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Effectiveness of a simulation activity on knowledge about glucose monitoring and hypoglycemia management: a pre-post intervention study

Eficácia de uma simulação na aquisição de conhecimentos sobre monitoramento glicêmico e gerenciamento de hipoglicemia: um estudo pré e pós-intervenção

Efectividad de una simulación en la adquisición de conocimientos sobre monitorización glucémica y manejo de hipoglucemias: un estudio pre y post intervención

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Abstract

Adequate management of diabetes requires professional improvement programs. This study aimed to analyze the effect of a simulation activity on the acquisition of knowledge about blood glucose monitoring and hypoglycemia management. The study employed a pre-post intervention approach and was carried out in a university hospital located in Brazil. The participants were 82 graduating nursing students and nursing professionals studying/working at the university hospital. The intervention consisted of theoretical sessions, a practical simulation about glycemic monitoring and hypoglycemia management, and the pre- and post-tests. The simulation consisted of a rubber hand mannequin that allows simulating the glucose testing. There was a significant increase in knowledge after intervention with the total number of correct answers increasing from 186 in the pre-test to 326 in the post-test (+140, $p < .001$). The intervention was effective in increasing the participants' knowledge about glycemic monitoring and hypoglycemia management, favoring a better nursing care for people with diabetes.

Keywords: Continuing education; Diabetes mellitus; Nursing education; Simulation.

Resumo

O manejo adequado do diabetes requer programas de aperfeiçoamento profissional. Este estudo teve como objetivo analisar o efeito de uma atividade de simulação na aquisição de conhecimentos sobre monitoramento glicêmico e manejo da hipoglicemia. O estudo utilizou uma abordagem pré e pós-intervenção e foi realizado em um hospital universitário no Brasil. Os participantes foram 82 graduandos de enfermagem e profissionais de enfermagem que estudam ou atuam em um hospital universitário. A intervenção consistiu em sessões teóricas, simulação prática sobre monitorização glicêmica e manejo da hipoglicemia, pré e pós-teste. A simulação foi realizada utilizando-se um manequim que permite simular o teste de glicose. Houve um aumento significativo no conhecimento após a intervenção com o número total de respostas corretas aumentando de 186 no pré-teste para 326 no pós-teste (+140, p <0,001). A intervenção foi eficaz na aquisição de conhecimentos sobre monitoramento glicêmico e manejo da hipoglicemia pelos participantes, favorecendo uma melhor assistência de enfermagem às pessoas com diabetes.

Palavras-chave: Educação continuada; Diabetes mellitus; Educação em enfermagem; Simulação.

Resumen

El manejo adecuado de la diabetes requiere programas de desarrollo profesional. Este estudio tuvo como objetivo analizar el efecto de una actividad de simulación en la adquisición de conocimientos sobre el control glucémico y el manejo de la hipoglucemia. El estudio utilizó un enfoque pre y post intervención y se llevó a cabo en un hospital universitario de Brasil. Los participantes fueron 82 estudiantes de enfermería y profesionales de enfermería que estudian o trabajan en un hospital universitario. La intervención consistió en sesiones teóricas, simulación práctica de monitorización glucémica y manejo de hipoglucemias, pre y post test. La simulación se realizó mediante un maniquí que permite simular la prueba de glucosa. Hubo un aumento significativo en el conocimiento después de la intervención y el número total de respuestas correctas aumentó de 186 en la prueba previa a 326 en la prueba posterior (+140, p <0,001). La intervención fue eficaz en la adquisición de conocimientos sobre el control glucémico y el manejo de la hipoglucemia por parte de los participantes, favoreciendo una mejor atención de enfermería a las personas con diabetes.

Palabras clave: Educación continua; Diabetes mellitus; Educación en enfermería; Simulación.

1. Introduction

Diabetes mellitus is a global public health problem, as half a billion people live with this condition globally. In 2019, one in 11 people aged 20 to 79 (463 million) had diabetes. Brazil occupies the fifth position in the worldwide prevalence of cases with 16.8 million people in 2019, and with a projection of 26 million in 2045 (+59%) (International Diabetes Federation, 2019).

A combination of factors including poor performance of health systems, low awareness of health professionals and the general population about the impact of the disease, and the fact that type 2 diabetes can go unnoticed due to the nature of its symptoms lead to underdiagnosis, which increases the risk of complications (Brazilian Society of Diabetes, 2019). As with other chronic diseases, the management of diabetes is problematic due to the multifactorial nature of the disease, and continuous actions are necessary to achieve the glycemic control needed to minimize diabetes-related complications (American Diabetes Association, 2020).

Most people with diabetes need hospitalization at some point in their lives, increasing healthcare costs (Brazilian Diabetes Society, 2015; International Diabetes Federation, 2019). In 2019, the International Diabetes Federation (IDF) estimated a global healthcare expenditure on diabetes of 760 billion US dollars (52.3 billion dollars in Brazil only) (International Diabetes Federation, 2019). Clinical guidelines recommend screening blood glucose in all hospitalized patients because hyperglycemia, with a previous diagnosis of diabetes or not, influences the prognosis and half diabetics are unaware of their diagnosis. Besides, 15 to 35% of hospitalized patients have diabetes, and 10% have hyperglycemia due to stress (Brazilian Diabetes Society, 2015; Brazilian Society of Diabetes, 2019). Patients with hyperglycemia at admission or with a previous diagnosis of diabetes should have their pre-prandial and bedtime blood glucose measured (Vilar, 2016).

On the opposite side, hypoglycemia is the most frequent complication in diabetes, characterized by glycemia below 70 mg/dL. This alteration affects 5-20% of hospitalized patients, increasing morbidity and mortality regardless of the severity of conditions (Brazilian

Diabetes Society, 2015; Brazilian Society of Diabetes, 2019; Vilar, 2016). Early recognition of hypoglycemia is essential due to its influence on prognosis and its adverse outcomes. The capillary blood glucose checking is a useful and fast method for identifying it (Brazilian Diabetes Society, 2015; Vilar, 2016).

In this sense, for the proper conduct of diabetes care, it is vital to invest in educational programs in hospital institutions using strategies such as simulations and problem-based learning activities, as they are useful in the training of health professionals, favor the improvement of clinical outcomes, increase professional self-confidence, and, consequently, promote the quality of healthcare and patient safety (Christ-Libertin, 2016; Dickerson & Lubejko, 2016; Mesquita et al., 2019).

In the Nursing scenario, simulation is an active tool in professional training that uses several resources that provide hands-on experience, reducing the risks of harm to patients (Christ-Libertin, 2016; Dickerson & Lubejko, 2016; Souza et al., 2016). This modality of teaching can provide technical skills, crisis management, clinical reasoning in critical situations, leadership, teamwork, and simulation situations that can cause harm real environments (Mesquita et al., 2019; Souza et al., 2016). The use of clinical simulation strategies applied to the theory favors professionals' self-confidence and satisfaction, while using simulation alone does not significantly improve knowledge and skills (Mesquita et al., 2019).

In clinical practice, weaknesses related to safe care for people with diabetes are observed. Interventions are needed, including improving the structure of the health care networks, establishing appropriate care routines for each institution, improving the professional team's skills, developing communication, and raising awareness about the importance of self-care and adherence to treatment (Oliveira et al., 2016). The lack of participation in educational programs offered to nursing professionals is associated with the lack of knowledge of continuing education actions, work overload, and the adoption of inappropriate conducts, in addition to some professionals considering educational actions "irrelevant" (Sade et al., 2019).

Thus, the relevance of this study lies in the fact that the improvement of knowledge of nursing students and nursing professionals regarding glycemic monitoring and hypoglycemia management will help to effectively influence the safety and quality of nursing care to patients with diabetes (Dias, 2014). Thus, the objective of this study was to analyze the effect of a simulation activity on knowledge about blood glucose monitoring and hypoglycemia management.

2. Methods

2.1 Study design

This study employed an analytical, quantitative approach. According to Pereira et al. (2018), the quantitative methodological design consists of obtaining quantitative or numerical data through measurements of quantities utilizing metrology, which includes numbers and their respective units.

A pre-post intervention method was used to analyze the effect of a simulation activity on knowledge about blood glucose monitoring and hypoglycemia management.

2.2 Setting and participants

The study was carried out at a university hospital in Fortaleza, Ceara, Brazil, from July to November 2019. The study population consisted of nursing students, registered nurses, and nursing technicians who were studying (experiencing clinical training) or working in the hospital during the data collection period, totaling 135 subjects. The sample size was determined using a single population proportion formula with the assumption of a 95% confidence interval, a margin of error of 5%, and a prevalence of 50%, leading to a total of 100 participants.

The following inclusion criteria were adopted: being allocated to hospital's sectors selected for the study, being present during the data collection period, and having a formal link with the institution. The exclusion criteria were absence at any of the research stages and vacation or leave during the study period. Of 100 participants recruited for the study, 18 were lost due to incomplete training, so 82 participants were included in the final sample.

2.3 Data collection and outcome measures

Two instruments were used for data collection: instrument A, with characterization and training/professional information from the participants (gender, age, family income, education level, training time, and time working at the institution); and instrument B consisting of the pre and post-test questionnaire with five multiple-choice questions (A, B, C, D, and E) with only one correct alternative, created based on the guidelines of the Brazilian Society of Diabetes (2019) regarding glycemic monitoring and hypoglycemia management. To avoid memorization bias, each question's disposition and items were changed from the pre to the post-test.

Before data collection, a pilot test was carried out with 12 subjects who were residents of a multi-professional diabetes care program to check the need for adjustments regarding the proposed method, time of execution, instruments' content, and the number of questions. It was concluded that there was no need for changes in the instruments.

2.4 Intervention

The intervention was conducted through in-service training, consisting of theoretical lectures and simulations carried out in an itinerant way, i.e., one of the researchers conducted the training in pre-selected inpatient units belonging to the hospital. An average of 13 training sessions was carried out with six individuals each time, and preferably in each unit's nursing stations (the most requested location by the participants).

Each training was developed with a duration of 60 minutes divided into four stages, as follows: (1) presentation of the proposal, justification of the pre-selected themes, consent obtaining, and individual filling out of the pre-test questionnaire; (2) theoretical explanation of the themes using Microsoft Office PowerPoint visuals; (3) simulation-based on an Australian study method,(Andersen et al., 2016) using a low-cost simulator (a rubber hand coupled to an extension set with hypoglycemic solution) and a fictitious clinical situation involving the capillary glucose measurement technique and the management of hypoglycemia; and (4) post-test and recording suggestions, questions and impressions about the training.

The theoretical explanation and the pre- (P1) and post-test (P2) questionnaires addressed the following contents: (1) blood glucose monitoring; (2) capillary blood glucose; (3) glycemic targets and recommended daily frequency; (4) configuration and codes of glucometers used; (5) safe practices for measuring capillary blood glucose; (6) concept and classification of hypoglycemia and its counter-regulating mechanisms, predisposing factors, symptoms, and management.

The simulator (Figure 1) was developed using the following materials: a rubber hand; an extension set; nitrile gloves; transparent silicone elastics; a microporous tape; a 10 mL syringe; distilled water; glucose 5% ampoules; and a red food coloring powder. Before going to the hospital's sectors, the simulator was assembled using the following steps: (1) preparation of the hypoglycemic solution by diluting 0.05 - 0.10 mL of 5% glucose in 10 mL distilled water, resulting in glucometer readings of approximately 18 to 54 mg/dL, and

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subsequently applying the red food coloring powder until reaching blood-like color; (2) paving nitrile gloves on the hand mannequin; (3) sealing the hole with a nitrile glove tip cutout and transparent silicone to avoid overflow of the solution when injecting it into the extension set, and determining the place for puncture to obtain the artificial blood drop; and (4) positioning the extension set using microporous tape, to allow the draw of the solution from the distal phalanges.

Figure 1. Simulator for glucose testing training.

Source: Authors.

One voluntary participant was asked to perform the blood glucose testing at each training session using the simulator. He/she should perform the capillary blood collection on the mannequin following the correct technique, which included performing the puncture at the rubber hand in the site to indicate the collection of the artificial blood drop, placing the blood drop on the glucometer's reagent strip, and obtaining the value. Based on this value and the clinical context exposed to the participants, a discussion was held about which conduct would be the most appropriate for the clinical case, providing a questions and answers moment.

2.5 Data analysis

The collected data were stored in the RedCap software, as it allows data importing and exporting, construction of reproducible reports, and data transfer to statistical analysis software such as the Statistical Package for the Social Sciences (SPSS), JASP Statistics, and Jamovi Stats. For statistical analysis, three tests were performed as follows: Shapiro-Wilk normality test, to compare the total number of correct answers in the pre and post-test; McNemar test, to compare results obtained per question in the pre- and post-test; and Wilcoxon test to compare the pre- and post-intervention overall values.

2.6 Ethical considerations

The study protocol was reviewed and approved by the Research Ethics Committee of the University in which the study was undertaken. All participants provided written informed consent before participation.

3. Results

The study sample was composed mainly of females (92.7%), with a mean age of 38 years (SD: 9.8 years) ranging from 22 to 60 years, 60.5% were married or cohabiting, 77.3% had a family income above three minimum wages, 89.1% were healthcare professionals, with an average time of formal education of 13 years (SD: 8.15 years), ranging from four months to 39 years, and 46.5% of these were nursing technicians (Table 1).

Table 1. Sociodemographic and professional profile of the sample.

Variables	**n (%)**	**(95% CI)**
Gender (n = 82)		
Female	76 (92.7%)	85.5 - 96.9
Male	6 (7.3%)	3.1 - 14.5
Age (in years) (n = 82)		
Mean ± SD	38.41 ± 9.8	
Median	37	-
Min – Max	22 - 60	
Marital status (n = 81)		
Single	25 (30.9%)	21.6 - 41.5
Married/cohabiting	49 (60.5%)	49.6 - 70.6
Divorced	7 (8.6%)	3.9 - 16.2
Family income (n = 75)[1]		
<2 minimum wages	6 (8.0%)	
2 to 3 minimum wages	11 (14.7%)	-
> 3 minimum wages	58 (77.3%)	
Institutional link (n = 75)		
Student	7 (8.5%)	3.9 - 16.0

Resident	2 (2.4%)	0.5 - 7.6
Staff	73 (89.1%)	80.9 - 90.4
Highest degree held (n = 73)		
Technician degree	34 (46.6%)	35.5 - 58.0
Baccalaureate degree	6 (8.2%)	3.5 - 16.2
Graduate degree	24 (32.9%)	22.9 - 44.2
Master's degree	8 (11%)	5.3 - 19.6
PhD degree	1 (1.4%)	0.1 - 6.2
Time of professional training (in years) (n = 73)		
Mean ± SD	13.34 ± 8.15	
Median	12	-
Min – Max	0.3 - 39	

[1]Minimum wage R$998.00 (USD118.42). Source: Authors.

The following proportions were found as to the number of conversions from errors to right answers from the pre-test (P1) to the post-test (P2): glycemic monitoring (3.6%), glycemic targets (50%), and frequency of capillary glucose checking (39.1%). A statistically significant improvement ($p < .001$) was found in questions about glycemic monitoring (glycemic targets and frequency of capillary glucose checking) in the different fictitious scenarios covered by the intervention. A decrease in the number of correct answers from P1 to P2 in question 1 was found, with no statistical significance ($p = .317$) (Table 2).

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Table 2. Distribution of right and wrong answers to questions about glycemic monitoring and hypoglycemia management in the pre (P1) and post-test (P2) (n=82).

	Pre-test (P1)	**Post-test (P2) Right**	**Post-test (P2) Wrong**	**Post-test (P2) Total**	**p-value[1]**
Blood glucose monitoring	Interpretation of glucometer codes				
	Right	73 (89.1%)	6 (7.3%)	79 (96.3%)	.317
	Wrong	3 (3.6%)	0 (0.0%)	3 (3.7%)	
	Glycemic goals				
	Right	14 (17.1%)	5 (6.1%)	19 (23.2%)	< .001
	Wrong	41 (50%)	22 (26.8%)	63 (76.8%)	
	Frequency of capillary blood glucose checking				
	Right	17 (20.7%)	6 (7.3%)	23 (28.1%)	< .001
	Wrong	32 (39.1%)	27 (32.9%)	59 (71.9%)	
Hypoglycemia	Guidelines for preventing hypoglycemia				< .001
	Right	22 (26.8%)	3 (3.7%)	25 (30.5%)	
	Wrong	45 (54.9%)	12 (14.6%)	57 (69.5%)	
	Proper correction of hypoglycemia				< .001
	Right	39 (47.6%)	1 (1.2%)	40 (48.8%)	
	Wrong	40 (48.7%)	2 (2.5%)	42 (51.2%)	

[1]McNemar test. Source: Authors.

Concerning hypoglycemia management, 54.9% of the participants obtained improved knowledge about preventing hypoglycemia with a significant improvement in the right answers in the post-intervention ($p < .001$). Besides that, a total of 48.7% of the sample changed their scores from wrong to right in the question about the proper correction of hypoglycemia ($p < .001$).

Table 3 presents a comparative analysis of the right answers in P1 and P2. From 410 answers (82 participants x 5 questions), 186 (45.3%) were right in P1. In P2, this number increased to 326 (79.5%). The average number of correct answers per person in P1 was 2.268 (SD: 1.112), and this number increased to 3.976 (SD: 1.077) in P2.

Table 3. Distribution of correct answers per question in the pre (P1) and post-test (P2) (n=410).

Total number of correct answers	**n (%)**	**Average**	**SD**
Pre-test (P1)	186 (45.3%)	2.268	1.112
Post-test (P2)	326 (79.5%)	3.976	1.077
p-value[1]	< .001		
p-value[2]	< .001		

[1]Wilcoxon test; [2]Shapiro-Wilk normality test. Source: Authors.

Correlations were tested between the average of correct answers before and after the intervention and the variables age, highest degree held, and time of professional training, but no significant correlations were found.

4. Discussion

This study analyzed the effect of a simulation-based activity on nursing students and staff's knowledge about blood glucose monitoring and hypoglycemia management. As for the sample's profile, there was a predominance of female subjects, which is common in the national scene, as reported in some studies carried out in public hospitals. Most participants had technical training and an average time of professional training of 10 years, which is a factor associated with adherence to permanent education activities according to the literature (Baptista et al., 2016; Mota et al., 2018).

The first question, related to the ability to interpret glucometer readings, included a brief clinical description and images of codes/symbols showed in the glucometer display. The number of right answers to this question decreased from the pre-test to the post-test.

Given the fact that the intervention was carried out in the hospital setting, a possible explanation for this finding is that some participants rushed to answer the questionnaire to finish the post-test and conclude their participation as soon as possible. It was observed that, during the post-test, some participants showed concern about requests received from patients, companions, and other professionals. Sometimes, the training session had to be interrupted, which may have hindered the assimilation of the training information. Despite being a gap, such problems represent an opportunity to reflect on the need to integrate educational interventions to nurses' daily work in the hospital scenario and promote positive perceptions about in-service training (Vargas et al., 2012).

It was evident that the use of simulation strategies linked to theory contributed to technical and scientific improvement. Scientific evidence points out that the combination of theoretical and practical approaches in training sessions can generate changes in several aspects, such as improving satisfaction and self-confidence, improving knowledge, skills, and attitudes, and changing behaviors, by transferring simulated learning to the real clinical environment (Baptista et al., 2016; Kaplan et al., 2015).

Also, simulation-based activities are an essential tool for professional training, which can be used by the nursing team and other health workers, including administrative personnel working in hospitals, allowing the translation from clinical research to practice (Neves et al., 2016).

In this context, simulation can generate substantial benefits for teaching in Nursing by bringing theory and practice closer together, meeting the proposed objectives, and developing diagnostic reasoning and clinical judgment. Besides, simulation contributes to the development of skills, abilities, and attitudes to collaborate to train professional nurses more prepared to work (Rodrigues et al., 2020).

The improvements found in the post-test show that the intervention had a positive effect on knowledge acquisition and assimilation. A similar study carried out at the Texas Medical Center has found a statistically significant improvement in post-intervention results compared to the pre-intervention [$t(14) = 2.04$, $p = .03$] (Bell-Gordon et al., 2014).

Corroborating the current study's findings, a quasi-experimental research carried out with 53 nursing professionals in a reference hospital in Brazil compared the knowledge and skills between two groups. The experimental group participated in a theoretical lecture combined with a simulation, and the control group attended the theoretical lecture only. Improvements in knowledge and skills measured by the authors were not significant. However, the degree of self-confidence among the experimental group participants was higher than in the control group ($p = .007$) (Mesquita et al., 2019).

Studies indicate that simulation-based education contributes to increased knowledge acquisition in diabetes mellitus and the development of skills necessary for qualified nursing care, such as clinical reasoning and communication (Jeong, 2018; Kang & Kim, 2016).

Also, the use of education associated with simulation has positive effects on the glycemic control of patients with diabetes, including the achievement of fasting, postprandial, and glycated hemoglobin targets, improvement in self-care behaviors, adherence to a healthy diet and a physical exercise program, adherence to blood glucose self-monitoring, and reduction of complications resulting from poor disease control (Ji et al., 2019).

The simulation-based intervention tested in the current study proved to be a positive nursing education strategy and professional training. The simulator built for the current study was an innovative tool. The improvements found can favor the reduction of hypoglycemia events in patients and generate a positive impact in reducing hospital mortality and hospital length of stay (Sleeman et al., 2018).

4.1 Limitations and implications

This study's main limitation is that lack of motivation among the participants may have happened due to work-related concerns or workload since the study employed in-service training. Thus, strategies to increase participants' adherence to training are suggested and incorporate permanent education programs into hospitals.

The study findings serve as a situational diagnosis of knowledge gaps in glycemic monitoring and hypoglycemia management. Some of these gaps remained after the educational intervention, pointing out the need to provide strategies to consolidate the participants' previous knowledge and improve the new knowledge acquired by them.

5. Conclusion

The educational intervention consisting of a theoretical session followed by a simulation-based activity effectively improved knowledge about glycemic monitoring and hypoglycemia management of nursing students and staff, favoring qualified nursing care for people with diabetes. Therefore, simulated interventions should be encouraged and replicated to promote clinical practice guidelines and favor patient safety.

Other studies must be developed addressing aspects related to the operationalization of clinical simulation for larger groups of professionals and students, seeking to build new possibilities that make simulation feasible in different teaching-learning situations.

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