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Levels of Knowledge in Nursing Students on Hemodynamic Monitoring – A Cross-Sectional Study

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Abstract

Introduction. Hemodynamic monitoring is of great importance because it covers all vital organic systems and their functioning, and any error in the interpretation of the monitored parameters can lead to a drastic deterioration of the patient's condition and cause death.

Aim. The aim of this study was to determine the levels of knowledge about hemodynamic monitoring of full-time and part-time students of the first, second, and third year of the undergraduate study of nursing at the University of Applied Health Sciences in Zagreb.

Methods. A cross sectional study was conducted. The survey subjects were students at the University of Applied Health Sciences in Zagreb (N=280) in the period between December 2020 and February 2021. For the purposes of the study, the authors created a questionnaire that students filled in using an online platform, and the results of the questionnaire were anonymous.

Results. The research found that most students have an adequate level of knowledge in the field of hemodynamic monitoring. By determining differences in knowledge of part-time and full-time nursing students, it was observed that students with work experience showed statistically significantly better results ($p<0.05$).

Conclusion. The conducted study showed an adequate level of knowledge of nursing studies, since a high number of students, outside of their faculty

obligations, have not been in contact with hemodynamic monitoring. The specificity and complexity of work in the intensive care unit comes from a particularly vulnerable population of patients who require maximum care, which is why nurses need continuous education, skill improvement, and training regarding new monitoring methods.

Introduction

The term *monitoring* refers to the dynamic monitoring of physiological parameters of patients (1). Quality monitoring has a major effect on reducing the possible poor outcome of treatment by recognizing changes before possible damage occurs. The appearance of a hemodynamic monitoring improved clinical assessment with the specificity and precision of measurements of hemodynamic parameters (2).

The main goal of hemodynamic monitoring in providing care for patients in critical conditions is to ensure adequate tissue oxygenation and organ perfusion, which is achieved by carefully observing the minute volume and systemic vascular resistance of the patient (3). Most often it is difficult to assess how to achieve these goals, i.e., whether the use of infusion solutions, the use of vasopressors, pharmacotherapy, or other types of treatment will prove to be most successful. Moreover, if the wrong treatment strategy is applied, the patient's condition may deteriorate further. For example, excessive patient hydration can lead to oedema, gas exchange, and acidosis (4,5).

Since the insertion of catheters, which is necessary for hemodynamic monitoring, requires sufficient education of healthcare workers, invasive hemodynamic monitoring represents an important intervention which requires advanced skills and knowledge (6). Considering the complex clinical environment and the use of specific technological apparatus, it is a great challenge for nurses to provide adequate nursing care to critically ill patients. Furthermore, nursing students face an even more demanding challenge, since their experience in a clinical setting is limited. Several studies have shown how invasive hemodynamic evaluation influences therapy management and important clinical decisions, meaning that nurses must be properly trained in order to provide the necessary care and that training needs to be implemented during their formal education (7).

Following the use of hemodynamic evaluation parameters in therapy management, these parameters are also efficiently implemented in the diagnostic decision processes. The main goal in hemodynamic monitoring is to interpret pharmacological, biochemical, and physiological changes. For critical care nurses, continuous education, both theoretical and practical, is essential (8). Continuous education and improvement of skills and 0and knowledge associated with hemodynamic monitoring increases patient safety and assures the quality of healthcare (9,10).

Patient monitoring in the intensive care unit is one of the most important duties of nurses. In this way, feedback is obtained on the effectiveness of the treatment methods used in relation to the general condition of the patient (11). Hemodynamic monitoring in this context is of immense importance because it covers all vital organ systems and their functioning, and any error in the interpretation of the monitored parameters can result in a drastic deterioration of the patient's health or even death (12).

Studies suggest that better education contributes to the development of theoretical knowledge and skills, but this does not necessarily mean their implementation in clinical practice is improved. In the long term, lack of knowledge is cited as one of the reasons for poor practical skills of healthcare personnel (13). Students believe that knowledge in the fields of nursing, clinical, and basic medical sciences is most important, as well as having good communication skills. They carefully assess their practical skills and competences, and most think traineeship programmes should be mandatory, with a minimum duration of 6 months (14).

One study evaluated the levels of knowledge of intensive care nurses in European countries by investigating their knowledge of hemodynamic monitoring, infections present in intensive care units, ventilation and respiratory care, the effects of drugs, causes of shocks, and other areas of intensive care (15). Although knowledge varied between states, there was no significant difference. Worse results were found in the areas of respiration/ventilation, and the authors of the study recommend prioritising these areas (15). Existing literature points to limited theoretical knowledge about hemodynamic monitoring within the scope of nurses, so Ahmed et al. conducted a

study with the aim of evaluating the knowledge and roles of nurses in intensive care units (16). The results pointed to insufficient knowledge of nurses in the field of hemodynamic monitoring, without statistically significant difference depending on the level of qualifications. The study is unique because it provides concrete insight into specific knowledge and skills on hemodynamic monitoring, i.e., provides useful feedback on the competences of nurses in intensive care units (16).

Considering that after finishing their undergraduate studies students are faced with numerous challenges while working in the field of hemodynamic monitoring, this study will contribute to a better understanding of their skill level and knowledge in Croatia, as well as in other countries. Furthermore, the results of this study could prove useful in determining the approaches to improving the skills they have according to the requirements of modern medicine.

Aim

The aim of this study is to investigate the level of knowledge of hemodynamic monitoring among students in the undergraduate study of nursing at the University of Applied Health Sciences in Zagreb. The specific aims of the study are to explore the associations between the year of study with the level of knowledge and to explore the association of work experience with the level of knowledge.

Hypotheses

1. The level of knowledge is associated with the year of study.
2. The level of knowledge about hemodynamic monitoring is higher in students with work experience.

Methods

A cross-sectional study was conducted on a sample of 280 nursing students at the University of Applied Health Sciences in Zagreb. The survey subjects were students at the University of Applied Health Sciences in Zagreb (N=280) in the period between December 2020 and February 2021. A convenience sample was used and the participants signed an informed consent form. The target population consisted of students of the undergraduate study of nursing. Prior to the study, the Ethical Committee of the University of Applied Health Sciences issued an approval (Class: 053-01/20-01/231, Reg. No. 251-379-10-20-02). The study was aligned with ethical standards in biomedical sciences and the Declaration of Helsinki (17). Participation was voluntary, and the participants were informed of all aspects of the study and consented to participate by providing their digital signature.

The instrument used in this study is the questionnaire "Levels of knowledge of nursing students about hemodynamic monitoring" created by the authors. The questionnaire has two types of questions, which the participants answered through an online platform, and the results of the questionnaire were anonymous. The questionnaire is designed to ensure a uniform representation of questions from all areas of hemodynamic monitoring in order to obtain a complete assessment of the student's knowledge of hemodynamics. The first part of the questionnaire examines demographic data: age, gender, full-time or part-time studies, and year of study. The second part of the questionnaire relates to the knowledge of nursing students about hemodynamic monitoring and consists of 11 questions in the form of statements (with possible answer being "correct" and "incorrect") and 19 questions with four possible answers, only one of which is correct. A score of 75% was considered successful. This number was selected because 50% of correct answers usually come from average students, while students who are above average provide an additional 25% of correct answers.

For continuous variables the arithmetic mean, standard deviation, and minimum and maximum result were presented. Since the continuous variables (total knowledge score on the test) statistically significantly deviate from the normal distribution, the description also shows the median and the interquartile ranges, which in this case represent a clearer measure of central tendency and scattering of results. The normality of distribution was checked by the Shapiro-Wilk test.

For nominal (categorized) variables, the number and percentage of subjects in the associated categories are shown, and statistical significance of the differences was calculated using a chi-squared test. The Mann-Whitney and Kruskal-Wallis tests were used to

test the significances of the differences in average scores on the total knowledge test,

The psychometric properties of the knowledge test are presented through the difficulty of the question, sensitivity and reliability of the test (whose homogeneity was calculated by the Kuder-Richardson formula, the result of which is 0.65), and the level of question discrimination (Table 1).

The differences closest to zero indicate the lowest level of discrimination, while differences of 15-20% indicate good discrimination – a condition that most questions in the test meet.

Results

A total of 280 students at the University of Applied Sciences in Zagreb participated in the study of the level of knowledge of nursing students of hemodynamic monitoring. Most of the subjects were female, 241 (86.1%), while noticeably fewer were males, only 39 (13.9%). The demographic data is presented in Table 2.

Table 1. **Discriminant validity of the test shown as the difference in correct answers between extreme groups (25% of the best and 25% of the worst results)**

	Lowest 25%	Top 25%	Difference
Hemodynamics is synonymous with the transportation role of the cardiovascular system.	88%	95%	-7%
Hemodynamic monitoring aims to ensure a reduction in tissue perfusion, so that the cardiovascular system receives a better supply of oxygen.	38%	89%	-51%
The diameter of the blood vessel is regulated by growth and development, and it is not possible to change its diameter.	72%	92%	-20%
The stroke volume is the amount of blood pumped during one heart action from which part of the heart:	46%	80%	-34%
The amount of blood pumped from the left ventricle for one minute is called:	62%	88%	-26%
Cardiac output is the product of the stroke volume and frequency, and the normal value is:	49%	86%	-37%
The ratio of heart filling time to frequency is explained as follows:	50%	76%	-26%
Knowledge concerning ECG is part of:	80%	87%	-7%
Which blood pressure represents the average pressure in the arteries during the heart cycle:	46%	77%	-31%
Which pressure represents peak cycle pressure:	18%	60%	-42%
Which type of blood pressure measurement is the most reliable?	36%	91%	-55%
Which artery does not represent one of the most common places for cannulation?	20%	56%	-36%
Central venous pressure is an indicator of blood pressure in the venae cavae and reflects the amount of blood returning to the heart, as well as the ability of the heart to pump the blood back into the arterial system.	80%	95%	-15%
In which part of the heart does the tip of the catheter by which the central venous pressure is measured most often end:	31%	74%	-43%
For the insertion of the central venous catheter, two nurses are needed, one of whom assists the physician in the insertion of a catheter, while the other nurse assists the two of them.	66%	95%	-29%

Insertion of the central venous catheter is done exclusively in the operating room due to the highest level of sterility.	39%	68%	-29%
The normal values of the central venous catheter are:	38%	64%	-26%
The most common places of insertion of central venous catheters are:	35%	53%	-18%
Pulse oximetry is an invasive method of measuring peripheral blood oxygen saturation.	47%	88%	-41%
Oxygen saturation level refers to the amount of oxygen which binds to the haemoglobin	89%	97%	-8%
In healthy individuals, the normal value of Sa02 is approximately:	61%	94%	-33%
A thermodilution catheter provides the basic hemodynamic parameters:	50%	78%	-28%
The Swan-Ganz catheter ends in:	22%	58%	-36%
The central venous pressure is an indicator of preload:	16%	48%	-32%
The intrathoracic volume of blood is the volume of blood in:	28%	59%	-31%
The LiDCO monitor is a minimally invasive hemodynamic monitor designed to optimize the hemodynamics of patients in terms of goal-oriented therapy.	70%	85%	-15%
Cardiac output can be determined reliably on the basis of clinical examination and routine assessment.	42%	69%	-27%
Hemodynamic monitoring can be:	69%	96%	-27%
Invasive monitoring includes:	59%	95%	-36%
Low central venous pressure indicates hypoxemia	19%	68%	-49%

Table 2. **Demographic data**

		n	%
Age of subjects	18-24	225	80.4
	25-34	39	13.9
	35-44	12	4.3
	45-65	4	1.4
Sex	male	39	13.9
	female	241	86.1
Type of study	full-time study	146	52.1
	part-time study	134	47.9
Year of study	first year	73	26.1
	second year	90	32.1
	third year	117	41.8
Total		280	100

Table 3 shows the sum total of the results of the knowledge test and the comparison of the type of study, the year of study, and other demographic indicators.

By determining the differences in students' knowledge, it was observed that students with work experience achieve statistically significantly better results, over 75% (p=0.013).

The highest number of correct answers were provided for the following question: Oxygen saturation level refers to the amount of oxygen which binds to the haemoglobin. 261 (93.2%) students offered the correct answer, i.e., 135 (92.5%) full-time and 126 (94%) part-time students answered the question correctly. The lowest number of correct answers was provided for the following question: Which artery does not represent one of the most common places for cannulation. Only 105 (37.5%) students answered correctly, i.e., 37 (25.3%) full-time and 68 (50.7%) part-time students answered the question correctly.

Statistically significant difference by year of study is visible only in the question "Knowledge concerning

Table 3. **Number and percentage of subjects with a total score on the questionnaire above 75%**

	Result above 75%		Result below 75%		Total	
	n	%	n	%	n	%
Total number of subjects	113	40	167	60	280	100
Type of study: Full-time study	50	34.2	96	66.8	146	100
Part-time study	63	47	71	53	134	100
Year of study: First year	27	37	46	63	73	100
Second year	36	40	54	60	90	100
Third year	50	42.7	67	57.3	117	100

Table 4. **Number and percentage of subjects who provided correct answers to individual questions, according to the type of study**

		Type of study				
		Full-time study		Part-time study		
		n	%	n	%	Chi-square *p*
Cardiac output is the product of the stroke volume and frequency, and the normal value is:	Incorrect	40	27.4	54	40.3	**0.023**
	Correct	106	72.6	80	59.7	
Knowledge concerning ECG is part of:	Incorrect	11	7.5	33	24.6	**<0.001**
	Correct	135	92.5	101	75.4	
Which artery does not represent one of the most common places for cannulation?	Incorrect	109	74.7	66	49.3	**<0.001**
	Correct	37	25.3	68	50.7	
For the insertion of a central venous catheter, two nurses are needed, one of whom assists the physician in the insertion of a catheter, while the other nurse assists the two of them.	Incorrect	30	20.5	13	9.7	**0.013**
	Correct	116	79.5	121	90.3	
Insertion of the central venous catheter is done exclusively in the operating room due to the highest level of sterility.	Incorrect	85	58.2	48	35.8	**<0.001**
	Correct	61	41.8	86	64.2	

Pulse oximetry is an invasive method of measuring peripheral blood oxygen saturation.	Incorrect	54	37	26	19.4	**0.001**
	Correct	92	63	108	80.6	
The Swan-Ganz catheter ends in:	Incorrect	92	63	67	50	**0.030**
	Correct	54	37.0	67	50	
The central venous pressure is an indicator of preload:	Incorrect	77	52.7	97	72.4	**0.001**
	Correct	69	47.3	37	27.6	
Cardiac output can be determined reliably based on clinical examination and routine assessment.	Incorrect	71	48.6	48	35.8	**0.039**
	Correct	75	51.4	86	64.2	
Low central venous pressure indicates hypoxemia.	Incorrect	99	67.8	59	44	**<0.001**
	Correct	47	32.2	75	56	
Total		146	100	134	100	

ECG is part of:" (p<0.001), for which the students of the first year of study provided only 50 (68.5%) correct answers, followed by the students of the second year with a significant difference of 80 (88.9%) correct answers, and the students of the third year with 106 (90.6%) correct answers.

The difference by type of study is statistically significant (p=0.013), and better results are achieved by part-time students (Figure 1). Differences by year of study are not statistically significant (χ2=0.624, df=2, p=0.732), but among part-time students there is a higher proportion of those who fulfilled the 75% solution criterion (χ2=4,732, df=1, p=0.038) (Figure 2).

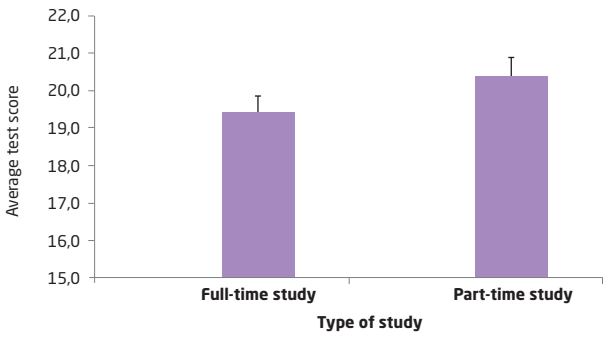

Figure 1. **Average test success by type of study**

Discussion

Quality hemodynamic monitoring in intensive care units requires competent and educated staff, especially in the case of critical care patients who require a continuous assessment of their status. This ensures timely recognition of the deterioration of status and timely provision of care to the patient.

The main goal of the study was to determine whether there is a difference in the level of knowledge about hemodynamic monitoring between full-time and part-time nursing students and the presence of a difference in knowledge in the first, second, and third years of study. The results of our study showed that part-time students achieve better results in the field of hemodynamic monitoring when compared to full-time students, which confirms our hypothesis. The most statistically significant difference is present in the responses to questions examining the level of knowledge related to arterial catheters and their roles, where the difference in the proportion of correct and incorrect answers in favour of part-time students is up to 30% (Table 4).

A difference in knowledge between the first, second, and third years of study was not confirmed, which

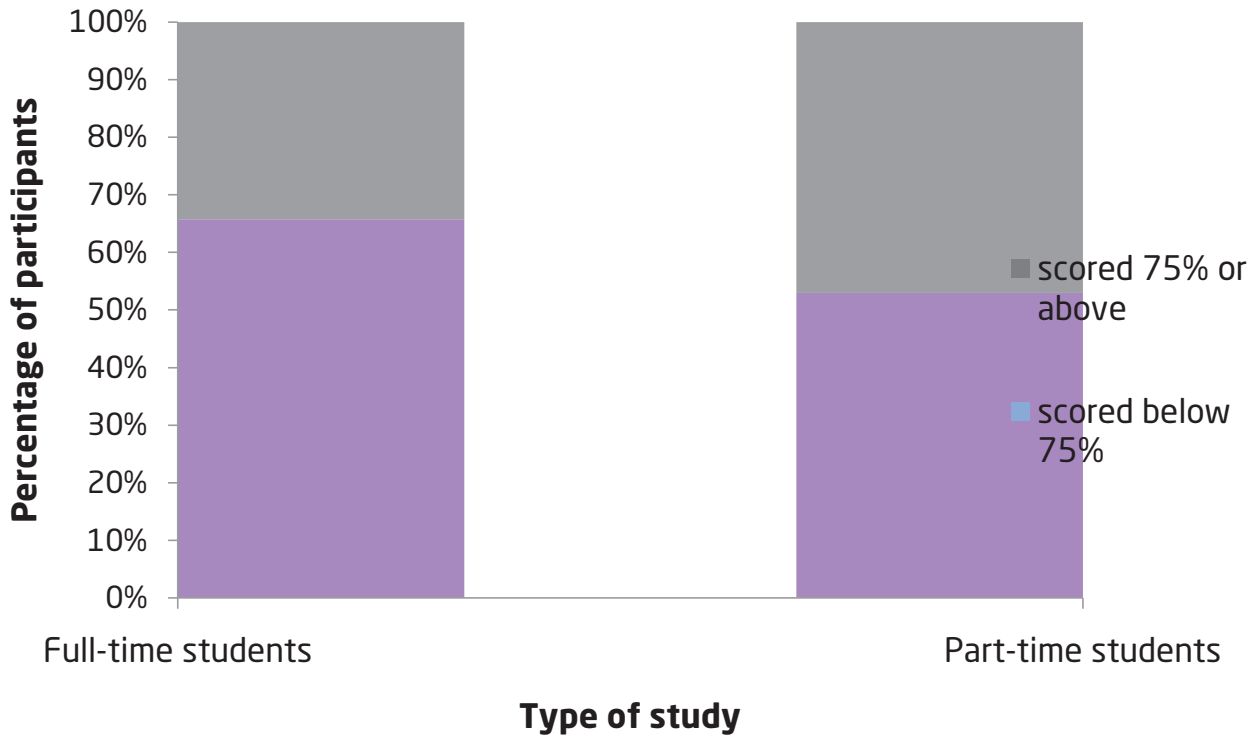

Figure 2. **Percentage of students who fulfilled the 75% test solution criterion, based on the type of study**

indicates that there is a need for improvement of clinical exercises. Lectures about hemodynamic and hemodynamic monitoring are implemented in several different courses in all three years of undergraduate study. The significance of difference between the knowledge of part-time and full-time students gives us valuable indicators for improving and highlighting the field of hemodynamic monitoring in clinical settings.

A Sudanese study conducted on 50 nurses shows insufficient knowledge of arterial catheters (18), which we can also link to this study because if the differences between full-time and part-time students are disregarded, the participants generally do not achieve good results in the field of arterial catheters. When asked about the catheter entry point, only 37.5% (N=105) of students provided the correct answer, and only 31.6% (N=60) of the correct answers to this question are also included in the survey conducted in Egypt (19).

Certain areas of hemodynamic monitoring, such as knowledge of central venous pressure values, catheter entry points, and knowledge of the roles of arterial catheters, result in poor knowledge of full-time and part-time nursing students, indicating the need for additional education in these areas (Table 4). A Sudanese study by Ahmed et al. conducted on 90 nurses showed unsatisfactory results in the field of hemodynamics, highlighting the need for additional training in order to make patients feel safer and nurses more satisfied with their approach in everyday work (16).

The results of the study show that students of all years of nursing, whether full-time or part-time, achieved a generally satisfactory level of knowledge in the field of hemodynamic monitoring (table 4). Nevertheless, part-time students achieved better results than full-time students, which is expected due to their constant contact with new information and less difficulty in understanding it. Khalel et al. conclude that continuous improvement of existing training programmes for nurses in the field of hemodynamic monitoring lays an excellent foundation for mastering advanced patient monitoring techniques (18). Furthermore, by constantly working in a hospital setting, part-time students acquire a greater amount

of knowledge that they can apply in the theoretical field, which may not always be the case with applying the theoretically learned content in practice. Recent theories of knowledge and knowledge acquisition through experience (i.e., experiential learning theory) support the fact that theoretical knowledge is also acquired faster and more efficiently through the practical application of it (20).

In any clinical setting, in particular in the field of intensive care, a higher level of knowledge and competence provides benefits for nurses and for the patient's safety and satisfaction (21).

Although this study targeted students of full-time and part-time nursing studies at the University of Applied Health Sciences in Zagreb regarding knowledge in the field of hemodynamic monitoring, other nursing studies in Croatia should be included in future studies in order to encompass a higher number of students studying at different universities. The questionnaire proved to be a good tool for collecting information, and its content can also be modified, depending on specific questions about hemodynamic monitoring that would like to be examined. Furthermore, the advantage of this study is that it has provided insight into both strong and weak points in students' knowledge related to monitoring hemodynamic status, which would be a good indicator for teachers and associates regarding which topics should be more represented. It would be suggested to increase hemodynamic monitoring themes in clinical exercises. The specificity and complexity of work in the intensive care unit is a result of the particularly vulnerable population of patients who require maximum care, which is why nurses require continuous education and improvement of skills and knowledge regarding new monitoring methods.

Conclusion

The following conclusions can be drawn from the results of this study: there is a statistically significant difference in the level of knowledge regarding hemodynamic monitoring between full-time and part-time students. Part-time students achieve better results, and differences in knowledge by year of study are not statistically significant. The study shows that there is an adequate level of knowledge among the participants, since a high number of them have not been in contact with hemodynamic monitoring outside of their university studies. However, the results of this study show that there is a need for some improvement of clinical exercises.

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RAZINE ZNANJA STUDENATA SESTRINSTVA O HEMODINAMSKOM MONITORINGU

Sažetak

Uvod. Hemodinamski monitoring od neizmjerne je važnosti jer obuhvaća sve vitalne organske sustave i njihovo funkcioniranje, a svaka greška u interpretaciji praćenih parametara može rezultirati drastičnim pogoršanjem bolesnikova stanja te dovesti do smrti.

Cilj. Cilj ove studije bio je istražiti razine znanja o hemodinamskom monitoringu redovnih i izvanrednih studenata prve, druge i treće godine na preddiplomskom studiju sestrinstva Zdravstvenog veleučilišta u Zagrebu. Hipoteze istraživanja bile su da je razina znanja povezana s višom godinom studija te da je razina znanja o hemodinamskom monitoringu veća kod izvanrednih studenata.

Metode. Ispitanici istraživanja bili su redovni i izvanredni studenti Zdravstvenog veleučilišta u Zagrebu (N = 280) u periodu od prosinca 2020. do veljače 2021. Za potrebe istraživanja autori su izradili upitnik koji su studenti rješavali *online*, a rezultati upitnika bili su anonimni.

Rezultati. Istraživanjem je utvrđeno da je kod svih godina redovnog i izvanrednog studija sestrinstva prisutna adekvatna razina znanja u području hemodinamskog monitoringa. Utvrđivanjem razlika u znanju studenata izvanrednog studija sestrinstva i redovnog studija sestrinstva uočeno je kako izvanredni studenti postižu nekoliko statistički značajno boljih rezultata ($p < 0,05$).

Zaključak. Provedena studija pokazuje zadovoljavajuću razinu znanja kod studenata redovnog studija sestrinstva, s obzirom na to da veliki dio studenata, izvan fakultetskih obveza, nije bio u kontaktu s hemodinamskim monitoringom. Specifičnost i kompleksnost rada u jedinici intenzivnog liječenja proizlazi iz posebno ranjive i osjetljive populacije pacijenata koji zahtijevaju maksimalnu skrb, zbog čega medicinske sestre i tehničari trebaju kontinuiranu edukaciju, usavršavanje starih i novih vještina i znanja te upoznavanje s novim metodama monitoringa.

Ključne riječi: hemodinamski monitoring, razina znanja, studenti sestrinstva, sestrinstvo