Saudi Pharmaceutical Journal 29 (2021) 134–142

Contents lists available at ScienceDirect

Saudi Pharmaceutical Journal

journal homepage: www.sciencedirect.com

Original article

Oral medications administration through enteral feeding tube: Clinical pharmacist-led educational intervention to improve knowledge of Intensive care units' nurses at Jordan University Hospital

N. Abu Hdaib [a,b], A. Albsoul-Younes [a], M. Wazaify [a,*]

[a] Department of Biopharmaceutics and Clinical Pharmacy, School of Pharmacy, The University of Jordan, Jordan
[b] Department of Pharmacy, Faculty of Pharmacy, Middle East University, Amman, Jordan

ARTICLE INFO

Article history:
Received 14 September 2020
Accepted 31 December 2020
Available online 7 January 2021

Keywords:
Medication administration
Enteral feeding
Clinical pharmacist
Feeding tube

ABSTRACT

Introduction: Medication administration through enteral feeding tubes is a practice that is commonly encountered in hospital settings, particularly in critically ill patients. This study aims to evaluate the knowledge of intensive care unit nurses regarding enteral medication administration and evaluate the effect of an educational intervention led by a clinical pharmacist that would improve nurses' knowledge regarding the subject.

Methods: A pre/post interventional study was conducted. Improvement in nurses' knowledge regarding medication administration through an enteral feeding tube was assessed using a validated questionnaire.

Results: Data were coded, entered, and analyzed using the Statistical Package for Social Sciences (IBM SPSS statistics 22). Independent samples *t*-test and paired *t*-test were used to detect any statistically significant differences in the mean total knowledge scores both between and within each group respectively. A P-value of <0.05 was considered statistically significant. The mean total knowledge score for nurses in the intervention and control group at the pre-interventional phase of the study was inadequate. There was a statistically significant improvement in the mean total knowledge score for the interventional group at the post-interventional phase of the study, while that of the control group remained inadequate (Intervention group total mean knowledge score at baseline 12.11 ± 3.75, post-intervention 21. 50 ± 2.36, p-value <0.001; Control group total mean knowledge score at baseline 12.05 ± 3.12, post-intervention 12.60 ± 3.76, p-value 0.96).

Conclusion: Incorrect drug preparation and administration for patients with feeding tubes can affect patients. The knowledge of nurses regarding the subject can be improved significantly via an educational intervention. The activation of clinical pharmacists' role and collaboration between pharmacists, physicians, and nurses is highly recommended in this clinical setting.

1. Introduction

Clinical nutrition is considered a part of medical treatment (The National Board of Health and Welfare, 2000; Kreymann et al., 2006). Enteral Nutrition is usually favored over parenteral nutrition for various reasons. Some of its advantages are fewer infectious complications, reduced cost, earlier gut function, and reduced length of hospital stay (Williams, 2008; Seres et al., 2013). However, in some clinical scenarios such as short bowel syndrome, bowel obstruction, and patients who may be at increased risk of morbidity and mortality, parenteral nutrition would be favored (Gramlich et al., 2004).

Enteral feeding tubes (EFTs) can be used for medication administration (Naysmith and Nicholson, 1998; Williams and Leslie, 2004; Gramlich et al., 2004; Sari et al., 2018), whether it was a nasogastric tube, orogastric tube, or an ostomy option, an effect of the exit site of the tube on the pharmacokinetic or side effect profile of the administered medication(s) should be addressed (White and Bradnam, 2015). Although it is feasible to administer

* Corresponding author at: Department of Biopharmaceutics and Clinical Pharmacy, School of Pharmacy, The University of Jordan, Amman 11942, Jordan.
E-mail address: m.wazaify@ju.edu.jo (M. Wazaify).

Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.jsps.2020.12.015
1319-0164/

medications through EFTs, this process is getting more complex with time as a result of developments that have been made on dosage forms and EFTs (Hossaini Alhashemi et al., 2019). This complexity resulted in an increasing gap between clinical practice and best practice (Dickerson, 2004; Magnuson et al., 2005; Bankhead et al., 2009; Sari et al., 2018; Hossaini Alhashemi et al., 2019).

Usually, nurses are the health care professionals who administer medications to patients and generally care for patients with EFTs (Phillips and Nay, 2007; Dashti-khavidaki et al., 2012). The nurse has to have the information and skills that would enable him/her to: prepare the medication, verify tube location, flush the tube, and monitor for complications. (Phillips and Nay, 2007; Hossaini Alhashemi et al., 2019).

This complexity regarding medication administration through EFT may be questionable since it is an oral medication that is administered into the gastrointestinal tract (GIT). However, we do not know how these oral medications perform after bypassing several natural levels of the GIT. Moreover, the use of medications through an EFT is an off-label use of these medications. This would burden the health care providers with the entire responsibility of what would happen as a result of this use (Matysiak-Luśnia and Łysenko, 2014; White and Bradnam, 2015).

Nurses tend to disregard the dosage form of the medication to be administered through an EFT (Mota et al., 2010). Many of the sophisticated dosage forms are used for patients, such as sustained-release (SR, XR) formulations, modified-release (MR) formulations, and enteric-coated (EC) dosage forms. These dosage forms may be unsuitable for administration through an EFT (Williams, 2008; Bankhead et al., 2009; Mota et al., 2010; Hossaini Alhashemi et al., 2019). These formulations are designed to simplify patients' dosage regimens and improve adherence, but they cannot be crushed for various reasons (Matysiak-Luśnia and Łysenko, 2014; Demirkan et al., 2017). For example, crushing SR formulations may destruct the coating structure or technology that permit the slow release of the active substance over time, which may lead to exposing the patient to a high dose of the drug at one time, increasing the risk of an adverse drug reaction (Beckwith et al., 2004; Hanssens et al., 2006; Matysiak-Luśnia and Łysenko, 2014). Detrimental consequences have been reported in the literature regarding this specific issue. A case report from the United States linked the death of a patient to hemodynamic instability resulting from the improper use of labetalol and crushed XR nifedipine through an EFT (Schier et al., 2003; Seifert and Johnston, 2005).

Several surveys were conducted to study the nursing administration of enteral medications (Mateo, 1996; Belknap et al., 1997; Seifert and Johnston, 2005; Boullata et al., 2007; Sari et al., 2018). These surveys suggest that nurses' practice regarding enteral medication administration significantly differs from the guidelines and that some of these common practices actually may affect drug delivery (Bankhead et al., 2009; Demirkan et al., 2017)

The following are examples of poor practices that have been reported in these surveys (Mateo, 1996; Belknap et al., 1997; Seifert and Johnston, 2005; Boullata et al., 2007): 5–43% of practitioners flush tubes before or between medications, 32–51% administer drugs separately from one another, 44–64% dilute liquid medication, 75–85% avoid crushing modified-release dosage forms.

Incorrect administration techniques could lead to measurable poor patient outcomes namely: Enteral tube obstruction, reduced drug efficacy, and increased drug toxicity (Bankhead et al., 2009; Sari et al., 2018). Tube obstruction was found to occur most commonly due to medication administration (Seifert et al., 1995; Bandy et al., 2019).

Interprofessional collaboration between nurses and pharmacists and educational interventions delivered by pharmacists have proved to be effective in improving nurses' knowledge regarding medication administration through EFTs, reducing medication errors that could happen during medication preparation and administration through EFTs, and reduce the incidence of negative health consequences resulting from improper medication administration through EFTs such as tube occlusion (Hanssens et al., 2006; Idzinga et al., 2009; Dashti-khavidaki et al., 2012; Hossaini Alhashemi et al., 2019)

Looking at previous literature, this is the first study in Jordan that addresses and specifies accurately the level of knowledge of ICU nurses regarding enteral medication administration and utilizes an educational intervention based on interprofessional collaboration between pharmacists and nurses to improve their knowledge.

This study aims to evaluate nurses' knowledge regarding oral medication administration through enteral feeding tubes at Jordan University Hospital. Also, the study aims to evaluate the effectiveness of a clinical pharmacist-led educational program on improving nurses' knowledge regarding the subject.

2. Methods

2.1. Study design

This study is a pre-/post- test interventional study. It has been conducted at intensive care units (ICUs) at Jordan University Hospital (JUH) during October 2016 and January 2017. Seven ICUs are available at JUH including: medical, surgical, neurological, coronary, pediatric, neonatal, and post interventional units. The main reason to choose the ICU setting is that enteral feeding is the preferred route of feeding for ICU patients (Heyland et al., 2003; Stroud et al., 2003; Kreymann et al., 2006).

2.2. Participants

All Staff nurses working in ICUs at JUH were considered eligible for participating in the study. Nurses who were assigned to work in the surgical, medical, neurological, coronary, pediatric, and post-interventional unit ICUs during the time of the study, were included. No sample size calculation was conducted since the entire population was targeted. The total number of nurses who worked in these six ICUs during the time of the study was 106 registered nurses (after excluding the 6 pilot study nurses who represent 5% of the population).

Since the study evaluates the knowledge of ICU nurses regarding oral medication administration through EFT, the research team decided to exclude the Neonatal ICU nurses from the study population for two reasons:

1. Neonates do not take oral medications frequently. This can be justified by the need for precise doses in this age group, and this can be achieved more easily with intravenous medication administration.
2. Neonatal ICU at JUH has already well-established clinical pharmacy services which can be a confounding factor in this study.

2.3. Outcomes and data collection

This study was conducted in three stages (Fig. 1). The main objective of the first stage was assessing the nurses' knowledge regarding medication administration through EFTs. The objective of the second stage of the study was to provide a clinical pharmacist-led educational intervention to the intervention group. The third stage was conducted three months after the baseline assessment, to re-assess the nurses' knowledge about the subject in both the intervention and control groups and to measure the

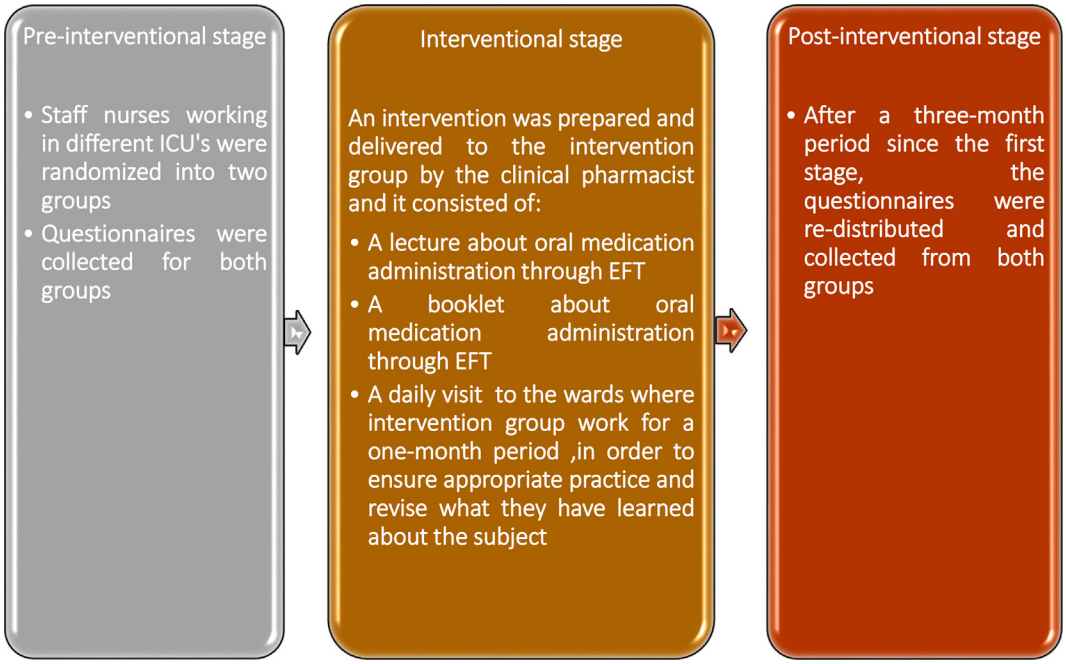

Fig. 1. Description of the different stages of the study.

effectiveness of the educational intervention. The three-month waiting period was chosen to avoid recall bias in both groups and to replicate at least an interval that is equal or longer than what was used in similar research (Idzinga et al., 2009; Dashti-khavidaki et al., 2012; Hossaini Alhashemi et al., 2019).

Before recruitment, a list with all the nurses' names and working units was provided by the head of the nursing department. These nurses were numbered consecutively from 1 to 106. Using www.randomization.com, these nurses were randomized into two groups.

During the pre-interventional stage, the researcher approached the staff nurses in the six included ICUs and asked them to take part in the study. Both the intervention and the control groups were approached to voluntarily participate in the study by completing the self-administered anonymous questionnaire. Nurses who were assigned for working in the A (7:00 am–3:00 pm) or B (3:00 pm–11:00 pm) shifts were approached and given a brief description of the questionnaire. The questionnaires were labeled with a number that indicates whether it belongs to the intervention or control group.

2.4. Study tool

A self-administered questionnaire adopted from Dashti-Khavidaki et al. (2012) was used after the acquisition of the corresponding author's approval. The questionnaire was translated from Persian to the Arabic language by a certified translator then back-translated by another translator from Arabic to Persian. The back-translated form was then compared to the original Persian version by an independent native Persian speaker to assure adequacy and quality of translation, finalizing the validation of the translation process.

The Arabic version of the questionnaire was then reviewed by two Ph.D. holders from the School of Pharmacy at the University of Jordan to assure face validity. An extensive review of the literature was used to assure content validity. The questionnaire was piloted on six nurses as mentioned before (5% of the target sample). This data was excluded from the final analysis. Pilot testing was used to ensure applicability, objectivity, and reliability of the questionnaire. Reliability testing was confirmed via Cronbach alpha measurement of internal consistency, and a result of 0.8 was obtained.

The final version of the questionnaire consisted of three parts: **Part A** contained nurse's demographic details (gender, age group, the total number of years of experience, the total number of years of experience at JUH, academic qualifications, and the ICU in which the nurse currently work).

Part B contained knowledge, attitude, and self-reported practice questions. It consisted of twenty-seven questions about four main domains of the process of oral medication administration through EFTs:

- Recognizing dosage forms
- Medication preparation
- Tube flushing before, between, and after medications' administration
- Recognizing drug-drug and drug-feed interactions

Part C contained a question that evaluated nurses' self-assessment of their knowledge regarding the subject, and nurses' willingness to participate in a workshop about enteral medication administration. The same validation process was undertaken for this part as the other parts of the questionnaire.

The intervene stage, the second stage, then took place. In this stage, the clinical pharmacist prepared a lecture about oral medication administration through EFT after a thorough literature review and emphasized the international guidelines and critical steps that would ensure best practice.

As a result of different working shifts and the relatively large number of nurses in the intervention group, they were divided into three subgroups who were given the same lecture as the other subgroups. The settings and content were kept as consistent as possible, any questions or notes that were not discussed in a prior lecture were written and communicated. The lecture was in the

form of an educational workshop; where both a theoretical and a practical part regarding preparation and administration techniques were included.

The clinical pharmacist's intervention delivered at this stage of the study required that the researcher spend one month with the intervention group nurses from different wards. The clinical pharmacist reviewed the medication records for patients who were cared for by an intervention group nurse. The available dosage form of the oral medications in the record, suitability for EFT administration, and reviewing the preparation and administration steps were done as part of the intervention. Working days were from Saturday to Thursday ~~of~~ each week in that month. Regarding the working hours, it was from 9:00 am until 4:00 pm. This way, both Shift A and Shift B nurses were seen and had the chance to benefit from the intervention.

The third stage took place three months later; it can be considered a replicate of the first stage. The nurses were approached again to complete the same questionnaire to assess any improvements in knowledge regarding medication administration through EFTs.

The total knowledge score for each nurse represents the number of questions that were answered correctly by the nurse. The knowledge score for each domain represents the number of correct answers to questions that follow each of these domains.

To assess nurses' knowledge regarding the subject, the mean total knowledge score for the intervention group nurses and the control group nurses were calculated, both at baseline and at the post-interventional phase. The mean knowledge score for each domain was calculated also, for both groups at baseline and the post-interventional phase.

The nurses' self-reported practice regarding enteral medication administration was also assessed by the questionnaire. One branched question in the questionnaire asked the nurses about how frequently they perform certain practices during the preparation and administration of oral medications through EFTs. Each answer was given a score that ranged from 1 to 5, with higher scores representing favorable practices that follow guideline recommendations (Bankhead et al., 2009). An average score was then calculated for each nurse. Then, to assess the self-reported practice score for each group (intervention and control groups), the mean self-reported practice score was computed for each group.

2.5. Statistical analysis

Data was coded, entered, and analyzed using the Statistical Package for Social Sciences (IBM SPSS statistics 22). Only nurses who completed the questionnaire both at baseline and at the post-interventional period were included in the final analysis.

Independent samples *t*-test was used to detect any statistically significant differences between the intervention and control groups' nurses with regards to the following: mean total knowledge scores, mean knowledge scores for each domain, and mean self-reported practice score both at baseline and post-interventional phase. The paired sample *t*-test was utilized to detect any statistically significant intra-group difference in the total mean knowledge score pre and post the intervention.

Independent samples *t*-test was utilized to compare the means of any other continuous data between the intervention and control groups. A Chi-square test was utilized to compare the frequencies of different categorical data for any statistically significant differences.

3. Ethicalll approval

The study was approved by The Postgraduate Studies Committee at The School of Pharmacy/The University of Jordan, The Institutional Review Board (IRB) at JUH, and two Scientific Research Committees: at the School of Pharmacy and Deanship of Academic Research at the University of Jordan. Both verbal and written consent was obtained from the nurses before their enrollment.

4. Results

The total number of nurses who completed the questionnaire both at baseline and post-interventional stage of the study was 86 (response rate = 81%), out of which 44 in the intervention group and 42 in the control group. Fig. 2 illustrates the number of nurses at the different stages of the study.

4.1. Demographics and characteristics of enrolled nurses

Data regarding nurses' gender, academic qualification, age group, years of experience, years of experience at JUH, and any formal training regarding enteral medication administration were collected. Nearly 50% of the respondents were females. All respondents except one nurse were in the age group of 18–39 years of age, 44% of them having 5–10 years of experience as registered nurses and almost 5 years of their experience wherein JUH. Table 1 represents the demographic data for the enrolled nurses for both the intervention and control groups.

In the first stage (baseline), nurses were asked to specify the training they have received, including lectures about medication administration in general during their orientation before and during their work at JUH. There was no statistical difference in the number of nurses who responded (yes) with regards to receiving formal training about medication administration through EFTs in both the intervention and control groups. None of the nurses specified any form of specialized training regarding medication administration through EFTs.

None of the demographic and clinical characteristics was significantly different between the two groups (P-values > 0.05).

4.2. Total knowledge scores and knowledge scores for each domain

The assessment of enrolled nurses' knowledge regarding the administration of oral medications through EFTs is represented as the mean total knowledge score for the nurses in each group at baseline (before any intervention), and the mean total knowledge score at the post-interventional stage (Table 2). The mean knowledge scores for each domain were also calculated both at baseline and post-interventional stage for the intervention and control groups (Table 2). The effect of the clinical pharmacist's intervention on the intervention group nurses' knowledge in each of the studied knowledge domains was satisfactory, with at least 48% improvement in the domains' mean scores observed after the intervention.

4.3. Self-reported practice scores

The average scores for the self-reported practice of nurses in both the intervention and control groups were re-assessed at the post-interventional phase. Table 2 summarizes the average score for self-reported practice for the enrolled nurses. The average self-reported practice score for nurses in the intervention group was significantly higher than that for nurses in the control group at the post-interventional phase. Independent samples *t*-test was used to test the equality of means between the two groups.

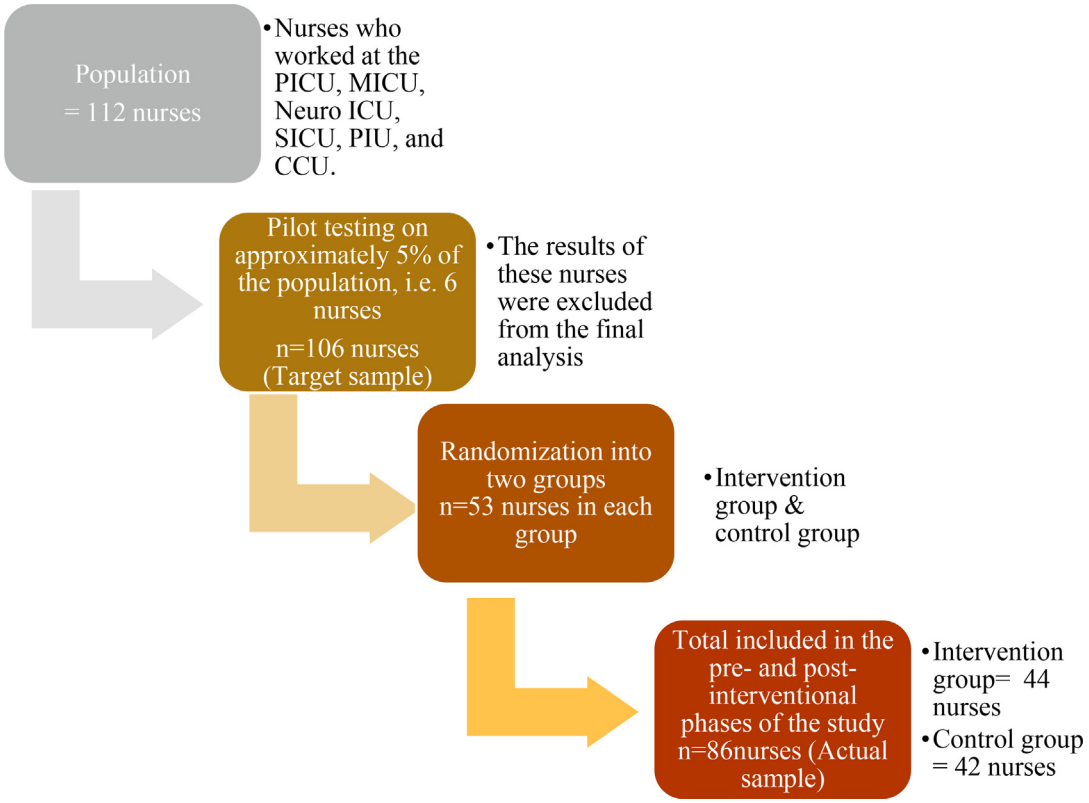

Fig. 2. Process of study sample recruitment.

Table 1
Demographic data and characteristics for the enrolled nurses (Total N = 86).

	Intervention group (N = 44)	Control group (N = 42)	P-value[1]
Gender (Number and percentage of females)	28 (63.6)	18 (42.9)	0.053
Age (Number and percentage)			0.066
18–28	28 (63.6)	19 (45.2)	
29–39	16 (36.4)	22 (52.4)	
40–50	0	1 (2.4)	
Years of experience (Number and percentage)			0.724
1–3	11 (25.0)	5 (11.9)	
3–5	13 (29.5)	11 (26.2)	
5–10	15 (34.1)	23 (54.8)	
More than 10 years	5 (11.4)	3 (7.1)	
Years of experience at JUH (Mean ± SD)	5.46 ± 3.87	5.68 ± 3.03	0.774[2]
Academic qualification (Number and percentage)			0.193
Bachelor degree	37 (84.1)	35 (83.3)	
Master degree	7 (15.9)	6 (14.3)	
Doctoral degree	0	1 (2.4)	
Formal training regarding enteral medication administration (Number and percentage)			0.685
No	39 (88.6)	36 (85.7)	
Yes	5 (11.4)	6 (14.3)	

JUH: Jordan university hospital.
[1]P-value was estimated using the Chi-square test.
[2]The P-value for years of experience at JUH was estimated using independent samples *t*-test.
P: Probability, SD: Standard Deviation.

4.4. Nurses' attitudes regarding their knowledge about medication administration through EFTs

After the completion of parts A and B of the questionnaire at baseline, enrolled nurses were asked in part C to self-assess their knowledge regarding medication administration through EFTs, and whether they would like to participate in an educational program regarding the subject. All of the 86 enrolled nurses answered these questions. The majority of enrolled nurses assessed themselves as having inadequate knowledge regarding the subject at baseline (76.74%), also the majority of nurses were willing to participate in an educational program regarding this subject at baseline (91.86%).

4.5. Clinical pharmacist effect on improving nurses' knowledge regarding administering medications through EFTs

The effect of the clinical pharmacist intervention on the nurses' knowledge regarding enteral medication administration was represented by calculating the improvement of the mean total knowledge scores for nurses in both groups, which is the difference between the mean scores at the post-interventional phase and baseline (Table 3). Also, a statistically significant difference was detected when we compared the mean total knowledge score before and after the clinical pharmacist-led educational program for the intervention group nurses, contrary to the same measure in the control group nurses. The mean score for each knowledge domain and the average self-reported practice score improved significantly in the intervention group nurses, but remained relatively unchanged or even decreased in the control group nurses.

Table 2
Mean total knowledge score, Mean knowledge score for each separate domain, and Mean self-reported practice score for the intervention and control groups (At baseline and post-intervention stage).

	At Baseline			At follow-up (post-intervention)		
	Intervention group	Control group	P-value[1]	Intervention group	Control group	P-value[1]
Total Knowledge Score (Mean ± SD)[2]	12.11 ± 3.75	12.05 ± 3.12	0.93	21.50 ± 2.36	12.60 ± 3.76	<0.001
Mean scores for each separate knowledge domain (Mean ± SD)						
Medication Preparation[3]	3.14 ± 1.41	3.07 ± 1.31	0.83	6.32 ± 0.93	3.21 ± 1.46	<0.001
Tube Flushing[4]	1.64 ± 0.97	1.64 ± 0.73	0.97	2.66 ± 0.53	1.60 ± 0.77	<0.001
Recognizing dosage forms[5]	4.60 ± 1.98	4.71 ± 1.74	0.76	7.84 ± 1.60	5.00 ± 2.36	<0.001
Recognizing drug-drug and drug-feed interactions[6]	2.75 ± 1.35	2.62 ± 1.13	0.63	4.68 ± 1.47	2.79 ± 1.30	<0.001
Self-reported practice score (Mean ± SD)[7]	3.24 ± 0.55	3.22 ± 0.56	0.92	3.88 ± 0.36	3.14 ± 0.51	<0.001

P: Probability, SD: Standard Deviation.
[1] P-value was estimated using an independent sample *t*-test.
[2] The minimum score was 6 in both groups, the maximum score was 22 in the intervention group and 19 in the control group
[3] The maximum score in this domain was 6 in both groups at baseline, and the maximum score was 8 in the intervention group and 7 in the control group at the post-interventional stage
[4] The maximum score in this domain was 3 in both groups at baseline and post-interventional stage
[5] The maximum score in this domain was 10 in the intervention group and 9 in the control group at baseline, and the Maximum score was 11 in the intervention group and 15 in the control group at the post-intervention stage
[6] The maximum score in this domain was 5 in both groups at baseline, and the maximum score was 7 in the intervention group and 6 in the control group
[7] For the Intervention group, the minimum score was 1.89, and the maximum score was 4.33. And for the control group, the minimum score was 1.78, and the maximum score was 4.11.

Table 3
Overall improvement of the mean total knowledge score as a measure of clinical pharmacist-led educational intervention.

	At Baseline	At Follow-up	P-value[1]	Improvement (mean difference)[2] in the mean total knowledge score
Intervention group	12.11 ± 3.75	21.50 ± 2.36	<0.001	9.39 ± 3.47
Control group	12.05 ± 3.12	12.60 ± 3.76	0.96	0.55 ± 2.05

Data presented as Mean ± SD.
[1]P-values were estimated using paired *t*-test.
[2]Mean difference is calculated by the following equation (Post-interventional phase mean score – baseline mean score).
P: Probability, SD: Standard Deviation.

5. Discussion

This is the first study in Jordan to investigate the knowledge and the adequacy of the self-reported practice of nurses regarding oral medication administration through EFTs and to assess the impact of clinical pharmacist intervention on improving the nurses' knowledge regarding the subject. The study showed an unsatisfactory baseline level of knowledge and self-reported practice among nurses regarding enteral medication administration. All of the studied knowledge domains were positively and significantly improved by a clinical pharmacist intervention.

Medication administration through EFTs is a nurse's responsibility in many healthcare institutions (Phillips and Nay, 2007; Demirkan et al., 2017; Sari et al., 2018; Hossaini Alhashemi et al., 2019), but with inadequate knowledge and skills, patient outcomes can be affected (Hanssens et al., 2006). Guidelines and educational materials regarding medication administration through EFTs are available (Beckwith et al., 2004; Bankhead et al., 2009). However, nurses may be inadequately trained or alerted about the subject. The high percentage of nurses enrolled in this study who wanted to be engaged in an educational program can reflect the desire of the nurses to improve their knowledge and skills about administering medications through EFTs. This lack of knowledge that was evident in many publications (Mota et al., 2010; Phillips and Endacott, 2011; Sari et al., 2018); is alarming and the need to improve the quality of enteral medication administration is considered urgent.

The enrolled nurses' in this study were found to have inadequate knowledge regarding appropriate oral medication administration through EFTs. The average total knowledge scores for the intervention and control groups at baseline were less than 50% of the maximum score that could be obtained. This inadequate knowledge regarding the subject was not surprising even to the enrolled nurses since the majority of nurses (around 75%) assessed themselves as having inadequate knowledge regarding enteral medication administration upon completing the questionnaire at baseline. The same observation was described in the study conducted by Abdullah et al. (2014), where they reported that all the studied samples had an unsatisfactory level of knowledge regarding enteral medication administration, and nearly half of the nurses answered knowledge questions incorrectly.

Besides, such finding is consistent with the findings of other studies that evaluated nurses' knowledge about proper medication administration via EFTs in different countries and settings (Mota et al., 2010; Dashti-Khavidaki et al., 2012; Khani et al., 2016; Sari et al., 2018). Educational workshops and collaboration between pharmacists and nurses to encourage best practices are necessary to overcome these repeated findings of inadequate knowledge regarding the subject.

The analysis of nurses' knowledge in all studied domains of the process of enteral medication administration, also revealed some undesirable findings. The nurses' knowledge was unsatisfactory for all the four domains of characterizing medication administration through EFTs at baseline: Recognizing dosage forms, medication preparation, tube flushing before, between, and after medications' administration, recognizing drug-drug and drug-feed interactions. Again, this was observed in previous studies that examined the same domains of nurses' knowledge regarding enteral medication administration (Dashti-Khavidaki et al., 2012; Khani et al., 2016).

The poor knowledge of nurses regarding special drug formulations can threaten patients' safety since the incorrect crushing of such preparation can lead to undesirable patients' outcomes and even death (Schier et al., 2003; Matysiak-Luśnia and Łysenko, 2014; Bandy et al., 2019). This can be attributed to possibly deficient academic education, specifically with regards to medications and dosage form characteristics, but this should be addressed universally to protect patients from potential harm. Physicians and pharmacists also have to collaborate with nurses to reduce the number of these medication errors and reduce the potential for patient harm.

Nurses' self-reported practice regarding medication administration through enteral tubes was found to be unsatisfactory for both groups at baseline (the average was less than 75% of the total score). This was consistent with the results of other surveys that were interested in nurses' practices during medication administration through EFTs. These surveys showed the inconsistency in nurses' practices, the low percentages of nurses who flush the tube before medication administration, after medication administration, and between different medications administration. Moreover, nurses have reported crushing solid dosage forms routinely (Phillips and Endacott, 2011; Guenter and Boullata, 2013). The self-reported practice is an important way to evaluate a process, but the fact that it could not be able to reflect real practice deficiencies cannot be eliminated. Although, this unsatisfactory average score can make our judgment about the inadequate knowledge of nurses regarding the subject more certain, it was expected that nurses would answer according to what they believed would be the "correct" answer.

The intervention has significantly improved knowledge and self-reported practice. These favorable results can be expected as a result of an educational program, especially after blaming the lack of nurses' knowledge regarding enteral medication administration for the undesirable results at baseline. This kind of educational intervention that aimed at increasing the awareness and knowledge of nurses regarding the subject was also evaluated in previous studies (Hanssens et al., 2006; Van den Bemt et al., 2006; Idzinga et al., 2009; Dashti-Khavidaki et al., 2012; Hossaini Alhashemi et al., 2019). The positive impact of these educational interventions seen in these studies differed from one study to another. The knowledge and practice domains were affected by each educational or pharmaceutical intervention to variable extents, while others were not affected significantly, such as medication preparation errors (Idzinga et al., 2009; Dashti-Khavidaki et al., 2012). In our study, statistically significant improvements in all the knowledge domains, and self-reported practice suggest that the close contact and collaboration between pharmacists and nurses on an individual basis can help in filling knowledge gaps and resolving technical or theoretical issues.

The main differences between the intervention and control groups for the outcomes measured at the post-interventional phase can be attributed to the education provided by the clinical pharmacist. The mean total knowledge score, the mean knowledge score for each domain, and the mean self-reported practice score were all significantly higher in the intervention group when compared to the nurses in the control group. Moreover, all can be categorized as adequate after the intervention (Knowledge score > 50% maximum score, practice score > 75% of the maximum score). Hanssens et al. (2006) reported earlier improvement in nurses' knowledge and self-reported practice as a result of an educational intervention. A finding that is limited by the absence of clinical outcomes that directly affect the patients. The argument of why this is considered as a limitation is that the lack of knowledge can be a cause of why nurses' deviate from the "recommended" practice and result in patient harm. However, "how and to what extent they deviate?" are questions that cannot be answered by such research. Sometimes, other factors would make a nurse deviate from what he or she knows, and thus observation of what a nurse does leads to a stronger argument. This limitation of lacking a relevant clinical outcome in Hanssens et al. (2006) study was overcome by measuring tube obstruction and the number of administration errors per nurse as outcomes to assess the intervention in Van den Bemt et al. (2006) study. The latter study aimed to improve the quality of oral medication administration to patients with EFTs, the difference in the number of tube obstructions was not statistically significant after the intervention, but a trend toward improvement was seen. On the other hand, the intervention reduced the number of administration errors significantly (OR 0.003, 95% CI 0.0005 to 0.02) (Van den Bemt et al., 2006)

This study found that the mean knowledge score for each domain, improved significantly in the intervention group nurses, in all the studied domains. This is contrary to the results found in Dashti-Khavidaki et al. (2012), where a similar intervention did not significantly affect the tube flushing and recognizing dosage form domains. This can be attributed to the design of the intervention to include and highlight the importance of all the aspects of medication administration through EFTs process, not only the medication preparation and administration steps. Moreover, the close contact between the clinical pharmacist and the intervention group nurses as part of the intervention allowed us to repeat and comment on their practices on an individual level to overcome any insufficient knowledge or misunderstanding regarding the subject, similar to the findings of Hossaini Alhashemi et al. (2019), where a similar educational intervention resulted in a statistically significant improvement in all the studied domains.

The mean differences in the total knowledge score and the mean scores for each knowledge domain in our study suggest that the greatest improvements were seen in the tube flushing, medication preparation, and recognizing dosage forms domains. These findings can be justified by the nurses' acceptance of the importance of their role in these domains, but their role in recognizing drug-drug or drug-feed interactions seemed less convincing to the nurses or needed more pharmacological, pharmacokinetic, and drug-specific information that needed to be fully comprehended by the nurses in the intervention group. Moreover, this poor pharmacological knowledge is a finding and a justification that is regularly encountered in similar research (Mota et al., 2010, Bandy et al., 2019). Also, the lack of interprofessional collaboration and regular guidance from pharmacists, nutritionists, and physicians regarding possible interactions might contribute to inadequate knowledge.

6. Study strengths and limitations

This study is the first one of its kind to characterize the process of oral medication administration through EFTs in Jordan. This would aid in sizing the problem especially that multiple variables were measured, namely: nurses' knowledge, nurses' self-reported practice, and nurses' attitudes toward educational intervention to enhance their knowledge regarding enteral medication administration.

Several limitations could be stated to make it easier to overcome them in future research, these include:

1. The study was conducted at six ICU departments at JUH, it was done in one hospital and generalization to other sites will depend on further research.
2. Self-report is always controversial in quantitative research. However, it does sound as if the nurses were being honest in their statements of knowledge deficits.

7. Conclusion and recommendations

Oral medication administration through EFTs is a complex process with many aspects to consider, multiple steps to perform, and multiple error-prone opportunities. Intensive care units' nurses' baseline knowledge and practice regarding enteral medication administration were found to be unsatisfactory, especially that they are dealing with critical patients. Nurses' knowledge and practice improved after the implementation of a clinical pharmacist intervention that was designed to help the nurses' to acquire the required information and skills to prepare and administer oral medications through EFTs. Nurses' willingness to become engaged in such educational programs accompanied by their self-assessment as having inadequate knowledge regarding the subject prompt actions toward offering and implementing similar educational sessions repetitively for intensivist nurses.

Some of the authors' recommendations for better practice:

- Clinical pharmacists along with a multidisciplinary healthcare team can aid in generating a protocol or institution-specific guideline that standardizes the process of medication administration through EFTs in the institution. This would ensure a longer-term effect on nurses' knowledge and practice that would not be affected by workflow changes.
- The repeated observation of the lack of satisfactory knowledge regarding oral medication administration through EFTs among nurses may suggest the need to introduce key points regarding enteral medication administration to the academic courses for nurses, orientation topics, and the continuous education and professional development requirements.
- An educational program could be offered to physicians during their undergraduate courses and in-hospital training. This could reduce the number of prescribed medications that are unsuitable for administration through EFTs.
- Proper training about the correct use, handling, and cleaning of the instruments used in the process of administering medications through an EFT should be offered to ICU nurses to optimize patient outcomes.
- A database of the medications available in the hospital that couldn't be crushed and considered unsuitable for administration through EFTs can be made. This would activate the role of both clinical and dispensing pharmacists in reducing the number of medication errors.
- A follow-up study to see how well the changes in practice endured over time and in the face of increased patient loads in ICU.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

The authors are grateful to the Middle East University, Amman, Jordan for the financial support granted to cover the publication fee of this research article.

References

Abdullah, M., Mohammed, W., Ismail, M., 2014. Nurses' knowledge and practices about administration of medications via nasogastric tube among critically Ill patients. J. Educ. Pract. 5 (1), 147–159.

Bandy, K.S., Albrecht, S., Parag, B., McClave, S.A., 2019. Practices involved in the enteral delivery of drugs. Curr. Nutr. Rep. 8 (4), 356–362. https://doi.org/10.1007/s13668-019-00290-4.

Bankhead, R., Boullata, J., Brantley, S., Corkins, M., Guenter, P., Krenitsky, J., Lyman, B., Metheny, N.A., Mueller, C., Robbins, S., Wessel, J., 2009. Enteral nutrition practice recommendations. J. Parenteral Enteral Nutr. 33 (2), 122–167.

Beckwith, M.C., Feddema, S.S., Barton, R.G., Caran Graves, R.D., 2004. A guide to drug therapy in patients with enteral feeding tubes: dosage form selection and administration methods. Hospital Pharm. 39 (3), 225–237.

Belknap, D.C., Seifert, C.F., Petermann, M., 1997. Administration of medications through enteral feeding catheters. Am. J. Crit. Care 6 (5), 382–392.

Boullata, J.I., Hudson, L.M., Spencer, C.T., Preston, A.M., Oakes, B.A., 2007. Drug Administration by feeding tube: results of a practice-based survey. Nutr. Clin. Pract. 22 (1), 126.

Dashti-Khavidaki, S., Badri, S., Eftekharzadeh, S.Z., Keshtkar, A., Khalili, H., 2012. The role of clinical pharmacist to improve medication administration through enteral feeding tubes by nurses. Int. J. Clin. Pharm. 34 (5), 757–764.

Demirkan, K., Bayraktar-Ekincioglu, A., Gulhan-Halil, M., Abbasoglu, O., 2017. Assessment of drug administration via feeding tube and the knowledge of health-care professionals in a university hospital. Eur. J. Clin. Nutr. 71 (2), 164–168. https://doi.org/10.1038/ejcn.2016.147.

Dickerson, R.N., 2004. Medication administration considerations for patients receiving enteral tube feedings. Hospital Pharm. 39 (1).

Gramlich, L., Kichian, K., Pinilla, J., Rodych, N.J., Dhaliwal, R., Heyland, D.K., 2004. Does enteral nutrition compared to parenteral nutrition result in better outcomes in critically ill adult patients? systematic review of the literature. Nutrition 20 (10), 843–848. https://doi.org/10.1016/j.nut.2004.06.003.

Guenter, P., Boullata, J., 2013. Nursing2013 survey results: Drug administration by enteral feeding tube. Nursing2016 43 (12), 26–33.

Hanssens, Y., Woods, D., Alsulaiti, A., Adheir, F., Al-Meer, N., Obaidan, N., 2006. Improving oral medicine administration in patients with swallowing problems and feeding tubes. Ann. Pharmacother. 40 (12), 2142–2147.

Heyland, D.K., Dhaliwal, R., Drover, J.W., Gramlich, L., Dodek, P., 2003. Canadian clinical practice guidelines for nutrition support in mechanically ventilated, critically ill adult patients. J. Parenteral Enteral Nutr. 27 (5), 355–373.

Hossaini Alhashemi, S., Ghorbani, R., Vazin, A., 2019. Improving knowledge, attitudes, and practice of nurses in medication administration through enteral feeding tubes by clinical pharmacists: a case-control study. Adv. Med. Educ. Pract. 10, 493–500. https://doi.org/10.2147/AMEP.S203680.

Idzinga, J.C., De Jong, A.L., Van Den Bemt, P.M.L.A., 2009. The effect of an intervention aimed at reducing errors when administering medication through enteral feeding tubes in an institution for individuals with intellectual disability. J. Intellect. Disabil. Res. 53 (11), 932–938.

Khani, J., Vazin, A., Shafiekhani, M., 2016. Evaluating knowledge, attitude and practice of intensive care unit nurses in administering medications via enteral tubes. Trends Pharmaceut. Sci. 2 (3), 195–204.

Kreymann, K.G., Berger, M.M., Deutz, N.E., Hiesmayr, M., Jolliet, P., Kazandjiev, G., Nitenberg, G., van den Berghe, G., Wernerman, J., DGEM (German Society for Nutritional Medicine), Ebner, C., Hartl, W., 2006. ESPEN guidelines on enteral nutrition: intensive care. Clin. Nutr. 25(2), 210–223.

Magnuson, B.L., Clifford, T.M., Hoskins, L.A., Bernard, A.C., 2005. Enteral nutrition and drug administration, interactions, and complications. Nutr. Clin. Pract. 20 (6), 618–624.

Mateo, M.A., 1996. Nursing management of enteral tube feedings. Heart Lung: J. Acute Crit. Care 25 (4), 318–323.

Matysiak-Luśnia, K., Łysenko, L., 2014. Drug administration via enteral feeding tubes in intensive therapy–terra incognita. Anaesthesiol. Intensive Therapy 46 (4), 307–311.

Mota, M.L.S., Barbosa, I.V., Studart, R.M.B., Melo, E.M., Lima, F.E.T., Mariano, F.A., 2010. Evaluation of intensivist-nurses' knowledge concerning medication administration through nasogastric and enteral tubes. Revista latino-americana de enfermagem 18 (5), 888–894.

National Board of Health and Welfare, 2000. Service and care to elderly persons 1999 2000.

Naysmith, M.R., Nicholson, J., 1998. Nasogastric drug administration. Professional Nurse (London, England) 13 (7), 424–427.

Phillips, N.M., Endacott, R., 2011. Medication administration via enteral tubes: a survey of nurses' practices. J. Adv. Nurs. 67 (12), 2586–2592.

Phillips, N.M., Nay, R., 2007. Nursing administration of medication via enteral tubes in adults: a systematic review. Int. J. Evidence Based Healthcare 5 (3), 324–353.

Sari, D., Kadifeli, D., Akbiyik, A., Taşkiran, N., 2018. Intensive care unit nurses' knowledge of medication administration via enteral tubes. Nurs. Crit. Care 23 (3), 141–146. https://doi.org/10.1111/nicc.12335.

Schier, J.G., Howland, M.A., Hoffman, R.S., Nelson, L.S., 2003. Fatality from administration of labetalol and crushed extended-release Nifedipine. Ann. Pharmacother. 37 (10), 1420–1423.

Seifert, C.F., Johnston, B.A., 2005. A nationwide survey of long-term care facilities to determine the characteristics of medication administration through enteral feeding catheters. Nutr. Clin. Pract. 20 (3), 354–362.

Seifert, C.F., Frye, J.L., Belknap, D.C., Anderson, D.C., 1995. A nursing survey to determine the characteristics of medication administration through enteral feeding catheters. Clin. Nurs. Res. 4 (3), 290–305.

Seres, D.S., Valcarcel, M., Guillaume, A., 2013. Advantages of enteral nutrition over parenteral nutrition. Therapeutic Adv. Gastroenterol. 6 (2), 157–167.

Stroud, M., Duncan, H., Nightingale, J., 2003. Guidelines for enteral feeding in adult hospital patients. Gut 52 (7), vii1-vii12.

Van den Bemt, P.M.L.A., Cusell, M.B.I., Overbeeke, P.W., Trommelen, M., Van Dooren, D., Ophorst, W.R., Egberts, A.C.G., 2006. Quality improvement of oral medication administration in patients with enteral feeding tubes. Quality Safety Health Care 15 (1), 44–47.
White, R., Bradnam, V., 2015. Handbook of drug administration via enteral feeding tubes. Pharmaceutical Press, East Smithfield, London.
Williams, N.T., 2008. Medication administration through enteral feeding tubes. Am. J. Health-System Pharm. 65 (24).
Williams, T.A., Leslie, G.D., 2004. A review of the nursing care of enteral feeding tubes in critically ill adults: part I. Intensive Crit. Care Nurs. 20 (6), 330–343.