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The influence of simulated medication administration learning on the clinical performance of nursing students: A comparative quasi-experimental study

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ABSTRACT

Background: Medication administration is a main role of nurses, and by mastering this skill, medication errors can be reduced. Simulation provides a safe environment for learning and improving medication administration. Simulation design may influence the students' learning curve and ability to transfer skills into the clinical setting.
Objective: To examine the influence of simulation-based learning of the medication administration process, on satisfaction, self-perception of preparedness, and clinical performance of students who practice simulation either individually or in a group.
Design: A comparative quasi-experimental study.
Setting: A public university in southern Israel.
Participants: Third-year nursing students in two consecutive academic years (78 in the individual sample and 50 in the group sample).
Methods: Nursing students participated in a scenario-based simulation for medication administration either individually or in a group. Self-reported questionnaires evaluated participants' satisfaction with the simulation experience, and perception of preparedness before and after the simulation. Faculty members observed and evaluated participants' medication administration during the simulation and in the clinical setting. Paired *t*-tests were performed to compare preparedness before and after the simulation experience. Linear regression models were formulated to elicit the predictors of preparedness after simulation and evaluations for medication administration in the clinical setting.
Results: The simulation experience increased participants' preparedness both when designed for an individual student and for a group of students. *Simulation performance* was the main contributor to the participant preparedness among the individual sample ($\beta = 0.51$, $p < 0.01$), whereas *previous preparedness* was the main contributor among the group sample ($\beta = 0.42$, $p < 0.01$). The association between simulation performance and clinical performance was mediated by *preparedness after simulation* in the individual sample, but not in the group sample.
Conclusions: Simulation improves students' preparedness for medication administration. Individual simulation also impacts clinical performance, via preparedness. Further research is needed to identify other factors that facilitate skills transfer into the clinical setting.

1. Introduction

Medication management is an important role of the nurse (Choo et al., 2010), thus a major challenge for faculty. Faculty members use different teaching methods in order to enhance preparation of undergraduate nursing students for medication management (Gill et al., 2019). However, students still find it difficult to master this fundamental competence (Manias and Bullock, 2002; Preston et al., 2019). One of the main risks of poor medication management is medication errors – a serious cause of morbidity and mortality in hospitalized patients (Keers et al., 2013; Thomas et al., 2019). Simulation experiences may improve medication management competences, including medication safety competence of nursing students (Ford et al., 2010; Lee and Quinn, 2019).

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For more than a decade, simulation has been embedded into undergraduate nursing curricula, sometimes as an addition, or to replace some of the traditional teaching of various nursing skills (Cant and Cooper, 2017; Howard et al., 2011), including medication administration (Härkänen et al., 2016). There are some reports on the development and evaluation of such simulations, indicating that simulation is an effective teaching method to enhance learning of medication administration (Hayes et al., 2015; Pauly-O'Neill and Prion, 2013). A few studies have examined the effectiveness of medication administration simulation compared to the traditional methods (Harris et al., 2014; Jarvill et al., 2018). Mariani et al. (2017) examined the impact of an enhanced medication safety program of simulation on nursing students' knowledge, competence and perceptions towards safe treatment, using a two-group pretest-posttest study design (N = 86). They found that medication administration simulation is an effective method for teaching about safe medication practices (Mariani et al., 2017). These studies showed the advantage of simulation in the preparedness of the student, and concluded that simulation may be useful in providing additional learning opportunities. However, these studies refer to a specific skill, rather than to the medication administration as a complete process. In Jarvill's study, which was an experimental two-group pretest-posttest study among 85 nursing students, the researchers examined the impact of simulation on the six R's of medication administration (Jarvill et al., 2018). In Harris's study, a quasi-experimental pilot study among 158 nursing students, simulation-based learning was compared didactic lectures, where the outcome variable was a 19-item medication calculation exam (Harris et al., 2014). However, the medication administration process involves additional aspects such as data collection, planning, patient teaching and monitoring (De Clerq et al., 2008, as cited in Dilles et al., 2011, p. 172). Using simulation across the entire medication administration process may result in better knowledge, preparation, and competence of the student. Furthermore, none of these studies addressed implications of the simulation method on competency transfer to the clinical setting.

Kirkpatrick's evaluation framework suggests that when evaluating the immediate and long-term outcomes of a new type of educational training, one should refer to four levels of evaluation: (1) participant's reaction, (2) participant's learning, (3) participant's performance, and (4) long-term results on an organizational level (Kirkpatrick and Kirkpatrick, 2006). While many studies refer to the students' reaction (i.e., satisfaction) and learning outcomes (such as critical thinking, self-confidence, and psychomotor skills), there is an obvious gap in simulation research with regard to level 3 and level 4 evaluation, i.e., the influence of simulation-based learning on clinical competencies and long-term implications (Lee et al., 2019; Norman, 2012; Stroup, 2014). Thus, a study to examine the continued effect of simulation applied to the clinical setting is warranted.

Simulation allows faculty to create a learning environment that replicates actual clinical scenarios, thus providing students with the opportunity to connect theory with clinical setting (Norman, 2012). Simulation-based learning enhances efficiency of the learning process in a controlled and safe environment, and can give students realistic exposure to scenarios that they may encounter in the clinical setting (Lateef, 2010). According to Bandura's social cognitive theory, observation and previous experience are two key factors of self-confidence and self-efficacy, which in turn impact human behavior (Bandura, 1986). Simulated reality experience in a safe environment that enables learning through observation and practice may enhance students' self-confidence and self-efficacy, and thus impact their future clinical performance.

While most of the medication administration simulations reported in the literature are carried out in groups of students with each participant assuming a different role (Harris et al., 2014; Hayes et al., 2015; Jarvill et al., 2018; Pauly-O'Neill and Prion, 2013), medication administration is in fact an individual task of the nurse, where she/he is responsible for all stages of the task (i.e., assessment, decision, preparation, administration, patient education and follow-up). Therefore, we assume that simulation that represents the nurse's actual role more precisely may result in a higher level of preparedness and performance in the clinical setting. The objective of this study was to evaluate the impact of medication administration simulation-based learning on students' preparedness and performance in the clinical setting, among students who practice simulation individually or in a group of students.

Study hypotheses:

1. Students will be satisfied with the simulation experience.
2. Simulation will increase preparedness for the medication administration process.
3. Medication administration evaluation in the simulation will be positively associated with preparedness following the simulation.
4. Medication administration evaluation in the simulation will be positively associated with medication administration evaluation in the clinical setting.

The hypothetic model is displayed in Fig. 1.

2. Methods

2.1. Study design and setting

A comparative quasi-experimental study was conducted among nursing students in two consecutive academic years (2017–2018) at a public university in southern Israel.

2.2. Participants

Third-year undergraduate nursing students enrolled in the surgical rotation course were recruited for the study. The individual sample consisted of 88 students in the surgical rotation course, of whom 83 enrolled in the study. The final sample included 78 participants after removing five observations with incomplete data. The group sample consisted of 73 students in the surgical rotation course, of whom 57 enrolled in the study. The final sample included 50 participants after removing seven observations with incomplete data.

2.3. Procedure and intervention

The surgical rotation course duration was six weeks. At the beginning of the course, participants completed the Medication Administration Preparedness Questionnaire (MAPQ; Avraham et al., 2018) for the first time. During the second week of the course, participants participated in a medication administration simulation, and within the following two weeks, they took part in a medication administration in a clinical setting. During the simulation and the clinical medication administration, faculty members of the Department of Nursing evaluated the students using the Medication Administration Evaluation Scale (MAES; Avraham et al., 2018): Faculty members who teach in the simulation rooms evaluated participants' performance during the simulation, whereas faculty members who teach in the clinical settings observed and evaluated the participants in the clinical setting. After the simulation, participants completed the MAPQ for the second time, as well as the Satisfaction with Simulation Experience (SSE; Levett-Jones et al., 2011; Williams and Dousek, 2012). A scenario for the medication administration simulation was developed by the faculty, and was published in a previous article (Avraham et al., 2018). One day before the simulation, each participant received information about the simulated patient including medical history, chronic medication list, daily nursing report and medical orders. During the simulation, participants were responsible for the treatment of a single patient: they were required to assess the patient, present the patient's medical history and current situation, make decisions about medication administration, prepare and administer the medications, educate the patient regarding medication

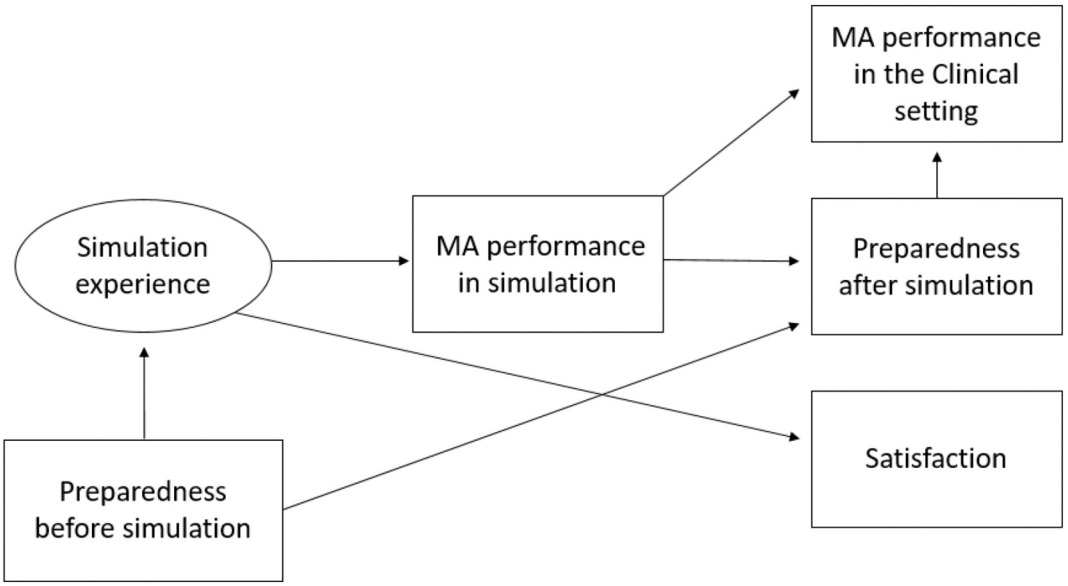

Fig. 1. Hypothetical model for the associations between study variables Note: MA = medication administration; rectangular shape indicates observed variable; oval shape indicates experience condition; arrow indicates regression path.

reaction and adverse effects, and assess the patient's reaction after administration. A formative evaluation (rather than a summative evaluation) was used in order to assist the participants in their progression towards better performance in the clinical setting (INACSL Standards Committee, 2016). Participants experienced the simulation either individually or in a group of students (2–3 students in each group). Whereas in the individual experience each student experienced all of the nursing process stages (i.e., assessment, diagnosis, decision-making, medication preparation and administration), in the group experience, the student shared roles, being either a nurse or an observer. Simulations were two hours long, used low-fidelity manikins, and included structured guidelines for faculty regarding the student's expected behavior and advancement during the scenario (for more details, see Avraham et al., 2018). Following the simulation, participants took part in faculty debriefing. A plus/delta debriefing model was used in the study to help participants reflect upon what went well and what would change after the simulation training (Decker et al., 2013; Jeffries, 2010). Medication administration in the clinical setting was to a real patient, having one of various medical conditions, and chosen for each student by the faculty member in the clinical setting. This experience was specific for each student, who performed on her/his own while under supervision of a qualified clinical instructor.

2.4. Measures

2.4.1. Satisfaction with simulation experience measure

A validated and reliable 18-item measure (Levett-Jones et al., 2011; Williams and Dousek, 2012) was used to assess participants' satisfaction with simulation. The tool consists of a 5-point Likert scale (from 1 = strongly disagree to 5 = strongly agree) divided into three subscales: debriefing and reflection (e.g., 'The facilitator provided constructive criticism during the debriefing.'), clinical reasoning (e.g., 'The simulation developed my clinical reasoning skills.'), and clinical learning (e.g., 'The simulation tested my clinical ability'.). The items were translated into Hebrew and back into English by two independent bilingual professionals. The measure was then compared to the original, and a few minor modifications were applied. The final Hebrew version was adapted and approved by an expert committee. Cronbach's α for the total score and for the three subscales ranged from 0.73 to 0.88 for the individual sample and from 0.80 to 0.90 for the group sample.

2.4.2. Medication administration preparedness questionnaire

This self-reported measure is based on nine principles and skills required for the medication administration process (Taylor et al., 2011), and measures the confidence that students feel with regard to each skill (e.g., 'How sure are you about your preparedness to describe pharmacological information regarding a medication?'). The development process and psychometric characteristics are presented elsewhere (Avraham et al., 2018). The measure consists of 12 Likert-type items rated on a 4-point scale (from 1 = very unconfident to 4 = very confident). Cronbach's α was 0.83 and 0.89 before and after the simulation, respectively, for the individual sample, and 0.87 and 0.94 before and after the simulation, respectively, for the group sample.

2.4.3. Medication administration evaluation scale

This measure aimed to evaluate participants' performance and behavior during the medication administration process. The original measure development and psychometrics are described elsewhere (Avraham et al., 2018). The first part, simulation/clinical MA (medication administration) evaluation, consists of 28 dichotomous items, based on principles and skills of the medication process (Taylor et al., 2011) that the observer fills in during the student's experience. We used a revised 18-item version of this measure, after combining items with similar themes (e.g., the items 'demonstrates pharmacological knowledge of the drug mechanism' and 'demonstrates pharmacological knowledge of the drug indication' became one item of 'demonstrates pharmacological knowledge'). The original measure was built as a checklist of Yes/No answers, but the variance was very low, making it impossible to distinguish between strong and weak students. In the revised version, the faculty rated each item on a five-point scale (from 1 = not performed at all, to 5 = fully performed). Cronbach's α for the individual sample was 0.92 during the simulation evaluation and 0.90 during the clinical evaluation. For the group sample, Cronbach's α was 0.97 during the simulation evaluation and 0.90 during the clinical evaluation. The second part, simulation/clinical behavior evaluation, used a global rating to assess participant behavior during the experience (e.g., 'To what extent did the student pay attention to details during data collection and after assessment?'). It includes six items rated on a 9-point scale (from 1 = not at all, to 9 = extremely). Cronbach's α for the individual sample was 0.95 during the simulation evaluation and 0.91 during the clinical evaluation. As for the group sample, Cronbach's α was 0.98 during the simulation evaluation and 0.94 during the clinical

evaluation.

2.4.4. Participants' personal characteristics

Responses to questions regarding participants' personal characteristics (age, gender, origin and family status) and previous experience with medication administration were collected at the beginning of the course.

2.5. Data analysis

All analyses were performed using IBM SPSS Statistics version 25. Independent *t*-tests and Chi square analyses were used to elicit differences between samples as to the participants' personal characteristics and study variables. Pearson correlations were used to identify associations between study variables. Paired t-tests were used to examine differences in preparedness before and after the simulation. Multivariate linear regression models were used to identify predictors of *preparedness after simulation* and *results of medication administration process evaluation in the clinical setting*. Statistical significance was determined at p values < 0.05.

2.6. Ethical considerations

The study was approved by the institutional review board at the Faculty of Health Sciences of XXX University. Although participation in the simulation was a required component of the course, participation in the study was voluntary. The students received an explanation about the purpose of the study, and their option to refuse or discontinue participation at any stage of the study. It was also made clear that the student's performance in the study would not influence her/his grade in the course. All participants signed an informed consent. The study was designed to be anonymous, using participant numbers for identification.

Table 1
Participants characteristics and study variables.

Characteristic		Individual sample ($n = 78$) [Mean (*SD*) or n (%)]	Group sample ($n = 50$) [Mean (*SD*) or n(%)]	*P* value*
Age		24.7 (1.88)	25.2 (2.39)	0.21
Gender	Women	67 (85.9)	45 (90)	0.59
	Men	11 (14.1)	5 (10)	
Family status	Single or divorced	65 (83.3)	42 (84.0)	0.53
	Married	13 (16.7)	8 (16.0)	
Origin	Israel	58 (74.4)	38 (77.6)	0.43
	USSR	20 (25.6)	11 (22.4)	
Previous experience		41 (52.6)	22(44.0)	0.22
Satisfaction		4.73 (0.32)	4.71 (0.39)	0.74
Preparedness before simulation		2.97 (0.42)	2.91 (0.48)	0.45
Preparedness after simulation		3.28 (0.46)	3.45 (0.51)	0.09
Simulation MA evaluation		4.34 (0.50)	4.55 (0.56)	0.03
Simulation behavioral evaluation		7.00 (1.48)	7.55 (1.77)	0.07
Clinical MA evaluation		4.74 (0.26)	4.77 (0.28)	0.52
Clinical behavioral evaluation		8.15 (0.73)	8.35 (0.80)	0.17

* *P* values are for Chi square for proportional variables, and for independent *t*-test for continuous variables.

3. Results

3.1. Sample characteristics

Sample characteristics are displayed in Table 1. No significant differences were found between samples with regard to age, gender, family status, origin, or previous experience. Participants in both samples were mostly women, single and born in Israel, and about half of them had previous experience with medication administration.

3.2. Study variables

Study variables and differences between samples are displayed in Table 1. A significant difference was found only for simulation MA evaluation, where participants in the group sample presented higher evaluation means. No other significant differences were found.

3.3. Correlations between study variables

Table 2 presents the coefficients of correlations between study variables for each sample. Among the participants in the individual sample, preparedness after simulation was associated with preparedness before simulation ($r = 0.43$, $p < 0.01$), simulation MA ($r = 0.36$, $p < 0.01$), clinical MA ($r = 0.35$, $p < 0.01$), and clinical behavior evaluation ($r = 0.43$, $p < 0.01$). Clinical MA was also associated with simulation MA evaluation ($r = 0.29$, $p < 0.05$), and clinical behavior evaluation ($r = 0.77$, $p < 0.01$). Among the participants in the group sample, preparedness after simulation was associated with preparedness before simulation ($r = 0.57$, $p < 0.01$) and with simulation behavior evaluation ($r = 0.28$, $p < 0.05$). Clinical MA evaluation in the group sample was associated only with clinical behavior evaluation ($r = 0.87$, $p < 0.01$).

3.4. Analyses of study hypotheses

According to Hypothesis 1, students will be satisfied with the simulation experience. Participants were generally very satisfied with the simulation experience, both in the individual sample ($M = 4.73$, $SD = 0.72$) and in the group sample ($M = 4.71$, $SD = 0.39$). Thus, hypothesis 1 was supported.

According to Hypothesis 2, simulation will increase preparedness for the medication administration process. Paired *t*-test revealed that participants' preparedness was significantly higher following the simulation experience, both in the individual sample ($t = 5.84$, CI: 0.20, 0.41, $p < 0.01$) and in the group sample ($t = 8.31$, CI: 0.41, 0.67, $p < 0.01$). Thus, hypothesis 2 was supported.

According to Hypothesis 3, simulation evaluation will be positively associated with preparedness following simulation. Table 3 presents the multivariate linear regression for the factors that predict preparedness after simulation. The variables that were significantly associated with preparedness after simulation in the univariate analysis were entered (i.e., satisfaction, preparedness before simulation, simulation MA evaluation, and simulation behavior evaluation). We controlled for previous experience. As shown for the individual sample, simulation MA evaluation along with other predictors was responsible for 42.7% of the variance in preparedness after simulation ($F = 10.73$, $p < 0.001$). In the group sample, the prediction model was also significant ($F = 6.96$, $p < 0.001$), but the main contributor was the students' preparedness before the simulation. Thus, hypothesis 3 was supported for the individual sample only.

According to Hypothesis 4, simulation evaluation will be positively associated with clinical evaluation. Among participants in the individual sample, simulation MA evaluation was positively associated with clinical MA evaluation ($r = 0.29$, $p < 0.05$) and clinical behavior evaluation ($r = 0.24$, $p < 0.05$) (see Table 2). According to the hypothetical relationships between simulation, preparedness, and clinical performance (Fig. 1), we also assessed the mediation of preparedness after simulation

Table 2
Correlations coefficient between study variables.

		Scale	*M*	*SD*	1	2	3	4	5	6	7	8	9	10
Individual sample	1	Satisfaction (total score)	4.73	0.32	1									
	2	Satisfaction with debriefing and reflection	4.88	0.28	0.82**	1								
	3	Satisfaction with clinical reasoning	4.64	0.49	0.88**	0.62**	1							
	4	Satisfaction with clinical learning	4.49	0.56	0.77**	0.39**	0.56**	1						
	5	Preparedness before simulation	2.97	0.42	0.06	−0.02	0.02	0.01	1					
	6	Preparedness after simulation	3.28	0.46	0.27*	0.22*	0.32**	0.12	0.43**	1				
	7	Simulation MA evaluation	4.34	0.50	0.18	0.16	0.19	0.10	−0.07	0.36**	1			
	8	Simulation behavior evaluation	7.00	1.48	0.20	0.05	0.25*	0.19	−0.18	0.17	0.80**	1		
	9	Clinical MA evaluation	4.74	0.26	0.11	0.04	0.17	0.06	0.08	0.35**	0.29*	0.20	1	
	10	Clinical behavior evaluation	8.15	0.73	0.05	−0.04	0.12	0.04	−0.06	0.26*	0.24*	0.19	0.77**	1
Group sample	1	Satisfaction (total score)	4.71	0.39	1									
	2	Satisfaction with debriefing and reflection	4.87	0.34	0.86**	1								
	3	Satisfaction with clinical reasoning	4.72	0.48	0.87**	0.62**	1							
	4	Satisfaction with clinical learning	4.32	0.68	0.86**	0.56**	0.71**	1						
	5	Preparedness before simulation	2.91	0.48	0.17	0.16	0.22	0.07	1					
	6	Preparedness after simulation	3.45	0.51	0.35*	0.18	0.47**	0.30*	0.57**	1				
	7	Simulation MA evaluation	4.55	0.56	0.37**	0.36**	0.20	0.37**	0.19	0.23	1			
	8	Simulation behavior evaluation	7.55	1.77	0.35*	0.33*	0.21	0.36**	0.24	0.28*	0.97**	1		
	9	Clinical MA evaluation	4.77	0.28	−0.03	−0.08	0.01	0.00	0.04	0.21	0.02	−0.04	1	
	10	Clinical behavior evaluation	8.35	0.80	0.00	−0.03	0.02	0.04	−0.13	0.11	0.01	−0.08	0.87**	1

* $p < 0.05$.
** $p < 0.01$.

Table 3
Multivariate regression models for the predictors of preparedness after simulation.

Sample	Variable	β	*SE*	*p*	R^2
Individual ($n = 78$)	Simulation MA evaluation	0.51	0.13	0.001**	0.427
	Simulation behavior evaluation	−0.21	0.04	0.176	
	Preparedness before simulation	0.37	0.10	<0.001**	
	Previous experience	0.19	0.08	0.043*	
	Satisfaction	0.21	0.12	0.021*	
Group ($n = 50$)	Simulation MA evaluation	−0.32	0.40	0.476	0.442
	Simulation behavior evaluation	0.39	0.12	0.378	
	Preparedness before simulation	0.42	0.13	0.002**	
	Previous experience	0.21	0.12	0.077	
	Satisfaction	0.23	0.16	0.064	

* $p < 0.05$.
** $p < 0.01$.

between MA performance in simulation and MA performance in the clinical setting (Preacher and Hayes, 2004). Table 4 presents the multivariate linear regressions for the factors that predict clinical MA evaluation. The first regression indicates that clinical MA evaluation was predicted by simulation evaluation ($p = 0.014$); the second regression indicates that preparedness after simulation was predicted by simulation MA evaluation ($p = 0.001$); the third regression includes both variables, and indicates that clinical MA evaluation was predicted by preparedness after simulation ($p = 0.018$), but not by simulation MA evaluation ($p = 0.131$). These results suggest that preparedness after simulation mediated the association between simulation MA evaluation and clinical MA evaluation. As for the group sample, no associations between simulation MA evaluation, preparedness after simulation and clinical MA evaluation were observed. Thus, hypothesis 4 was supported for the individual sample only.

Table 4
Linear regression models testing Preparedness after simulation as a mediator of the relationship between Simulation MA evaluation and Clinical MA evaluation in the individual sample ($n = 78$).

	β	*SE*	*p*	R^2
Regression 1				
Outcome: clinical MA				0.08
Predictor: simulation MA	0.286	0.06	0.014	
Regression 2				
Outcome: preparedness after simulation				0.13
Predictor: simulation MA	0.360	0.09	0.001	
Regression 3				
Outcome: clinical MA				0.15
Mediator: preparedness after simulation	0.286	0.07	0.018	
Predictor: simulation MA	0.181	0.06	0.131	

In summary, the simulation experience among participants in the individual sample impacted their satisfaction, preparedness and clinical MA evaluation, whereas the simulation experience among participants in the group sample impacted their satisfaction and preparedness, but not their clinical MA evaluation.

4. Discussion

This study aimed to evaluate the influence of medication simulation-based learning on competence in two samples of nursing students, an individual sample and a group sample. Our findings indicate that the simulation increased students' preparedness for the medication administration process, and when simulation was conducted individually, the resulting preparedness influenced performance in the clinical setting. We can discuss these findings in light of recent literature.

Simulation-based learning provides students with opportunities to think and act in the nursing role and thus supports their ongoing

development of clinical judgment (Lawrence et al., 2018). Our findings support previous studies (Guhde, 2011; Lewis and Ciak, 2011; Preston et al., 2019), that have found scenario-based simulation for medication administration and management to be a teaching strategy that students find valuable. Simulation in a scenario design enables students to practice technical skills, while experiencing clinical reasoning, critical thinking and decision making throughout the scenario, all of which are important for gaining a deep understanding of the situation practiced.

Simulation is useful in creating a learning environment which contributes to the students' knowledge, skills, safety, and confidence (Mariani et al., 2017; Norman, 2012). We found that the simulation increased students' learning, expressed by higher preparedness after the simulation in both samples (individual and group). This finding is consistent with previous studies (Shin et al., 2015). However, in the comparison between samples, increase in preparedness in the individual sample was mainly due to the simulation experience, whereas level of preparedness before the simulation was the main contributor among students in the group sample. Since stronger preparedness before simulation predicted preparedness after the simulation in both samples, we conclude that simulation may contribute more to students who demonstrate confidence in their preparedness for the medication administration process. On the other hand, the simulation experience itself contributed to the level of preparedness only when the student practiced alone. We assume that students who experienced the simulation alone actually practiced all stages of the medication administration process, and as a result, their experience was better, and contributed to their preparedness. When in a group, students cannot always be actively exposed to all stages of the process, as they must share the experience with other students. Therefore, the group simulation experience may contribute less to their preparedness.

Simulation-based learning has been found to improve students' confidence and skills learning, but the literature with regard to the impact of this learning on clinical competencies is scarce (Norman, 2012; Stroup, 2014). To the best of our knowledge, the impact of simulation design (individual vs. group) on learning transfer has not previously been studied. We have found that preparedness after simulation impacted clinical performance only among students who experienced the medication administration process individually throughout the simulation scenario. Various reasons may contribute to this influence. First, it seems obvious that the influence of simulation on students' learning is more intense when the simulation experience is individual. In order to be able to use the skills acquired in the simulation, one should be actively involved with all the processes undertaken in the scenario, which is possible only when the training is performed alone. An individual simulation experience motivates students to be active participants in the learning, to perform throughout the medication administration process, and as a result, to better transfer their experience into the clinical setting. Second, while experiential learning depends more on the learner's cognitive abilities (Kolb, 1984), when participating in observational learning the learner must be motivated in order to learn from the model (the one who actually experienced) (Bandura, 1986). In the case of simulation learning, it is possible that less motivated students will benefit less from simulation in a group, but will benefit greatly from an individual experience. It is also possible, that lack of motivation may characterize borderline students, who find the medication administration process difficult. Consequently, the borderline and less motivated students may benefit more from individual rather than group simulation. Finally, individual simulation enables the observer/evaluator to focus on a single participant in each training session, which may improve the effectiveness of the debriefing and the reflection process following simulation. Thus, the participant receives indications about each step of her/his simulation experience, and can more easily improve her/his performance within the clinical setting.

When considering the value of simulation, it has been argued that such value comes with ensuring that the education practice benefits the patient (Harder, 2018). Our findings show that simulation of the medication administration process increased student preparedness for this skill, no matter what design was used. However, in the individual design this preparedness positively influenced the students' clinical performance, therefore the simulation indirectly benefits the patient, who received more professional treatment. Although we did not evaluate patient outcomes directly (e.g. by measuring errors reduction), when students become better prepared for the medication administration process, and succeed to transfer their simulated learning into clinical practice, we can cautiously conclude that simulation as an educational tool has clinical value for patients.

"Notwithstanding, the high costs and resources required for simulation-based education, including facilities, equipment and materials, human resources (e.g., training, experience, specialized skills), and time commitments (Fletcher and Wind, 2013; Isaranuwatchai et al., 2016; Maloney and Haines, 2016), may be even higher in an individual simulation design. It is questionable if individual simulation is cost-effective: What are its costs and resources? Can we expect a return on the investment, and what are its advantages compared to the next best alternative? Literature about the cost-effectiveness of simulation-based learning in general, and individual simulation in particular, is scarce (Maloney and Haines, 2016), thus, further research is warranted."

4.1. Strengths and limitations

The main strength of this study is the analysis of data from a pre-test post-test quasi-experimental study, which enabled causal inferring. In addition, the separate analyses of the two samples – individual simulation vs. simulation in a group of students, enabled a comparison between two different simulation designs. A limitation of this study is that it was conducted in only one simulation center, therefore the results could have been influenced by the faculty approach or by the institution's physical characteristics, and thus generalizability of findings is decreased. We also note that observational biases such as halo effect and observer subjectivity, and the absence of interrater reliability, may have impacted the accuracy of the MEAS measurement. However, in order to minimize the differences among observers' evaluations, we employed faculty members that had used this measure before, and conducted pre-observation training for each session.

4.2. Recommendations for future research

Further research is needed in order to examine the impact of simulation on other nursing skills, and in other clinical fields. It is also essential to examine the influence of this method on patients' long-term outcomes, and the cost-effectiveness of individual versus group simulation learning.

4.3. Implication for nursing education

The development of simulation-based learning that optimally imitates nursing practice in the real world is essential both due to the clinical settings shortage, and in order to improve students' clinical competence and performance. Therefore, this strategy should be an integral part of each nursing program aimed to educate and prepare students for medication administration practice. Although it requires greater resources, individual simulation better prepares students for their clinical tasks. Individual medication administration simulation-based learning has become a mandatory tool in the curriculum of the surgical rotation course in the Department of Nursing that conducted the study, and will be implemented in additional curricula of clinical courses.

5. Conclusions

Simulation-based learning is an effective teaching method that can prepare students to manage the medication administration process.

Simulation that addresses the entire medication administration process, including knowledge of pharmacology, assessment, critical thinking and skills, better imitates the nursing role of medication administration in the clinical setting. If the faculty's goal is to qualify students to be professional clinicians, individual simulation may be more useful in helping students to transfer newly acquired knowledge into practice.

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Ethical approval

The study was approved by the institutional review board of the Faculty of Health Sciences at Ben-Gurion University.

Declaration of competing interest

The authors declare that no conflicts of interest exist.

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