ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA DOI: 10.5336/nurses.2024-102782

Development of Simulated Vials and Assessment of Their Effectiveness in Students' Drug Preparation Training: Two Stage (A Descriptive and a Randomized Controlled) Study

Beceri Eğitiminde Simüle Edilmiş Flakonların Geliştirilmesi ve Hemşirelik Öğrencilerinin İlaç Hazırlama Eğitimindeki Etkililiğinin Değerlendirilmesi: İki Aşamalı (Bir Tanımlayıcı ve Bir Randomize Kontrollü) Çalışma

Nurten ALAN[a], Dilek ÖZDEN[a], Gülşah GÜROL ARSLAN[a], İlkin YILMAZ[a], Gizem GÖKTUNA[a]

[a]Dokuz Eylül University Faculty of Nursing, Department of Fundamentals of Nursing, İzmir, Türkiye

This study was presented as an oral presentation at 6th National 2nd International Fundamental Nursing Care Congress, September 15-17, 2022, İstanbul, Türkiye.

ABSTRACT Objective: This study is to develop unpackaged vials prepared with non-allergic powdered substance to be used in skill training of students and to evaluate the effectiveness of the vials. **Material and Methods:** The research was conducted in two stages with faculty members and students of Dokuz Eylül University Faculty of Nursing between July 2020 and August 2021. The first phase was planned as descriptive and the second phase as randomized controlled. In order for the powder used in the vial to serve the skill practice in the best way, 1 g starch was added to the 1st group vial, 1 g powder to the 2nd group vial and 1 g powdered sugar to the 3rd group vial, and the vial was closed with a closure machine. At the first stage of the study, the operability of the simulated vials prepared for the experimental group was evaluated by the nurse instructors who had experienced the ability to withdraw medication from the vial (n=47). In the second stage, the students were given a theoretical presentation about drug preparation from the vial. Students who wanted to participate were randomly divided into experimental (n=122) and control (n=120) groups. After the application was demonstrated by the instructor, the students were asked to perform the skill. At the end of the application, experimental group students performed the skill with a simulated vial, and control group students performed the skill with a previously used vial. The functionality of the vial and skill application were evaluated by the students. SPSS 22.0 program was used for data analysis. The Kruskal-Wallis H test was used to evaluate the effectiveness of the powder substance in terms of number, percentage, average, minimum-maximum values, and vial functionality. The Mann-Whitney U test was used as a pairwise comparison test in independent groups to compare the functionality of the vial in the experimental and control groups. In the first stage, starch, powder, powdered sugar vial groups were evaluated by faculty members. In the second stage, students randomly practiced with the simulated vial or previously used vials. Data for the study were gathered utilizing several forms, including the faculty member information form, the vial effectiveness assessment form, the student nurse information form, and the feedback form for skills practice. The students' and the lecturers' descriptive data were expressed in numerical figures, percentages, and average values. Kruskal-Wallis test, the Mann-Whitney U test were used to compare the effectiveness of the vials. **Results:** In the first stage, the most effective vial was determined as powdered sugar ($p<0.001$). Students evaluated simulated vials as more effective than used vials ($p<0.05$). Simulated vials prepared with powdered sugar were found to be more effective than vials prepared with starch and powder. They were found to be more effective than used vials utilized for practice by students. **Conclusion:** Simulated vials containing powdered sugar can be ideal for developing vial drug preparation skills in laboratory conditions as they look like the original drug vials very much.

Keywords: Drug preparation; clinical skills; vial drug preparation; simulation; nursing

ÖZET Amaç: Bu çalışmanın amacı, öğrencilerin beceri eğitiminde kullanılmak üzere alerjik olmayan toz madde ile hazırlanmış ambalajsız flakonların geliştirilmesi ve flakonların etkinliğinin değerlendirilmesidir. **Gereç ve Yöntemler:** Araştırma, Temmuz 2020-Ağustos 2021 tarihleri arasında Dokuz Eylül Üniversitesi Hemşirelik Fakültesi öğretim elemanları ve öğrencileri ile iki aşamada yürütüldü. İlk aşama tanımlayıcı ve ikinci aşama randomize kontrollü olarak planlandı. Flakon içinde kullanılan toz maddenin beceri uygulamasına en iyi şekilde hizmet etmesi için 1. grup flakona 1 g nişasta, 2. grup flakona 1 g pudra ve 3. grup flakona 1 g pudra şekeri eklenerek flakon kapatma makinası ile kapatıldı. Çalışmanın ilk aşamasında deney grubu için hazırlanmış simüle flakonlar, flakondan ilaç çekme becerisini deneyimlemiş hemşire öğretim elemanları tarafından işlerliği değerlendirildi (n=47). İkinci aşamada öğrencilere flakondan ilaç hazırlama ile ilgili teorik sunum anlatıldı. Katılmak isteyen öğrenciler randomize olarak deney (n=122) ve kontrol (n=120) grubuna ayrıldı. Öğretim elemanı tarafından uygulama gösterildikten sonra, deney grubu öğrencileri simüle flakon ile kontrol grubu öğrencileri ise daha önce kullanılmış flakon ile beceriyi gerçekleştirdiler. Simüle flakonun işlevselliği ve beceri uygulaması öğrenciler tarafından değerlendirildi. Çalışma verileri, öğretim üyesi bilgi formu, şişe etkinlik değerlendirme formu, öğrenci hemşire bilgi formu ve beceri uygulama geri bildirim formu kullanılarak toplandı. Öğrenci ve öğretim elemanlarının tanımlayıcı verileri sayısal değerler, yüzdeler ve ortalama değerler olarak ifade edildi. Flakonların etkinliğini karşılaştırmak için Kruskal-Wallis testi ve Mann-Whitney U testi kullanıldı. **Bulgular:** İlk aşamada en etkili flakon pudra şekeri olarak belirlendi ($p<0,001$). Öğrenciler simüle edilmiş şişeleri kullanılan şişelere göre daha etkili olarak değerlendirdi ($p<0,05$). Pudra şekeri ile hazırlanan simüle şişelerin, nişasta ve tozla hazırlanan şişelerden daha etkili olduğu görüldü. Öğrencilerin pratik yapmak için kullandıkları şişelerden daha etkili oldukları bulundu. **Sonuç:** Pudra şekeri içeren simüle flakonlar, orijinal ilaç flakonlarına çok benzediğinden laboratuvar koşullarında flakon ilaç hazırlama becerilerinin geliştirilmesi için ideal olabilir.

Anahtar Kelimeler: İlaç hazırlama; klinik beceri; flakon ilaç hazırlama; stimülasyon; hemşirelik

Correspondence: İlkin YILMAZ
Dokuz Eylül University Faculty of Nursing, Department of Fundamentals of Nursing, İzmir, Türkiye
E-mail: ilkinyilmaz85@gmail.com

Peer review under responsibility of Turkiye Klinikleri Journal of Nursing Sciences.

Received: 14 Mar 2024 ***Received in revised form:*** 04 Jun 2024 ***Accepted:*** 06 Jun 2024 ***Available online:*** 20 Jun 2024

Skill training in nursing forms the basis of nursing students' educational experiences. Many vocational psychomotor skills are taught in nursing faculties, from vital signs to intravenous therapy and suctioning applications.[1] In the educational steps followed in the teaching of skills, the skills practice step ensures the development of the skill.[2]

On the way to excellence, repeated practice improves skills.[3] The use of simulation methods in skills teaching increases patient and employee safety through repeated practice and application in low-risk environments before practicing them in real life.[4-8] While a model or manikin can be used for almost every skill, skill-specific materials are used in basic skills such as parenteral drug preparation applications.[9] Parenteral drug administration is taught in clinics and nursing faculties by using expired or ready-made demo vials and ampoules. These methods are advantageous as they are very close to reality. On the other hand, expired drugs may contain active ingredients; demo vials and ampoules are expensive; they may not be produced for every need; and they are difficult to obtain and purchase.[9] Practice with demo and expired drugs can endanger not only patient safety but also employee safety. During drug preparation containing active substances, drug particles are spread on gloves and hands and to the environment.[10] Cutaneous hypersensitivity reactions such as drug-induced allergic contact dermatitis can be seen on the skin of the person preparing the drug.[11,12]

In Türkiye, every medicine that is over-demand and expired in clinics is returned to hospital pharmacy with a status report because when fake or expired drugs are administered to patients during an emergency or carelessly, they may cause serious side effects.[13-15] In Türkiye, parenteral drug administration is a skill that is taught through used vials that have been prepared for the patient and have no drug inside or ready-made vials bought by the students.

Used drug vials have several drawbacks. One of these is exposure to liquids containing a few drops of active or impaired antibiotics that remain in the vial. Another is the growth of strains that cause sepsis and bacterial meningitis, such as *Staphylococcus epidermidis*, *Pseudomonas aeruginosa*, *Enterobacter cloacae*, *Candida albicans*, and *Serratia marcescens*, even within 24 hours in the fluids of multiple drug vials.[16,17] Another drawback is that there is no negative pressure in the used vial. In multiple uses of vials, the negative pressure characteristic of the air in the vial is lost. The negative pressure feature makes it easier to inject the liquid in the syringe into the vial. Multiple uses do not allow the proper amount of air-liquid exchange between the vial and the syringe, and thus, liquid splashes out and results in dose loss. Dose losses are among the errors in parenteral drug administration and lead to the violation of patient safety.[18] Finally, since students cannot see the powder substance in the vial, they pretend while doing the application. Therefore, they cannot learn how to calculate the dose. Since it is not cost-effective to have students purchase drugs in vial form, it is unethical for students and faculty members, the risk of exposure to active substances is high, and university education is free, used vials are utilized for teaching the skill in the faculty where the research was conducted.

Teaching the drug preparation from a vial in nursing schools with purchased active drugs or used vials causes risks and problems that may arise due to the loss of the natural feature of the active substance and the structure of the vial. This study was planned based on the need for cost-effective vial materials, which were prepared in the form of unpacked vials with non-allergic powder substance and had a lower risk of side effects compared to vials containing drugs, in the skills training of students.

MATERIAL AND METHODS

DESIGN

The research consisted of two stages. The first stage was designed as a descriptive study and the second as a randomized controlled trial. The consort flow chart of the study is given in Figure 2.

SETTING AND TIME OF THE STUDY

The first stage of the research was carried out in July 2020 and the second stage in August 2021 in the nursing faculty of a university because laboratory courses were postponed due to pandemic lockdowns.

POPULATION AND SAMPLE OF THE STUDY

In the first stage, the study population consisted of faculty members working in the faculty of nursing (n=55), and the sample included those who were determined by the random sampling method and volunteered to participate in the study (n=47).

In the second stage, the study population consisted of students who had taken the second-year nursing fundamentals course of the faculty of nursing (n=265), and the sample group included students who voluntarily participated in the study (n=244). Students who did not want to participate in the research were excluded (n=21).

As a result of the research, a post hoc power analysis was conducted on the G-power 3.1 software package for the Kruskal-Wallis H test for the faculty members. The power calculated based on a medium effect size (d=0.5), Type I error of 5% (α=0.05), and Type II error of 20% (1-β=0.80) was found as 99.01%.

As a result of the research, a post hoc power analysis was performed by using the mean difference test of the power analysis software accessed on "www.OpenEpi.com" for the Mann-Whitney U test for students. The power that was calculated based on a medium effect size (d=0.5), Type I error of 5% (α=0.05), and Type II error of 20% (1-β=0.80) was as 87.52%.

RANDOMIZATION

In the second stage of the study, students were randomly assigned to experimental and control groups. Convenience sampling was used for randomization. The randomization list was created on random number generator software (Research Randomizer, www.randomizer.org).

DATA COLLECTION

Study data were collected by using an faculty member information form, the vial effectiveness assessment form, the student nurse information form, and the feedback form for skills practice.

The faculty member information form included items about age, gender, academic title, and total work experience.

The Vial Effectiveness Assessment Form was prepared in line with the relevant literature.[9,13-15,18] It contains 10 items each of scored on a 5-point Likert-type scale with options, including strongly agree (5), agree (4), undecided (3), disagree (2), and strongly disagree (1). Items 1, 4, and 6 on the form are reverse-coded when the total item score is calculated. As the total score decreases, the positive characteristics of the vial increase. The effectiveness form ranges from 10 to 50 points. There are items on the form about the properties of powder substance content of the vial. Therefore, faculty members filled out all 10 items, but the students did not fill out items 2, 3, and 4 because of no powder substance in the vials in the control group. The minimum and maximum scores range between 10 and 50 for faculty members and 7 and 35 for students. Five faculty members who were experts in the field were consulted regarding the effectiveness of the form, and the CVI of the final version of the form was found as 0.98.

The student information form included items about students' age, gender, and research group. The feedback form for skills practice was created by the researchers in line with the relevant literature.[19,20] There are 11 items on the form to assess the skill to withdraw drug out of a vial. Each item on the form is evaluated on a 5-point Likert-type scale with options, including strongly agree (5), agree (4), undecided (3), disagree (2), and strongly disagree (1). Higher scores on the form indicate higher student satisfaction with the practice.

IMPLEMENTATION OF THE RESEARCH

First Stage

Faculty members were informed about the study. Verbal and written informed consent was obtained from volunteers. Simulated vials were created by two researchers as much as the number of faculty members. Simulated vials were prepared as 10 mL Type III white glass vials with hydrolytic resistance. First, the weight of vials was set at zero with a Mettler-Toledo ME203 brand precision scale. Next, starch, powder, and powdered sugar were added to the vials with the handle of a teaspoon. Different teaspoons were used for each ingredient so that the food ingredients would not mix. Since the vials on the market

usually contain one g of drug, one g of starch, powdered sugar, or powder was added to the simulated vials. Flip-off caps were placed by Sonkaya SMC 100 FL® flip-off vial capping machine. A total of 47 vials were prepared for each group. The outer surface of the vials was covered with a plain white label (Figure 1). Each vial was given a different number. Three different boxes were created, and the vials were placed in a box according to their groups. One vial from each vial box was randomly distributed to the faculty members in the sample group. The matching of the numbers on the vials and the vial group was organized by the two researchers who prepared the vials. Faculty members were taken to the laboratory rooms in turn. They were asked to write the vial number on the effectiveness forms, prepare the vials with a maximum of 10 mL of water for injection, and fill out the effectiveness form. The Vial Effectiveness Assessment Form included the following criteria: rapid dissolution of the powder material, calculation of dry powder volume, effortless withdrawal of liquid into the syringe, prevention of substance foaming in the vial, avoidance of needle tip clogging during liquid withdrawal, prevention of liquid condensation in the syringe, seamless movement of the syringe piston, and clarity of the liquid substance. The results obtained in the first stage determined the type of vials prepared in the second stage of the study.

FIGURE 1: A sample vial (contains powdered sugar).

Second Stage

The "vial drug preparation" was presented theoretically to all students within the scope of the fundamentals of nursing course. At the end of the lesson, students were informed about the study. Oral and written informed consent was obtained from volunteer students.

After the count of volunteer students was determined, they were randomly divided into experimental and control groups (Figure 2). Vials containing 1 g of powdered sugar were prepared for students in the experimental group by following the same procedures for the vials prepared for faculty members (Figure 1).

Before the laboratory studies were initiated, the charge nurses of the clinical practice services were contacted about the purpose and method of the study and the collection of used vials in a box every morning. Charge nurses gave information to the working nurses about the study. Because of the higher risk of the side effects of drugs such as antibiotics and anti-inflammatory drugs and the fact that the preparation time of the drug was very close to the laboratory hours, vials from the proton pump inhibitor (PPI) group, which were administered in the 6-o'clock treatment in the morning on the laboratory day, were selected. After preparing the patients' PPI therapy, the nurses collected the used vials in a clean box provided by the researchers instead of throwing them into the sharp container. These vials were collected from the clinics before the study on laboratory days and they were practices with students. Used vials did not have a flip-off cap, as they were used by nurses in the hospital for drug preparation. There were also droplets of liquid medicine with active ingredients in these vials. Thus, it was aimed to keep the microorganism growth in the vial at a minimum level.

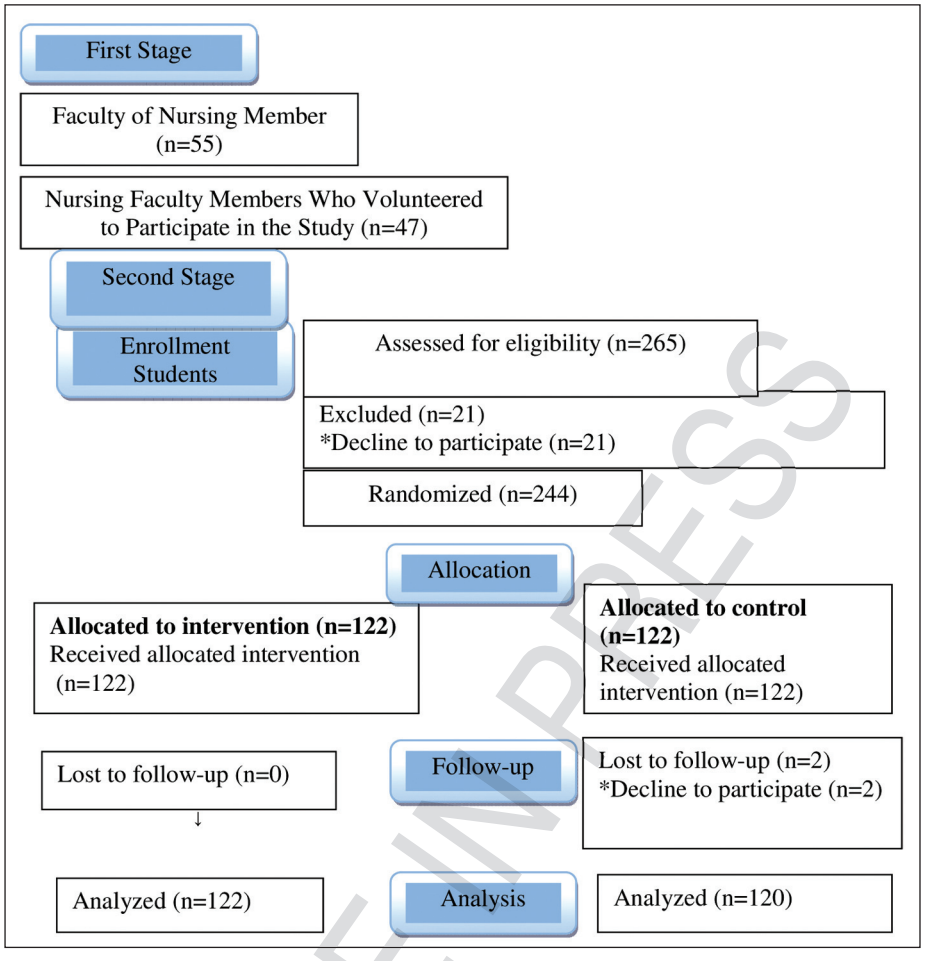

FIGURE 2: Consort flow diagram.

Volunteer students came to the laboratory lesson in groups of 12. They practiced between 09-12 in the morning and 14-17 in the afternoon. One of the researchers showed each group how to prepare the drug in the vial with the demonstration method. Then, students were asked to wait outside the room for their turn to try the practice. The researcher invited the students in the experimental and control groups one by one to the laboratory according to the randomization list. The students in the experimental group practiced with a vial containing 1 g of powdered sugar. The students in the control group practiced with used vials. After the vials were prepared, students were requested to put the vials into the sharp container to prevent or reduce the exposure to active substances, the risk of an allergic reaction, and the risk of accidentally administering the drug to themselves. No allergic reactions were observed during the study.

After the students in the experimental and control groups finished the practice, they filled out the "Vial Effectiveness Assessment Form (7-item form), the Student Nurse Information Form, and the Feedback Form for Skills Practice". To ensure equal opportunity, after the data collection stage of the research was completed, students in the control group who did not want to participate in the study were also allowed to experience the application with an unused simulated vial.

ETHICS OF THE STUDY

At the outset, the approval of the Dokuz Eylül University Non-Interventional Research Ethics Committee of the university (date: May 08, 2019; no: 2019/12-24) and written permission of the institution where the study was conducted were obtained. Oral and written consent of the students and faculty mem-

bers participating in the study was obtained after they were informed. The study was conducted in accordance with the principles of the Declaration of Helsinki. A grant support was received from the Scientific Research Projects Coordination Unit of the University to carry out the research (Project no: 2019.KB.SAG.063, Project ID: 2336).

STATISTICAL ANALYSIS

Study data were conducted on the SPSS 22.0 software package. Data entry and analyses of the study were conducted by two other researchers who were not involved in the preparation of vials and working with volunteer students.

In the first stage of the study, the normality distribution of the items on the vial effectiveness assessment form, which was employed to assess the effectiveness of the three vials used during withdrawal of drug out of vials by faculty members, was examined. Since all items and total item scores were not normally distributed, the difference between the three vials was determined by the Kruskal-Wallis test. Numbers, percentages, mean and minimum-maximum values were used for the items on this form. In the second stage of the study, the descriptive data of the students were presented as numbers, percentages, and mean values. Since all items and total scores on the vial and skills forms were not normally distributed, the Mann-Whitney U test was used to compare the effectiveness of vials in the experimental and control groups.

RESULTS

The mean age of the faculty members participating in the study was 33.80±8.26, 89.4% were female, 68.1% were lecturers, and 53.2% had 6-10 years of work experience. The mean age of the students participating in the study was 20.91±1.51, and 58.3% were female (Table 1).

The comparison of the mean total scores of the items regarding instructors' assessment of the vial types indicated that powdered sugar was the most effective vial type with 13.89±3.80 points ($p<0.001$) (Table 2).

Students' mean total scores for the assessment of vial effectiveness were determined as 11.72±3.95 in the experimental group and 12.70±3.91 in the control group. The difference between the mean scores was statistically significant ($p<0.05$). Students' mean total scores regarding the feedback form for skills practice were determined as 50.78±4.20 in the experimental group and 50.07±5.31 in the control group. The difference between the two groups was not statistically significant ($p>0.05$) (Table 3).

Students' assessment of the effectiveness of the vial type containing powdered sugar was evaluated

TABLE 1: Descriptive characteristics.

For faculty members (n=47)	n	%
Gender		
Female	42	89.4
Male	5	10.6
Age ($\bar{X}$±SD) (year)	33.80±8.26 (minimum: 24-maximum: 52)	
Academic title		
Lecturer	32	68.1
Associate professor	12	25.5
Professor	3	6.4
Total work experience (year)		
0-5	3	6.4
6-10	25	53.2
≥10	19	40.4
For students (n=242)		
Gender		
Female	141	58.3
Male	101	41.7
Age ($\bar{X}$±SD) (year)	20.91±1.51 (minimum: 19-maximum: 31)	

SD: Standard deviation.

TABLE 2: Results of item-total score variance analysis of vial effectiveness assessment of faculty members.

Vial types	$\bar{X}$±SD	Mean rank	Variance analysis	*p* value
Starch (n=47)	22.19±7.30	75.66		
Powder (n=47)	29.44±6.80	106.13	H: 80.161	<0.001
Powdered sugar (n=47)	**13.89±3.80**	**31.21**		

H: Kruskal-Wallis H test; SD: Standard deviation.

TABLE 3: Distribution of total scores regarding students' feedback about vial effectiveness and their skills to withdraw drug out of a vial.

	$\bar{X}$±SD	Mean rank	U test	*p* value
Total score for the assessment of vial effectiveness				
Experimental group (n=122)	**11.72±3.95**	**111.73**	6128.000	**0.028**
Control group (n=120)	12.70±3.91	131.43		
Total feedback score for skills practice				
Experimental group (n=122)	50.78±4.20	123.62	7061.000	0.630
Control group (n=120)	50.07±5.31	119.34		

U: Mann-Whitney U test; SD: Standard deviation.

TABLE 4: Analysis of the items for the assessment of the effectiveness of the vial type containing powdered sugar according to the experimental and control groups.

Assessment		$\bar{X}$±SD	Mean rank	U test	p value
I felt the negative pressure difference inside the vial while inserting the needle.	Experimental group	**4.36±0.70**	**135.11**	5659.500	**0.001**
	Control group	3.73±1.35	107.66		
The needle clogged while I was withdrawing the new fluid formed in the vial.	Experimental group	1.51±1.07	116.50	6710.500	0.163
	Control group	1.50±0.81	126.58		
Since the new liquid in the vial was a homogeneous solution.	Experimental group	**4.44±0.90**	134.84	5692.000	**0.001**
It was easily drawn into the syringe.	Control group	4.04±1.10	107.93		
After pulling the liquid from the vial into the syringe.	Experimental group	1.85±1.14	120.42	7188.000	0.792
I had difficulty moving the plunger of the syringe	Control group	1.83±1.03	122.60		
While drawing the solution in the vial into the syringe. The liquid splashed outside.	Experimental group	**1.25±0.76**	**110.67**	5999.000	**0.001**
	Control group	1.49±0.85	132.51		
The liquid in the vial got on my hand.	Experimental group	1.23±0.80	117.66	6851.500	0.164
	Control group	1.26±0.67	125.40		
After the liquid was withdrawn out of the vial.	Experimental group	2.67±1.46	128.07	6518.500	0.128
A precipitate formation was observed in the syringe.	Control group	2.37±1.28	114.82		

U test: Mann-Whitney U test; SD: Standard deviation

according to experimental and control groups (Table 4). A statistically significant difference was determined in the experimental group in terms of feeling the negative pressure difference in the vial, easy withdrawal of the liquid in the vial into the syringe and splashing of liquid outside while withdrawing the drug out of the vial (p=0.001, for all).

DISCUSSION

Parenteral drug therapy, which is learned at the nursing undergraduate level, is frequently administered to patients by nurses. Regardless of whether vials are given by the intravenous, muscular, or subcutaneous route, the skill to withdraw the drug out of a vial or ampoule makes up an important step in drug therapy. For this skill, which is learned at the undergraduate level of nursing education, simulation tools that are easily available, cost-effective, and easy to prepare and apply are necessary. In our study, powdered sugar was found to be the most suitable of the vials prepared with starch, powder, and powdered sugar. Soto et al. reported that the use of powdered sugar in the production of personalized vials was a good alternative in terms of cost and effectiveness. In the same study, it was mentioned that salt could be used instead of powdered sugar, but that it might not be preferred because a hypertonic solution would be obtained.[9] In our study, starch and powder were preferred as alternatives, considering that 1 g of salt solution could create a very dense solution concentration with a maximum of 10 mL of liquid. Starch, powder, and powdered sugar are widely used, easily

available, and affordable products, which were the major factors for preferring them. The fact that powdered sugar is a water-soluble substance compared to powder and starch may have made the vial containing powdered sugar more effective.

The simulated vial was found to be more effective than the used vial by students. No similar study has been found in the literature. Feeling the negative pressure in the vial, easily drawing the liquid prepared with powdered sugar into the syringe, less splashing of the liquid outside when drawing the liquid out of the vial, compared to the unused vial, resulted in obtaining better results with the simulated vial than the classical method (used vial). Used vials may cause the liquid to splash around in repeated use, due to the loss of negative pressure in the vial during practice. As a result, it may cause the development of an allergic reaction due to exposure to the impaired active substance. Drug resistance in microorganisms and risk of an allergic reaction may develop in nurses who prepare the drug, due to the growth of microorganisms within 24 hours and the splashing of drug particles in used vials.[16,17] While the contact of the active substance with the skin may cause chemical dermatitis, its absorption in the mucosal area by splashing into the eyes and face may cause more serious allergic reactions such as anaphylaxis.[11,12] In addition, the absence of powdered substance in used vials may cause the student to experience stress in the clinical field since the dilution phase of the drug cannot be experienced.[21–24]

The main goal of the simulation is to increase patient and employee safety by ensuring that the clinical practice is experienced as close to the original as possible.[7,25] While preparing the simulation reality, steps such as infrastructure possibilities, budget, number of personnel, and ease of implementation should be considered. The first things that simulation reality reminds are low, medium, and high-fidelity models or mannequins. Indeed, simulation should be adaptable to every field and every subject.[5,7] While the student nurses learn vial drug preparation skills in the vocational skills laboratory, they need a material that is highly realistic and protects patient and employee safety. When students cannot practice with realistic material, they may have difficulty in fulfilling their skill goals and as a result, effective learning cannot take place.[26] Reasons, such as the high cost of the drugs in the form of vials on the market, the availability of simulated vials abroad (such as Pocket Nurse®), and the unavailability of the ready demo vials in Türkiye contributed to the emergence of this study. The simulated vial containing powdered sugar is superior to vials available on the market since it is cost-effective [Pocket Nurse® demo vial, $2.09 vs. simulated vial: $0.47, (date: March 31, 2022)], it can be customized according to the needs of the educator and student, and it can be used safely in repeated applications. The high level of satisfaction of the students with the simulated vial applications encourages its production and application.

STRENGTH AND LIMITATIONS

A review of the literature indicated that there were no national or international studies on the skills training of nursing students with simulated vials. Simulated vials have many advantages. First of all, simulated vial materials are recyclable in nature. Second, different variants of simulated vials can be produced. In addition, its preparation with ingredients used in daily life makes it much safer in terms of hypersensitivity reactions than active drug ingredients. On the other hand, these vials have some disadvantages, as well. Since powdered sugar is a food item, it can mold within a few days after the liquid is injected into the vial. For this reason, the vial should be disposed of immediately after the practice in the sharp container. Also, another disadvantage is that these vials cannot be used repeatedly due to the flip-off cap.

CONCLUSION

In this study, which was carried out to find the product that best simulates students' skills to prepare drugs from a vial, the vial prepared with powdered sugar was found to be more effective than those prepared with starch and powder. It was also found to be more effective than the used vial by students. The simulated vial containing powdered sugar can be preferred over the demo products on the market, as it is reliable, practical, and accessible to have students acquire vial drug preparation skills. In further research, studies on vials prepared with different substances can be planned with samples consisting of a larger

number of nurses, and cost-effectiveness calculations can be presented.

Source of Finance

This study was supported by the Scientific Research Projects Coordination Unit of the University to carry out the research (Project no: 2019.KB.SAG.063).

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Nurten Alan, Dilek Özden, Gülşah Gürol Arslan, İlkin Yılmaz, Gizem Göktuna;* ***Design:*** *Nurten Alan, Dilek Özden, Gülşah Gürol Arslan, İlkin Yılmaz, Gizem Göktuna;* ***Control/Supervision:*** *Nurten Alan, Dilek Özden, Gülşah Gürol Arslan;* ***Data Collection and/or Processing:*** *Nurten Alan, İlkin Yılmaz, Gizem Göktuna;* ***Analysis and/or Interpretation:*** *İlkin Yılmaz, Gizem Göktuna;* ***Literature Review:*** *Nurten Alan, Dilek Özden, Gülşah Gürol Arslan, İlkin Yılmaz, Gizem Göktuna;* ***Writing the Article:*** *Nurten Alan, Dilek Özden, Gülşah Gürol Arslan, İlkin Yılmaz, Gizem Göktuna;* ***Critical Review:*** *Nurten Alan, Dilek Özden, Gülşah Gürol Arslan, İlkin Yılmaz, Gizem Göktuna;* ***References and Fundings:*** *Nurten Alan, İlkin Yılmaz, Gizem Göktuna;* ***Materials:*** *Nurten Alan, İlkin Yılmaz, Gizem Göktuna.*

REFERENCES

1. Aldridge MD. Nursing students' perceptions of learning psychomotor skills: a literature review. Teach Learn Nurs. 2017;12(1):21-7. doi:10.1016/j.teln.2016.09.002
2. Nicholls D, Sweet L, Muller A, Hyett J. Teaching psychomotor skills in the twenty-first century: Revisiting and reviewing instructional approaches through the lens of contemporary literature. Med Teach. 2016;38(10):1056-63. PMID: 27023405.
3. Ericsson KA. Deliberate practice and acquisition of expert performance: a general overview. Acad Emerg Med. 2008;15(11):988-94. PMID: 18778378.
4. Gaba DM. The future vision of simulation in healthcare. Simul Healthc. 2007;2(2):126-35. PMID: 19088617.
5. Bates JT, Kelly CW, Lane JE. Low-Cost Model for Battlefield Wound and Hemorrhage Training. Mil Med. 2022:usab556. PMID: 35015891.
6. Aggarwal R, Mytton OT, Derbrew M, Hananel D, Heydenburg M, Issenberg B, et al. Training and simulation for patient safety. Qual Saf Health Care. 2010;19 Suppl 2:i34-43. PMID: 20693215.
7. Fusco LA, Alfes CM, Weaver A, Zimmermann E. Medication Safety competence of undergraduate nursing students. Clin Simul Nurs. 2021;52:1-7. doi: 10.1016/j.ecns.2020.12.003
8. INACSL. INACSL Standards of Best Practice: SimulationSM Simulation Glossary. Clin Simul Nurs. 2016;12:S39-S47. doi:10.1016/j.ecns.2016.09.012
9. Soto C, Stiner J, Noji DO, Rusheen JM, Huang YM. Creating a simulated pharmacy. simul healthc. 2016;11(3):218-22. PMID: 27093512.
10. Ml H, T W, Jq Z, Yj S, Tj G, Lk Z, et al. Evaluation of external contamination on the vial surfaces of some hazardous drugs that commonly used in Chinese hospitals and comparison between environmental contamination generated during robotic compounding by IV: Dispensing robot vs. manual compounding in biological safety cabinet. J Oncol Pharm Pract. 2022;28(7):1487-98. PMID: 34162245; PMCID: PMC9465550.
11. Lin YF, Yang CH, Sindy H, Lin JY, Rosaline Hui CY, Tsai YC, et al. Severe cutaneous adverse reactions related to systemic antibiotics. Clin Infect Dis. 2014;58(10):1377-85. PMID: 24599767.
12. Nicholson P, Brinsley J, Farooque S, Wakelin S. Patch testing with meropenem following a severe cutaneous adverse drug reaction. Contact Dermatitis. 2018;79(6):397-8. PMID: 30156311.
13. Torrie J, Cumin D, Sheridan J, Merry AF. Fake and expired medications in simulation-based education: an underappreciated risk to patient safety. BMJ Qual Saf. 2016;25(12):917-20. PMID: 26792816.
14. FDA's Investigation into Patients Being Injected with Simulated IV Fluids Continues. Ohio Nurses Rev. 2015;90(1):6-7. PMID: 26477080.
15. Robyn MP, Hunter JC, Burns A, Newman AP, White J, Clement EJ, et al; Centers for Disease Control and Prevention (CDC). Notes from the field: adverse events associated with administration of simulation intravenous fluids to patients--United States, 2014. MMWR Morb Mortal Wkly Rep. 2015;64(8):226-7. PMID: 25742384; PMCID: PMC4584720.
16. Mattner F, Gastmeier P. Bacterial contamination of multiple-dose vials: a prevalence study. Am J Infect Control. 2004;32(1):12-6. PMID: 14755229.
17. Khalili H, Sheikhbabayi M, Samadi N, Jamalifar H, Dalili D, Samadi N. Bacterial contamination of single- and multiple-dose vials after multiple use and intravenous admixtures in three different hospitals in iran. Iran J Pharm Res. 2013;12(1):205-9. PMID: 24250590; PMCID: PMC3813212.
18. Prot S, Fontan JE, Alberti C, Bourdon O, Farnoux C, Macher MA, et al. Drug administration errors and their determinants in pediatric in-patients. Int J Qual Health Care. 2005;17(5):381-9. PMID: 16115809.
19. Abdallah B, Irani J, Sailian SD, Gebran VG, Rizk U. Nursing faculty teaching a module in clinical skills to medical students: a Lebanese experience. Adv Med Educ Pract. 2014;5:427-32. PMID: 25419165; PMCID: PMC4235477.
20. Unver V, Basak T, Watts P, Gaioso V, Moss J, Tastan S, et al. The reliability and validity of three questionnaires: The Student Satisfaction and Self-Confidence in Learning Scale, Simulation Design Scale, and Educational Practices Questionnaire. Contemp Nurse. 2017;53(1):60-74. PMID: 28084900.
21. Avraham R, Shor V, Hurvitz N, Shvartsur R, Kimhi E. Transferability of medication administration simulation training to clinical settings. Teach Learn Nurs. 2018;13(4):258-62. doi:10.1016/j.teln.2018.07.004
22. Lee SE, Quinn BL. Incorporating medication administration safety in undergraduate nursing education: a literature review. Nurse Educ Today. 2019;72:77-83. PMID: 30453203.
23. Ferguson A, Delaney B, Hardy G. Teaching medication administration through innovative simulation. Teach Learn Nurs. 2014;9(2):64-8. doi:10.1016/j.teln.2013.12.004
24. Schelbred AB, Nord R. Nurses' experiences of drug administration errors. J Adv Nurs. 2007;60(3):317-24. doi:10.1111/j.1365-2648.2007.04437.x
25. Brazil V, Scott C, Matulich J, Shanahan B. Developing a simulation safety policy for translational simulation programs in healthcare. Adv Simul. 2022;7(1):1-7. doi: 10.1186/s41077-022-00200-9
26. Harris MA, Pittiglio L, Newton SE, Moore G. Using simulation to improve the medication administration skills of undergraduate nursing students. Nurs Educ Perspect. 2014;35(1):26-9. PMID: 24716338.