)	3.0 (2.0-7.0)	52.4 (31)	1.9 (0.7-5.4)	91 (28)	5.0 (3.0-10.0)	48.5 (28)	3.0 (0.7-5.0)	0.295	0.941
Non-verbal patient	8 (3)	0.0 (0.0-1.0)	6.8 (4)	0.0 (0.0-0.6)	3 (1)	0.0 (0.0-0.0)	4.2 (2)	0.0 (0.0-0.0)	0.433	0.370
Non-verbal person	20 (7)	1.0 (0.0-2.0)	22.3 (13)	0.3 (0.0-1.7)	15 (4)	1.0 (0.0-2.0)	15.9 (9)	0.7 (0.0-2.0)	0.710	0.941
Non-verbal surrounding environment	125 (42)	7.0 (3.0-11.0)	58.9 (35)	2.8 (0.8-5.3)	164 (50)	9.0 (4.0-18.0)	47.9 (27)	3.7 (0.8-4.9)	0.189	0.852
Non-verbal logistics	31 (10)	1.0 (0.5-2.5)	28.1 (17)	0.4 (0.1-1.4)	55 (17)	3.0 (1.0-5.0)	59.8 (34)	1.0 (0.3-5.6)	0.053	0.165
Total	570 (48)	29.0 (23.0-42.5)	269.1 (49)	13.7 (9.4-21.5)	610 (52)	39.0 (20.0-54.0)	284.7(51)	14.2 (9.8-27.0)	0.390	0.433

IQR, interquartile ranges. *In minutes.

Table 5. Comparison of number and duration of interruptions between morning and noon medication administration rounds.

Interruptions	Frequency (%)	Morning MAR (n=16)			Frequency (%)	Noon MAR (n=16)			Mann-Whitney U Test	
		Median (IQR)	Duration* (%)	Median (IQR)		Median (IQR)	Duration* (%)	Median (IQR)	Frequency (P-value)	Duration (P-value)
Verbal	353 (48)	19.0 (12.3-31.0)	119.8 (35)	6.7 (3.8-8.9)	225 (50)	13.5 (6.8-20.5)	89.3 (42)	5.5 (3.1-7.8)	0.047°	0.323
Verbal colleague	200 (27)	9.5 (8-17.3)	59.1 (17)	3.0 (1.4-5.3)	136 (30)	8.5 (3.3-13.0)	53.7 (25)	3.4 (1.9-4.8)	0.094	0.985
Verbal patient	11 (2)	0.0 (0.0-0.8)	7.6 (2)	0.0 (0.0-0.8)	10 (2)	0.0 (0.0-1.0)	6.1 (3)	0.0 (0.0-0.3)	0.867	0.897
Verbal person	142 (20)	7.0 (4.3-12.3)	53.1 (16)	2.1 (1.4-4.1)	79 (17)	4.0 (3.0-7.8)	29.6 (14)	1.7 (0.6-2.9)	0.035°	0.119
Non-verbal	375 (52)	24.5 (12.0-33.3)	219.4 (65)	14.4 (5.6-19.8)	227 (50)	13.0 (11.0-15.8)	125.3 (58)	6.0 (3.5-10.6)	0.035°	0.029°
Non-verbal colleague	116 (16)	6.0 (2.3-11.5)	67.5 (20)	4.1 (0.9-6.3)	65 (14)	4.0 (2.0-5.0)	33.3 (15)	1.2 (0.7-2.0)	0.128	0.073
Non-verbal patient	7(1)	0.0 (0.0-1.0)	9.6 (3)	0.0 (0.0-1.1)	4 (1)	0.0 (0.0-0.8)	1.4 (1)	0.0 (0.0-0.0)	0.724	0.402
Non-verbal person	19 (3)	1.0 (0.0-2.0)	23.5 (7)	0.7 (0.0-2.2)	16 (4)	1.0 (0.0-1.8)	14.8 (7)	0.2 (0.0-1.6)	0.669	0.669
Non-verbal surrounding environment	186 (26)	11.0 (7.0-16.5)	74.3 (22)	4.6 (3.0-5.6)	103 (23)	4.5 (2.3-8.8)	32.5 (15)	1.0 (0.5-2.9)	0.007°	0.007°
Non-verbal logistics	47 (6)	2.0 (0.0-4.0)	44.6 (13)	0.5 (0.0-4.3)	39 (9)	2.0 (1.0-3.0)	43.3 (20)	0.7 (0.2-2.1)	0.696	0.539
Total	728 (62)	46.0 (27.3-53.8)	339.1 (61)	21.5 (12.8-27.9)	452 (38)	28.0 (17.0-37.5)	214.7 (39)	12.5 (9.0-18.0)	0.005°	0.032°

MAR, medication administration rounds; IQR, interquartile ranges. *In minutes; °Significant (P<0.05). IQR, interquartile ranges. *In minutes.

(sterile cockpit rule from aviation profession)^{30,34} Performing observational studies such as those carried out by the researchers may serve as an eye-opener and contribute to a culture of continuous improvement. Last but not least, no matter how evident the need is to limit the number of interruptions, the ultimate goal is to decrease the number of MEs. So far the empirical evidence of an association between interruptions and MEs, however promising, is still limited and more research into this area is also needed.^{16,30,36}

Study limitations

Our study has several limitations. The study was performed on surgical and non-surgical units of one academic hospital. Pediatric and neurological units were not included, and only the morning and noon MARs during the week were observed in a limited time period. Therefore, generalizability of the results may be limited, especially to other MAR times and during weekends. One remarkable finding was that there are seldom any interruptions by patients, whereas usually staff perceptions are that these occur much more often than they actually do. However, the observations of the interruptions were limited to the medication trolley. As a consequence, the observer did not follow the nurse into the patients' rooms. Therefore, the number of interruptions by patients may be underestimated. Due to the nature of the study, observations could not be performed blinded. However, the observations were unobtrusive and the subjects were not aware of the specific purpose of the study.

Future research should consider including all MAR times (day and night time as well as weekends) and record observations for an extended period of time. Establishing a clear definition of interruptions, as well as testing inter-observer reliability prior to the observation period, proved to be valuable. Including other specialties, and looking into possible differences between them, may provide evidence for a significant difference between the specialties and possible causes for this.

In a follow-up study, the effect of the introduction of *do-not-disturb* tabards on the frequency of interruptions (verbal as well as non-verbal) and error rate during the MAR will be determined, as well as the relationship between interruptions and MEs.

Implications and future research

Interruptions are an important problem in the complex reality of nursing practice because of their high frequency and for the risk they introduce into medication process. Interruptions come from many different sources: colleagues, the surrounding environment or the nurse him- or herself. An ideal mix of interventions targets not only a reduction in interruptions by colleagues, but also considers

ways to decrease self-initiated interruptions and reduce sources of interruptions in the nurse's surrounding environment. Finally, understanding the causality between interruptions and MEs is an important topic for further research.

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