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Research Article

Analysis and Identifying Risk Profile for Medication Errors in the Neonatal Intensive Care Units

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Abstract

A medication error is 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. Neonates are vulnerable for medication errors because neonates have a rapidly changing body surface area and weight; a rapidly developing system of drug absorption, metabolism and excretion; an inability to communicate with the provider; and off-label or unlicensed drug usage.

Aim: Determine the frequency of medication errors in NICU, recognize the nature and risk profile of medication errors, identify the risk factors and to relate the errors to clinical characteristics of the patients and complexity of care.

Methods: The study was descriptive prospective observational study for medication error that occurred in NICU of ALzhraa University hospital and Damanhur Teaching Hospital in Egypt. The data had been collected over one year using the standardized check list designed for medication errors, it checked each step in the medication process. It also considered to identify all possible failures (environment-related, equipment problems, human errors or any other faults in the system). List the root causes that could generate each failure. Determine the possible effects of each failure.

Results: This study included 649 neonates. There were 265 cases with one or more medication errors (40.8%). The prescription and transcription errors were the most frequent errors followed by administration errors. Wrong dosage form was the most common prescription errors. More medication errors occur with decreasing gestational age, birth weight and increasing length of stay and complexity of care. Work overload, time shift and medication knowledge deficiency were the main risk factors of prescribing and transcription errors. Unavailable dosage form and dispensing delay were the main causes of dispensing errors.

Conclusions: Prescription and transcription errors are common type of medication errors. Multiple risk factors are responsible for medication errors. Medication errors should be regularly monitored and results should be communicated to all staff to prevent medication errors through interactive incident reporting system.

Keywords: *Medication Errors, Newborn Infants, Patient Safety, NICU*

Abbreviations

NICU: Neonatal Intensive Care Unit; ENSTN: Egyptian Neonatal Safety training Network; P&P: Policy and Procedures

Introduction

A medication error 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. Such events may be related to professional practice, health care products, procedure and systems; including prescribing, order communication, product labeling, packaging, nomenclature, compounding, dispensing, distribution, administration, education, monitoring and use [1].

Iatrogenic events occur in all medication processes, but particularly during prescription and administration [2].

Adverse events in the neonatal intensive care unit (NICU) are common and at least more than half of these events are preventable [3]. The most common adverse event reported in neonates is medication related [4].

Neonates are vulnerable for dosing and dispensing errors because they have a rapidly changing body surface area and weight; a rapidly developing system of drug absorption, metabolism and excretion; an inability to communicate with the provider; and off-label or unlicensed drug usage. Most of the drugs used in neonates are available in dosages and units ready for dispensing in children or adults. This needs a lot of calculation and has a potential for errors [4,5].

The majority of studies on medication errors have been performed in adults and older children; thus, there is a lack of information regarding the epidemiology of medication errors in neonates in the neonatal intensive care unit (NICU). Neonates pose particular challenges to the system for prescribing, dispensing, administering and monitoring medications compared with older children and adults [6].

Objective of the Study

The main objective was to help ensure that medicines are used safely and prevent incidents from happening again through expanding knowledge of medication errors and its subsequent effects on the care and outcome of the neonates in NICUs. Also develop capacity for reporting, analyzing and learning from mistakes.

Aim of Work

1. Determine the frequency of medication errors in NICU.
2. Recognize the nature and profile of medication errors in NICU.
3. Recognize the risk factors for medication errors in the NICU.
4. Relate the errors to clinical characteristics of the patients, the complexity of care provided and the availability of human and technological resources.

Patients and Methods

Analytical prospective observational study for medication error that occurs in NICU was studied in AL-Zhraa University hospital and Damanhur Teaching Hospital. The data had been collected over one year using the check list designed for medication errors and Egyptian Neonatal safety Training Network incident report system.

This study included 649 neonates. 54.9% were male newborn infants and 45.1% were female newborn infants. The gestational age ranged from 20 - 42 weeks with mean of 35.55 ± 3.50 weeks. There were 384 cases without medication errors (59.2%) and 265 cases with one or more medication errors (40.8%).

- All personal, clinical history, examination and laboratory results of all cases were recorded.

- The check list for each step in the medication use process was considered to:
    1. Identify all possible failures, (environment-related, equipment problems, human errors or any other faults in the system).
    2. List the root causes that could generate each failure.
    3. Determine the possible effects of each failure.
- Medication error is defined as any preventable event that occurs in the process of ordering, transcribing, dispensing, administering or monitoring a drug irrespective of whether the injury occurred or potential for injury was present [7].
- The references for neonatal medication; indications, doses, frequency, concentration, infusion rates were manual of neonatal care, Neofax 2011, Neofax 2014, Neonatal formulary 7th edition [8-11].
- Root cause analysis using method of Ishikawa diagrams (fishbone diagrams) [12].

Check list for error of medication

Patient Information

Patient Name:	Patient Hospital ID:
Patient Age:	Patient Sex:
Date of Report:	Name of Reporter:
Patient Location at Time of Error:	Date of Error:
Disease states/problems:	

Order urgency

- Patient location (NICU or Nursery).
- Type of order (new admission, transfer, post-op, etc.)
- Order triaged as urgent, emergent, routine, or general ward stock

Therapeutic review

- Review right and left sides of order sheet.
- Doctor (signature present, consult service suggestions, appropriate prescriber).
- Formulary/restrictions/product availability.
- Complies with medication order writing standards.
- Contraindications.
- Laboratory tests/levels (e.g. SCr, K).
- Renal function.
- Dose (weight, renal function, hepatic function, normal range).
- Dosage form.
- Route (appropriate, available).
- Schedule/frequency (appropriate, ± food, spacing with other medications).
- Administration (NPO, rate, administration policies for IV medications).

- Duration (number of days).
- Start date/start time.
- Stop date/stop time.
- Drug interactions.
- Discontinue existing orders replaced by new order.
- Comments/notes.

Medication Order Information

Name of medication:
How was order written?
Did patient receive the medication? • Yes (If yes, what did patient receive [drug, dose, route, time of administration]?) • No (If no, how was error intercepted?)
What was the outcome? • Adverse drug event occurred. Describe injury that occurred and actions taken to minimize injury. • Adverse drug event did not occur (no apparent patient injury or ill effect noted).
To enable a complete assessment of the medication error, please describe, in detailed narrative, the occurrence of the error. Provide any suggestions or recommendations regarding how to prevent future occurrences of this type of error.

Check list for medication use process

Ordering	Yes	No	Other
Drug information			
Drug information resources are available to prescribers.			
Protocols are used for highly toxic drugs.			
Clinical pharmacist actively reviews patient records and orders, attending rounds, and easily accessible to interact with prescribers.			
A pharmacist is available as a consultant 24 hours a day.			
Other (describe):			
Patient information			
Patient information (e.g., diagnosis, lab values, etc.) is available to the medical staff prior to ordering drugs.			
Allergy information is available on order sheets.			
All orders are accompanied with basic information (e.g. patient's name, birth date and physician).			
Other (describe):			
Order Entry Tools			
Pre-printed order forms are available.			
Clear guidelines and standards for writing medication orders have been established (e.g. eliminating the use of abbreviations).			
Other (describe):			
Pharmacy order entry/Verification			
Applicable			
The pharmacy computer system has standardized set of checks (e.g. screening for patient allergies, duplicate drug therapies, potential drug/lab interactions, drug/drug interactions, dose ranges, etc.).			
The pharmacy computer system is interfaced with the laboratory system and has alert features.			
Orders cannot be entered into the pharmacy system until the patient's weight information has been entered.			
Orders cannot be entered into the pharmacy system until the patient's allergy information has been entered.			
All medication orders (except for emergency medication) must be verified by a pharmacist prior to administration.			
Other (describe):			
Not applicable			
Dispensing			
Access to information			
Drug information resources are available to pharmacist.			
Patient information (e.g. diagnosis, lab values, etc.) is available to pharmacy staff prior to dispensing.			
Allergy information is available to pharmacist.			
Other (describe):			
Distribution of medications			
High hazard medications are not kept on general patient care units.			
Unit-dose distribution systems are maintained.			
All intravenous medications are mixed in the pharmacy areas and are not mixed by nurses on the floor.			
Other (describe):			
Administering			
Access to information			
Drug information resources are available in the patient care areas.			
Patient information (e.g. diagnosis, lab values, etc.) is available to the patient caregivers prior to administering.			
Allergy information is available to the nurses.			
Other (describe):			
Standardization/Automation			
Administration times are standardized.			
Electronic or computer-generated medication records are available.			
Bar coding is used in the medication administration process.			
Other (describe):			
Monitoring			
A multidisciplinary team to address medication safety has been established.			
Medication errors are thoroughly evaluated in an open, non-punitive manner.			
A non-punitive, anonymous medication error reporting system has been established.			
Medication errors are monitored, tracked, and evaluated on a routine basis.			
The hospital has established a safety plan.			
Other (describe):			
Error of medication			
Prescription/Ordering Errors			
Wrong medication			
Contraindicated for the patient			
Belongs to another (i.e. wrong patient)			
Wrong drug-drug interaction			
Wrong drug –allergy			
Wrong drug-indication			
Wrong dosing: total daily dose or charge and maintenance; includes errors such as using milligrams (mg) instead of micrograms (µg(			
Omission of a drug that was being administered and it is not stated that it was suspended.			
Omission of a written prescription of an administered medication (verbal orders).			
Omission of time an administered drug was prescribed			
Error in dosing interval/schedule.			
Dose not adjusted.			
Inadequate dilution of a drug or solution.			
Wrong route			
Omission of the infusion time of a drug.			
Inadequate intravenous infusion rate.			
Illegible order.			
Other			
Transcription/Verification Errors			
Wrong drug			
Wrong dose			
Wrong dosing schedule			
Wrong route			
Dispensing Errors			
Wrong patient			
Wrong drug			
Wrong dose			
Wrong time (dose dispensed late)			
Wrong dosage form (inappropriate for route)			
Other			
Administration Errors			
Wrong patient.			
Wrong drug.			
Wrong time.			
Wrong frequency or dose delayed (30 minutes before or 1 hour after the prescribed time).			
Wrong administration (wrong drug or wrong patient (.			
Wrong delivery route.			
Omission: no administration of a drug.			
Wrong dosing: total or single dose.			
Error in dilution.			
Wrong infusion rate (wrong IV push rate)			
Deteriorated product.			
Expired product.			
Monitoring errors			
Monitoring not ordered.			
Monitoring not performed.			
Monitoring result not acted upon.			
Risk factors (possible cause of medication errors)			
Patient knowledge deficiency			
Allergy information not available.			
Concomitant medications not available.			
Concomitant conditions not available.			
Lab values/clinical information not available.			
Other			
Medication knowledge deficiency			
Indications for medication use.			
Available dosage forms.			
Appropriate dosing guidelines.			
Appropriate routes for administration.			
Drug compatibility.			
Other			
Non-adherence to policies and procedures			
Use of abbreviations in medication ordering.			
Incomplete medication order processed.			
Drug delivery problem (dispensing delay).			
Non-standard dosing schedule used.			
Medication "borrowed" from another patient.			
Patient identification not checked.			
Drug preparation error.			
Other			
Miscellaneous			
Illegible physician hand writing.			
Memory lapse.			
Drug stocking problem (drug not available).			
Equipment failure (e.g. IV pump failure).			
Work overload.			
Time available per patient.			
Nursing staff deficiency.			
Time shift.			
Other			

Statistical Analysis

The collected data was verified and validated. The SPSS version 18 was used. The data represented in numbers and percentages for qualitative data. and mean (standard deviation; SD) and range for quantitative data. We used Chi square test and MC: Monte Carlo for comparison between two groups. P was considered significant when ≤ 0.05.

Results

The results are shown in table 1 to table 8 and figure 1 to figure 2.

	No.	%
Sex		
Male	356	54.9
Female	293	45.1
Gestational age (Weeks)		
Min. - Max.	20.0 - 42.0	
Mean ± SD.	35.55 ± 3.50	
Median	37.0	
Pre-term	204	31.4
Late pre-term	100	15.4
Full term	345	53.2
Length of stay (days)		
1 - 7	480	74.2
8 - 14	85	13.1
15 - 21	48	7.4
22 - 30	26	4.0
>30	8	1.2
Min. - Max.	1.0 - 58.0	
Mean ± SD.	6.47 ± 7.47	
Median	4.0	
Weight (kg)		
< 1	31	4.8
1 - < 1.5	69	10.6
1.5 - < 2.5	177	27.3
2.5 - < 4	335	51.7
≥ 4	36	5.6
Min. - Max.	0.40 - 5.44	
Mean ± SD.	2.51 ± 0.91	
Median	2.50	

Table 1: *Distribution of the studied cases according to demographic data in total sample (n= 649).*

Total studied cases	649	/100 NICU patient admissions	
Total medication errors	624	96.1	/100 medication error
Adverse drug events	53	8.2	8.5
Near-misses	568	87.5	91
Sentinel (death or permanent harm)	3	0.5	0.5

Table 2: *Rate of medication errors, adverse events and near- misses/100 NICU patient admissions.*

This table showed the rate of medication errors recorded for 96.1/100 newborn admitted to NICU. While adverse event occurred at a rate of 8.2/100 newborn admitted to NICU.

	Total					χ^2 (p)
	Prescription/Ordering Errors	**Transcription/Verification Errors**	**Dispensing Errors**	**Administration Errors**	**Monitoring errors**	
	254	227	25	111	7	774.916*(< 0.001*)
p_1		< 0.001*	< 0.001*	< 0.001*	< 0.001*	
p_2			< 0.001*	< 0.001*	<0.001*	
p_3				< 0.001*	0.001*	
p_4					< 0.001*	

Table 3: *Statistical difference between categorization of medication errors.*

Table 3 showed a statistically significant difference between categorization of medication errors with Prescription and Transcription are significant.

χ^2: Chi square test

p_1: p value for Chi square test for comparing between Prescription/Ordering Errors and others

p_2: p value for Chi square test for comparing between Transcription/Verification Errors and others

p_3: p value for Chi square test for comparing between Dispensing Errors and others

p_4: p value for Chi square test for comparing between Administration Errors and Monitoring errors

**: Statistically significant at $p \leq 0.05$*

	Term							
	Pre-term (n = 204)		**Late pre-term (n = 100)**		**Full term (n = 345)**		χ^2	**P**
	No.	**%**	**No.**	**%**	**No.**	**%**		
Total Prescription/ Ordering Errors	127	62.3	38	38.0	89	25.8	71.599*	< 0.001*
Total Transcription/Verification Errors	109	53.4	32	32.0	86	24.9	46.257*	< 0.001*
Total Dispensing Errors	3	1.5	4	4.0	18	5.2	4.866	0.088
Total Administration Errors	64	31.4	13	13.0	34	9.9	43.268*	< 0.001*
Total Monitoring errors	4	2.0	0	0.0	3	0.9	2.720	$^{MC}p = 0.367$

Table (4): *Relation between gestational age and categorization of medication errors in total sample.*

Table 4 showed a statistically significant difference between pre-term, late-preterm, and full term neonates as regards prescription/ordering errors, transcription/verification errors and administration errors. It showed that preterm newborns had the highest percent of prescription/ordering errors, transcription/verification errors and administration errors.

χ^2: Chi square test

MC: Monte Carlo

**: Statistically significant at $p \leq 0.05$.*

	Length of stay											
	1 – 7 (n = 480)		8 – 14 (n = 85)		15 – 21 (n = 48)		22 – 30 (n = 26)		>30 (n = 8)		χ^2	p
	No.	%	No.	%	No.	%	No.	%	No.	%		
Total Prescription/Ordering Errors	119	24.8	53	62.4	41	85.4	32	123.1	7	87.5	145.484*	$^{MC}p < 0.001^*$
Total Transcription/Verification Errors	107	22.3	52	61.2	37	77.1	24	92.3	6	75.0	140.330*	$< 0.001^*$
Total Dispensing Errors	12	2.5	3	3.5	4	8.3	5	19.2	1	12.5	17.513*	$^{MC}p = 0.001^*$
Total Administration Errors	47	9.8	26	30.6	22	45.8	14	53.8	2	25.0	71.119*	$^{MC}p < 0.001^*$
Total Monitoring errors	2	0.4	0	0.0	2	4.2	2	7.7	1	12.5	17.855*	$^{MC}p = 0.001^*$

Table 5: *Relation between lengths of stay with categorization of medication errors in total sample.*

Table 5 showed a statistically significant difference as regards all categorization of medication errors according to length of stay. It showed that the percent of medication errors increase with increase in the length of stay.

*χ^2: Chi square test; MC: Monte Carlo; *: Statistically significant at $p \leq 0.05$*

	Weight											
	< 1 (n = 31)		1 - < 1.5 (n = 69)		1.5 - < 2.5 (n = 177)		2.5 - < 4 (n = 335)		≥ 4 (n = 36)		χ^2	p
	No.	%	No.	%	No.	%	No.	%	No.	%		
Total Prescription/Ordering Errors	15	48.4	41	59.4	101	57.1	91	27.2	6	16.7	64.662*	$< 0.001^*$
Total Transcription/Verification Errors	12	38.7	36	52.2	81	45.8	92	27.5	6	16.7	31.816*	$< 0.001^*$
Total Dispensing Errors	0	0.0	1	1.4	7	4.0	14	4.2	3	8.3	3.554	$^{MC}p = 0.430$
Total Administration Errors	3	9.7	30	43.5	43	24.3	31	9.3	4	11.1	56.915*	$< 0.001^*$
Total Monitoring errors	0	0.0	1	1.4	3	1.7	3	0.9	0	0.0	1.364	$^{MC}p = 0.786$

Table 6: *Relation between weights with categorization of medication errors in total sample.*

Table 6 showed a statistically significant difference as regards all categorization of errors according to weight.

χ^2: Chi square test ,MC: Monte Carlo

**: Statistically significant at $p \leq 0.05$*

	No.	% Total cases with errors (n = 265)	% total medication errors (n = 624)
Prescribing/ordering Errors			
Patient Knowledge Deficiency	2	0.8	0.3
Medication Knowledge Deficiency	85	32.1	13.6
Non-Adherence to P&P	30	11.3	4.8
Miscellaneous	109	41.1	17.5
Other	2	0.8	0.3
Transcription/Verification Errors			
Patient Knowledge Deficiency	2	0.8	0.3
Medication Knowledge Deficiency	44	16.6	7.1
Non-Adherence to P&P	30	11.3	4.8
Miscellaneous	138	52.1	22.1
Other	3	1.1	0.5
Dispensing Errors			
Patient Knowledge Deficiency	2	0.8	0.3
Medication Knowledge Deficiency	24	9.1	3.8
Non-Adherence to P&P	0	0.0	0.0
Miscellaneous	2	0.8	0.3
Other	3	1.1	0.5
Administration Errors			
Patient Knowledge Deficiency	1	0.4	0.2
Medication Knowledge Deficiency	22	8.3	3.5
Non-Adherence to P&P	2	0.8	0.3
Miscellaneous	66	24.9	10.6
Other	21	7.9	3.4
Monitoring errors			
Patient Knowledge Deficiency	0	0.0	0.0
Medication Knowledge Deficiency	3	1.1	0.5
Non-Adherence to P&P	0	0.0	0.0
Miscellaneous	6	2.3	1.0
Other	1	0.4	0.2

Table 7: *Distribution of the studied cases according to root causes of medication errors-by medication use process in total cases sample (n = 649).*

NB: Miscellaneous include: Illegible physician hand writing ,Memory lapse.,Drug stocking problem (drug not available),Equipment failure (e.g. IV pump failure),Work overload, Time available per patient, Time shift, Nursing staff deficiency.

Table 7 showed root causes of medication errors by medication use process in total sample. Miscellaneous causes and medication knowledge deficiency constituted the greatest proportion of root causes of medication errors.

Type of error	Type of error	Severity of outcome	Number of errors	% from total number of errors
Error, No harm		Total	568	91
	B	-Error did not reach patient	170	27.2
	C	-Error reached patient, but no harm caused	148	23.7
	D	-Error reached patient, monitoring of patient needed	250	40.1
	E		53	8.5
	F	-Required intervention	48	7.7
	G	-Required hospitalization	-not applicable	-
	H	-Permanent patient harm	0	0
		-Required intervention to sustain life	5	0.8
Error, Death	I	Patient died	3	0.5

Table 8: *The classification of medication errors according to grade of harm.*

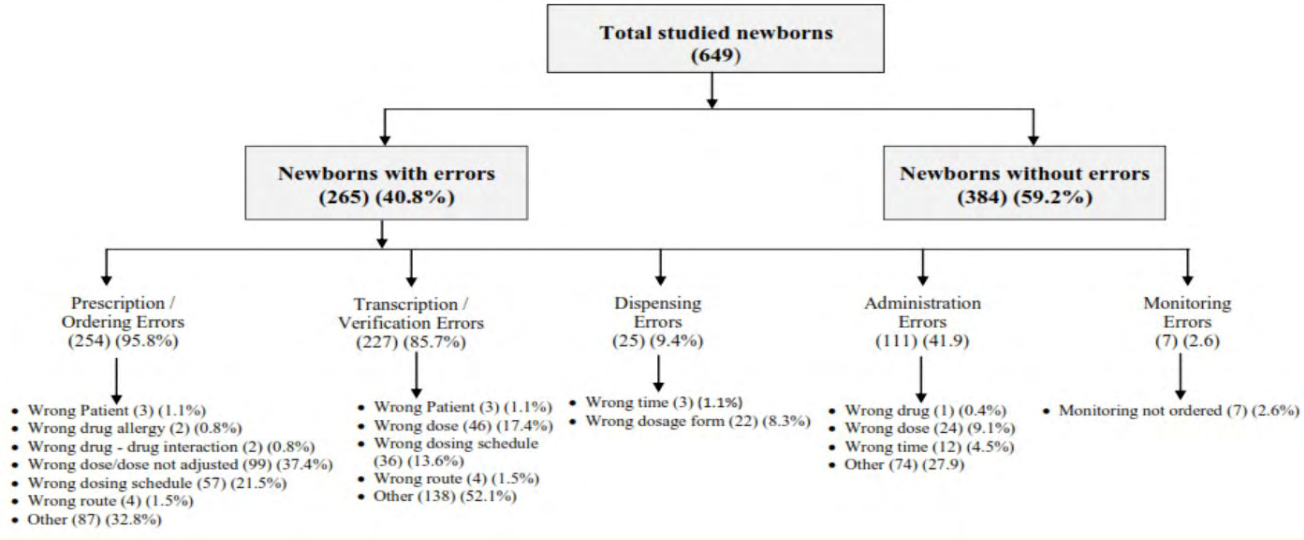

Figure 1: *Distribution of the studied cases according to final diagnosis in total sample, more than one errors occurred/patient. Percentage of errors was calculated in regards to cases with errors.*

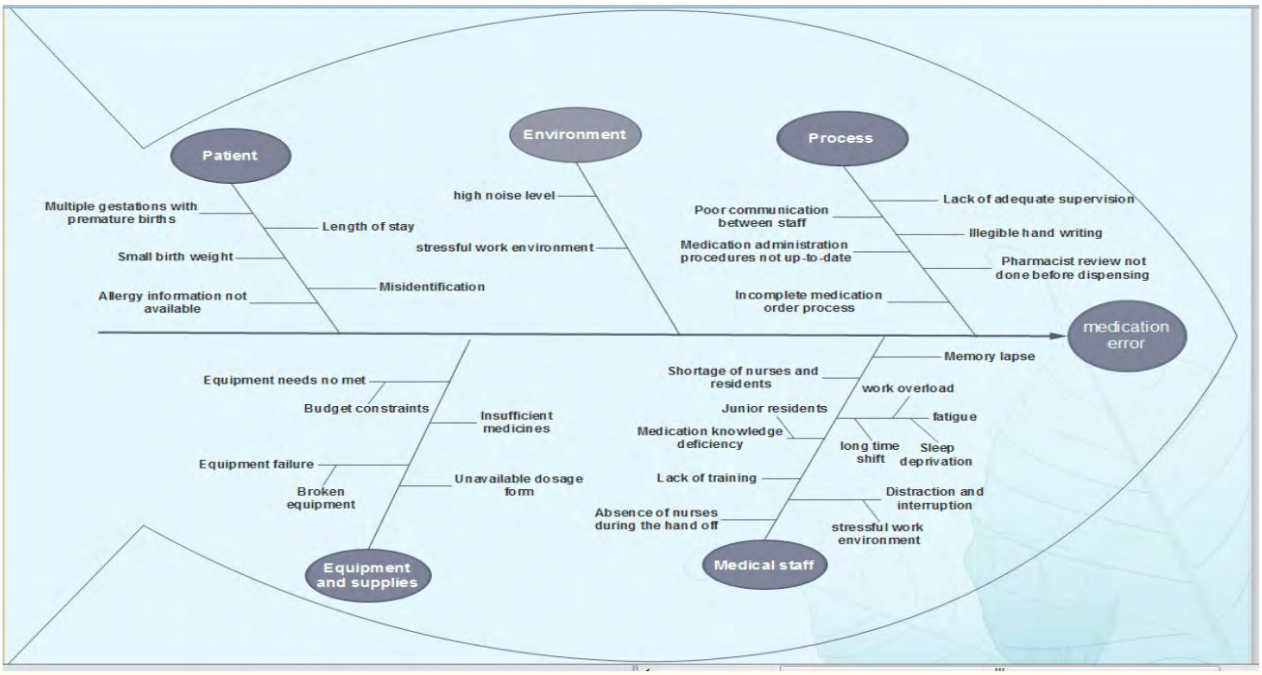

Figure 2: *Root cause analysis of medication errors.*

The results of the present study showed the following:

- Medication errors are prevalent in the NICU of both AL-Zhraa University hospital and Damanhur Teaching Hospital.
- Errors was related to Anti-infective drugs in 83.4%.
- Prescription and transcription errors are the most frequent errors followed by administration errors.
- Wrong dosage form was the most common prescription errors.
- Medication errors increased with decreasing gestational age, birth weight and increasing length of stay and complexity of care.
- Multiple risk factors are responsible for the occurrence of medication errors.
- More than one error occurred in one patient.
- Work overload, time shift and medication knowledge deficiency were the main risk factors of prescribing and transcription errors.
- Nursing staff shortage, equipment failure and work overload were the main risk factors of administration errors.
- Unavailable dosage form and dispensing delay were the main causes of dispensing errors.
- The impact of medical errors or adverse events is difficult to assess due to occurrence of multiple events in the same patients.

Discussion

Although medication errors are not necessarily more frequent in neonatal units than in adult wards, the likelihood of adverse drug events is greater in neonates as they are fragile, cannot metabolize and eliminate drug adequately. Prescriptions must be adapted to individuals, with separate calculation of each dose for each neonate according to body weight or surface area, gestational age, postnatal age as

well as clinical diagnosis, which increases the risk of prescription errors [2]. Lack of specific formulation for newborn, also the unlicensed and off-labelled drugs use appeared to be associated with medication errors in neonates [13].

In this work our aim was to determine the frequency of medication errors in the studied NICUs, recognize the nature and risk profile of medication errors, identify the risk factors for medication errors in the NICU and relate the errors to clinical characteristics of the patients, the complexity of care provided and the availability of human technological resources. The present study included 649 newborn infants. There were 384 (59.2%) cases with no recorded medication errors and 265 (40.8%) cases with one or more medication errors. The total number of medication errors was 624 among these 265 cases that showed that more than one errors/patient occurred. These data showed that medication errors were prevalent in the studied NICUs. The rate of medication errors per 100 NICU patient admissions was 96.1%, some authors [4,14] reported 91 medication errors per 100 NICU patient admissions. Chedoe., *et al.* [15] evaluated 11 studies; they had problems to compare incidences because medication error rates were calculated differently.

Our study showed that the most frequent type of medication involved in medication errors was anti-infective medication with reported incidence of 'antibiotics prescription' error was among 25.7% of total cases; which is consistent with that found by Jain., *et al* [16].

The study showed that medication errors occurred at each step of the drug management pathway, but it was significantly higher at the prescription step as constituted 39.1% of total errors, followed by transcription/verification errors in 34.9%, administration errors in 17.1%, dispensing errors in 3.8% and monitoring errors in 1.1%. Prescribing errors were reported to be the highest medication errors of total error reports (14 - 74%) in different studies by other researchers [17-19].

Dosing errors were the most common type of medication errors during prescription as recorded in 37.4% of total cases with errors (as wrong dose/dose not adjusted) and in 21.5% (as wrong dose schedule). Similar to our finding, several authors reported dosing errors as the most common medication error in the NICU [14,17,20,21]. The percentage of dose errors was significantly higher in preterm infants (22.5%), followed by late-preterm (13%) and full term infants (11.6%).

Our study revealed that dose errors occurred due to knowledge deficiency for patient and or medication with non-adherence to P&P, use of abbreviations in medication ordering, illegible physician hand writing, memory lapse, work overload, and time available per patient as well as Lack of neonate-specific drug protocols or information. Jain., *et al.* [16] reported also lack of physician experience, high-intensity physician workloads as well as the lack of neonate-specific drug protocols or policies on the ward, incorrect use of units and wrong administration route as causes for dose errors. These small size neonates are vulnerable to dosing errors because of a misplaced decimal point or a trailing zero. They cannot communicate symptoms that may alert the providers to seek proper care [5].

The transcription-based medication errors reported in 34.9% being significantly in preterm infants. It was related to multiple causes as memory lapse during the transfer of patient data as weight, postnatal age and omission of clinical data and laboratory results. Other studies showed lower percentage than us [19]. The administration phase errors was reported in the 17.8% of total medication errors occurred in our study, which was less than reported from several studies as range was between 31 - 63% [19-22]. This could be due to different NICU environment and work settings.

The present study identified that administration errors included wrong dosage in 9.1%, wrong time in 4.5% and others as (wrong infusion rate, wrong preparation) in 27.9% of cases with errors. Wrong time and dilution were also reported by Sorrentino and Alegiani [22]. Ligi and colleagues reported that 47% of administration errors in the NICU were tenfold dosing error [4].

Dispensing errors comprised 3.8% of total errors, it was due to wrong dosage form; inappropriate for route and late dispensed time. Other authors reported rates from 11.9 - 25% of total errors and their errors were associated with mistakes in labelling and dilution of formulations [17,20,22].

Monitoring errors was reported as 1.1% of total errors which agreed with report of Krzyzaniak., *et al* [19].

The present study showed that errors were significantly more frequent in newborn infants with lower birth weight, lower gestational age and longer NICU stay, which is similar to that found by other researcher [23], who found that higher incidence of medication errors occurring during the care of preterm infants. Preterm and low birthweight infants need complex care, often critically ill, requiring intensive treatments, assisted ventilation, and prolonged length of stays, factors that independently increase their risk of adverse events including medication errors [4].

Our study showed that medication errors were multifactorial. Majority of these errors were latent and need system approach. The most important factors identified included: work overload, prolonged time shift, medication knowledge deficiency, and shortage of medical staff, illegible hand writing, memory lapse, incomplete prescriptions and unavailable dosage form. These findings were consistent with Elbahnasawy., *et al*. [24], who advice medication error improvement programs to focus on system improvements and team communication. Also our results agreed with others as Tang et al., 2007 (25) they identified personal neglect (e.g. other problems while administering medications, heavy workload, and new staff, such as a new graduate or change in ward).

As regard the risk of prescription medication errors, our study found that medication knowledge deficiency occurred in (32.1%), work overload in (29.8%), decrease time available per patient in (29.8%) and prolonged time shift in (20.4%) of prescription errors. Le Grognec., *et al.* [25], suggested lack of awareness and the route of drug administration to have a significant role in the incidence of medication errors [26]. Acheampong and Anto, 2015, found that medication knowledge deficiency has long been known as a major contributor to prescribing errors, which is in agreement with our study [27].

The present study founded that illegible hand writing was responsible for 9.8% of prescription errors and 14% of transcription errors. Pallas., *et al.* 2008, reported 39.5% of incorrect handwritten prescriptions in a third level neonatal unit with 11.1% of dosage errors [28].

As regard administration errors nursing staff deficiency (24.2%), work overload (20%), decrease time available per patient (20.4%), medication knowledge deficiency (8.3%) and equipment failure (8.7%) were the main risks for administration errors. Our study found that the most important factor that contributed to administration errors generally and wrong administration errors and timing errors especially was the shortage of nurse numbers in relation to number of cases which could be (1 to 3 or 1 to 4 sometimes) leading to overwork of each nurse and delay in drug administration and the absence of a pharmacist that can train health providers. The poor training and staff development may be one of the contributing factors of administration errors. Nurses generally learn how to perform drug related tasks from each other without formal training. There were lack of lectures, and lack of guidelines for medication administration or preparation. Nurses also were unaware of administration errors.

The present study found that the necessary calculations involved in the ordering of medications and in the dilution of stock drugs in the NICU place these patients at risk for medication errors which is concordant with Uppal., *et al* [29].

We reported near miss errors in 87.5% of cases with errors; (91/100 medication error), near miss lead to minor grade of harm; grade B (error did not reach patient) in 27.2%, grade C (error reached patient, but no harm caused) in 23.7, grade D (error reached patient, monitoring of patient needed) in 40.1%.

Our analysis showed 8.2% of errors were adverse event; (8.5/100 medication error) which caused varying degree of harm E (required intervention) in 7.7%, H (required intervention to sustain life) in 0.8%. Sentinel event correspond to grade harm I in 0.5% of cases.

Neonates were identified as the highest risk group in the hospital, experiencing the greatest number of medication errors and potential adverse drug events. Similar, lower and higher results were reported by others [16,19,20,30,31]. The discrepancy reflects the use of

multiple definitions of harm and categories between the different studies and inclusion of near miss in the reports, also some include errors in delivery room too. The impact of medical errors or adverse events is difficult to assess due to differences in case-mix, confounding factors for mortality, and occurrence of multiple events in the same patients [4,20,32].

Prevention of medication errors needs recognition, identification of root causes, and implementation of corrective actions. Also dissemination of errors through reporting system, apply responsive educational forum to increase awareness and knowledge of the health care workers to the type, causes, risk factors.

ENSTN safety standard included recommendation to prevent errors in its general standards number 6: Use medicines safely in NICU, Standard 10: Improve the safety of using infusion pump, standard 12: Accurately and completely reconcile medical care and medications across the continuum of care of the newborn infants and standard16: Improve recognition and response to changes in a patient's condition. Also the specific standards standard 9: Proper use of surfactant and standards 10: Judicious use of medications that have effect on quality of life and Standard 14: Prevent total parenteral nutrition errors [33].

Conclusions

Medication errors are prevalent in the studied NICUs. Prescription and transcription errors are the most frequent errors followed by administration errors. More medication errors occur with decreasing gestational age, birth weight and increasing length of stay and complexity of care. Multiple risk factors are responsible for the occurrence of medication errors in each case. Work overload, time shift and medication knowledge deficiency are the main risk factors of prescribing and transcription errors. Shortage of nursing staff and work overload are the main risk factors of administration errors.

Recommendations

Medication errors must be regularly monitored and results should be communicated to all staff through interactive incident reporting system as ENSTN. Promotion of medication safety education has to be implemented and include medication administration best practices and continuous training programs. Latent errors in healthcare system should be improved through adequate ratio for nurse/doctor & patient number, suitable working hours, safe care environment and involvement of pharmacists in medication order review and on patient care round. Promotion and modernization of patient safety culture by improving communication among NICU staff, medication error reporting, monitoring, tracking, training, no blame, implementation of guidelines and continuous maintenance of equipment.

Conflict of Interest

There is no any financial interest or any conflict of interest exists.

Bibliography

1. National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP). What is a medication error? NCCMERP (2013).

2. Palmero D., *et al*. "A bundle with a preformatted medical order sheet and an introductory course to reduce prescription errors in neonates". *European Journal of Pediatrics* 175.1 (2016): 113-119.

3. Sharek P., *et al*. "Adverse events in the neonatal intensive care unit: development, testing, and findings of an NICU-focused trigger tool to identify harm in North American NICUs". *Pediatrics* 118.4 (2006): 1332-1340.

4. Ligi I., *et al*. "Iatrogenic events in admitted neonates: a prospective cohort study". *Lancet* 371.9610 (2008): 404-410.

5. Stavroudis TA., *et al*. "Medication errors in neonates". *Clinics in Perinatology* 35.1 (2008): 141-161.

6. Kunac DL and Reith DM. "Identification of priorities for medication safety in neonatal intensive care". *Drug Safety* 28.3 (2005): 251-261.

7. Kozer E., *et al*. "Variables associated with medication errors in pediatric emergency medicine". *Pediatrics* 110.4 (2002): 737-742.

8. Dukhovny S. "Appendix B in Effects of Maternal Drugs on the Fetus in Manual of neonatal care 7th edition". (2011): 932-972.

9. Neofax ed 24 (2011): 1-435.

10. Micormedex, NeoFaxEssentials. (2014): 7-861.

11. Neonatal formulary 6th edition "The Neonatal Formulary (NNF6).

12. Tague NR. "Seven basic quality tools: the quality toolbox. Milwaukee, Wisconsin". *American Society for Quality* (2004): 15.

13. Conroy S. "Association between license status and medication errors". *Archives of Disease in Childhood* 96.3 (2011): 305-306.

14. Dabliz R and Levine S. "Medication safety in neonates". *American Journal of Perinatology* 29.1 (2012): 49-56.

15. Chedoe I., *et al*. "Incidence and nature of medication errors in neonatal intensive care with strategies to improve safety: a review of the current literature". *Drug Safety* 30 (2007): 503-513.

16. Jain S., *et al*. "Medication errors in neonates admitted in intensive care unit and emergency department". *Indian Journal of Medical Sciences* 63.4 (2009): 145-151.

17. Antonucci R and Porcella A. "Preventing medication errors in neonatology: Is it a dream?" *World Journal of Clinical Pediatrics* 3.3 (2014): 37-44.

18. Abdelrahman Z., *et al*. "Descriptive analysis of medication errors reported to the Egyptian national online reporting system during six months". *Journal of the American Medical Informatics Association* 23.2 (2016): 366-374.

19. Krzyzaniak N and Bajorek B. "Medication safety in neonatal care: a review of medication errors among neonates". *Therapeutic Advances in Drug Safety* 7.3 (2016): 102-119.

20. Stavroudis TA., *et al*. "NICU medication errors: Identifying a risk profile for medication errors in the neonatal intensive care unit". *Journal of Perinatology* 30.7 (2010): 459-468.

21. National Association of Neonatal Nurses (NANN). "Medication Safety in the Neonatal Intensive Care Unit Position Statement #3060" (2014).

22. Sorrentino E and Alegiani C. "Medication errors in the neonate". *Journal of Maternal-Fetal and Neonatal Medicine* 25.4 (2012): 83-85.

23. Kugelman A., *et al*. "Iatrogenesis in neonatal intensive care units: observational and interventional, prospective, multicenter study". *Pediatrics* 122.3 (2008): 550-555.

24. Elbahnasawy HT., *et al*. "Guideline Model for Nurses to Prevent the Medication Errors and Adverse Drug Events in Pediatric Inpatients". *Journal of American Science* 8.8 (2012). 611-617.

25. Tang F., *et al*. "Nurses relate the contributing factors involved in medication errors". *Journal of Clinical Nursing* 16.3 (2007): 447-457.

26. Le Grognec C., *et al*. "Medication errors resulting from drug preparation and administration". *Therapie* 60 (2005): 391-399.

27. Acheampong F and Anto BP. "Perceived barriers to pharmacist engagement in adverse drug event prevention activities in Ghana using semi-structured interview". *BMC Health Services Research* 15.1 (2015): 361.

28. Pallas CR., *et al*. "Improving the quality of medical prescriptions in neonatal units". *Neonatology* 93.4 (2008): 251-256.

29. Uppal N., *et al*. "Drug formulations that require less than 0.1 mL of solution to prepare doses for infants and children". *Canadian Medical Association Journal* 183.4 (2011): E246-E248.

30. Elshazly A., *et al*. "Medical errors in neonatal intensive care unit at Benha University Hospital, Egypt". *Eastern Mediterranean Health Journal* 23.1 (2017): 31-39.

31. Aly., *et al*. "Iatrogenic Hazards in Neonatal Intensive Care Unit". Master Thesis, AL-Azhar University (2013).

32. Garrouste-Orgeas M., *et al*. "Impact of adverse events in critically ill patients on behalf of the Outcomerea study group". *Critical Care Medicine* 36 (2008): 2041-2047.

33. Egyptian Neonatal Safety Training Network (ENSTN). "Egyptian Neonatal Safety Standards" (2014): 11-25.

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