

# Nurses' knowledge of pressure ulcer management related to monitoring the financial costs of pressure ulcer treatment: a prospective intervention study

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## ABSTRACT

**Background** A good level of knowledge among healthcare professionals in pressure ulcer (PU) management is integral to monitoring the cost-effectiveness of PU responses.

**Aim** The study aimed to assess the level of nurses' knowledge about the management of PUs through a standardised Pressure Ulcer Knowledge Test (PUKT) questionnaire at different stages: before and after targeted education.

**Design** This was a prospective intervention study using the PUKT with pre-test, online education, post-test I, face-to-face education, and post-test II phases.

**Settings** 117 nurses (pre-test), 106 nurses (post-test I after online education), and 145 nurses (post-test II after face-to-face education) from a Czech university hospital's Surgical, Internal, and Anaesthesiology Departments. Full stratified sampling was used.

**Method** Statistical analysis of the data was performed using the Chi-squared test and Fisher's exact test, a nonparametric Kruskal-Wallis test, and Mann-Whitney rank test at the statistical level <0.05 and multiple linear regression. Statistical Package for Social Sciences (SPSS) version 28.0 software was used for calculations.

**Results** The pre-test and post-test I score were consistent (74.2% and 74.1%, respectively). Post-test II, after face-to-face education, improved to 93.3%.

**Conclusion** A sufficient level of knowledge is necessary for the subsequent construction of economic models to generate valid data and implement measures at the national level. Repeated education ensures knowledge retention and quality patient care.

**Implications for practice** Healthcare facilities can enhance care for PU patients by fostering motivation and effective education strategies.

**Keywords** education, knowledge nurse, pressure injury, pressure ulcer, PUs management

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## KEY MESSAGES

- Face-to-face training led to a significant improvement in nurses' knowledge.
- Long-term knowledge retention is essential for quality care and economic analysis.
- The proper classification of PUs remains a challenge for nurses in clinical practice.

## BACKGROUND

Pressure ulcers (PUs) represent a significant global burden on healthcare systems and are a significant complication of treatment in hospitalised patients, especially in intensive care patients.<sup>1-3</sup> Several epidemiological studies conducted

in inpatient care have provided data on prevalence, and, in particular, patients with reduced mobility and altered consciousness are at higher risk of developing PUs.<sup>4,5</sup> PUs impact the patient's health status and quality of life and increase hospital costs. With the reduction of the public sector and the healthcare finances at the national level in the Czech Republic, awareness of the economic impact of PUs is being raised. Health economic studies should be conducted to establish an accurate costing model for PUs, which should include direct and indirect costs incorporating medical and non-medical services.<sup>6-8</sup> The quality of monitoring the cost of PUs care depends not only on the instrument used to collect the data but also and above all, on human resources. This is also related to the reporting of PUs themselves, where there is

an underestimation and underreporting of PUs, especially in the lower PUs categories.<sup>9</sup>

The data record itself should be easy to understand for staff. Still, at the same time, it must provide yield without imposing additional administrative requirements and be compiled by clinical evidence-based guidelines. It is also important that general nurses and especially nurses practicing in wound care can correctly describe all monitored wound parameters and all related aspects of the patient's overall health. However, this requires the healthcare staff's education and professional approach with knowledge of PU prevention and therapy and practical skills in using validated objective scales completed by clinical experience.

A good level of knowledge of healthcare professionals in PU management is integral to implementing new clinical evidence-based practices and monitoring the cost-effectiveness of PU measures and treatments. However, many studies demonstrate that nurses' knowledge verified by standardised questionnaires is insufficient, as confirmed by a systematic review.<sup>10</sup> Also, based on the authors' previous analysis, the inadequate knowledge of nurses in the Czech Republic in PU management was verified.<sup>11</sup>

Studies on increasing the level of nurses' knowledge of PU management confirm that education in the clinical setting is irreplaceable and significantly impacts and improves the level of PU management provided by nurses.<sup>12,13</sup>

## METHODS

### Aim

This study aims to assess the level of nurses' knowledge about the management of PUs through a standardised PUKT questionnaire at different stages, before and after targeted education.

### Study design

This is a prospective intervention study that deals with validating health professionals' knowledge of PU prevention and treatment in the context of verification of datasets for monitoring the cost of PU treatment.

### Pressure Ulcer Knowledge Test (PUKT)

For the implementation of the research, a standardised questionnaire form was used, entitled: Pressure Ulcer Knowledge Test (PUKT).<sup>14</sup> The PUKT was chosen as the most comprehensively evaluated in terms of psychometry, namely content and design validity, homogeneity, mutual reliability, test-retest, and feasibility compared with PZ-PUKT and PUKAT.<sup>15</sup> Necessary modifications were done for extending the collection of information in the field of new classification regarding the PUs and Incontinence Associated Dermatitis (IAD) and socio-cultural conditions at the national level in the Czech Republic (questions no. 47 to 49). In these items, the definition of IAD was added.<sup>16</sup> The final form of the questionnaire contains 54 structured items, of which 49 are knowledge items, and 5 items include respondents' sociodemographic data (gender, age, level of education, type of workplace, length of experience). The cut-off point for the PUKT questionnaire is a 90% successful rate (the best results are achieved when 90% of the items are answered correctly). The questionnaire was translated by two expert interpreters (the wound care nurse experts with high-level

English knowledge). The validity of the translation was verified in a previous study carried out by the authors.<sup>11</sup>

### Sample

The study included nurses from the Surgical Department, Internal Department, and Anaesthesiology Department of the University Hospital involved in the project, which was called: Cost analysis of pressure ulcers treatment—determinants of care. Full stratified sampling was used, and all nurses working in the three clinics were contacted. Completion of the anonymous questionnaire was voluntary. Still, 75% of all nurses working at selected departments during the study's data collection period participated.

### Data collection

To test the knowledge of nurses in individual areas of PU care and to prepare targeted education, the items of the questionnaire were divided into four parts: knowledge of PU risk assessment; general knowledge of PUs and IAD; knowledge of PUs classification; and knowledge related to nursing interventions. Data collection, including education, took place in five phases.

In the first phase, the pre-test was sent electronically to the clinical sites to the head nurses, who then distributed it to the nurses on their work email. The author's team developed annotated educational lectures based on analysing the correct answer scores of the pre-test in the monitored areas. The second phase was educational. The biggest barrier during the educational phase was the COVID-19 pandemic, which did not allow us to provide face-to-face education during that period. The research team on PU issues and wound healing managers from the clinical sites involved in the project prepared an online education package in the form of six annotated lectures and one educational video. In the third phase, using the same PUKT questionnaire, we verified whether the educational activities increased knowledge on the issue of pressure ulcer management. After analysing the first post-test, it was decided that in-person training for nurses in their work environment was necessary. In the fourth phase, face-to-face contact education of all nurses at the participating workplaces (n=145) took place with the help of case studies and explanations of the issue. Nurses had access to online educational materials to supplement the face-to-face education. The fifth phase used the second post-test to verify the effect of the face-to-face educational activities, at this moment the online study materials were not available (see Figure 1).

The study design was adapted to maximise the educational impact on nurses within the limitations imposed by the COVID-19 pandemic, avoiding the potential biases and logistical challenges that a crossover design would have introduced. This approach allowed a progressive, flexible, and practical methodology that ultimately aimed to enhance PU management knowledge and support accurate economic data collection. The study was partially done during the COVID-19 pandemic. As there was a high fluctuation of staff in the departments at that time, there is no possibility to retrospectively identify the number of nurses completing the survey as pre-test and post-test. We have, therefore, been focusing on group analysis, as all nurses (even the new incoming professionals) underwent the education.

## Data analysis

Statistical analysis of the data was performed using the Chi-Square Test, Fisher's Exact Test, the nonparametric Kruskal-Wallis Test, and the Mann-Whitney Rank Test at the statistical level <0.05 and multiple linear regression. Statistical Package for Social Sciences (SPSS) version 28.0 software was used for the calculations.

## RESULTS

A total of 117 nurses in the pre-test, 106 nurses in post-test I, and 145 nurses in post-test II participated in the study. The socio-demographic characteristics of the respondents are shown in Table 1.

In the pre-test, it was assumed that the nurses' knowledge would be insufficient and would not reach a cut-off of 90% in the number of correct responses to the PUKT, which was confirmed by analysis (74.2%). During online education training, we experienced collaborating clinics with high nurse caseloads, which influenced their low motivation in PU management education. Based on these barriers, online

education did not have an effect on increasing nurses' knowledge of the material discussed. In the first post-test nurses achieved 74.1% of the correct answers. However, to monitor the costs of PU treatment, it was necessary to have educated staff in the collaborating clinics with good knowledge of PU classification, including preventive interventions and PU treatment so that the collected data would be valid for further economic analyses. As soon as the epidemiological situation allowed, we proceeded to full-time training. Post-test II, administered after face-to-face education, showed an increase in correct responses to 93.3%.

Table 2 shows the median number of correct responses in each area of interest in the pre-test and post-test I and II. Only in the area of knowledge of PU risk assessment, where nurses showed a good level of knowledge, no statistically significant difference was demonstrated. In the other three parts, knowledge differed significantly, in post-test II, the proportion of correct answers was significantly higher than in the pre-test and post-test I.

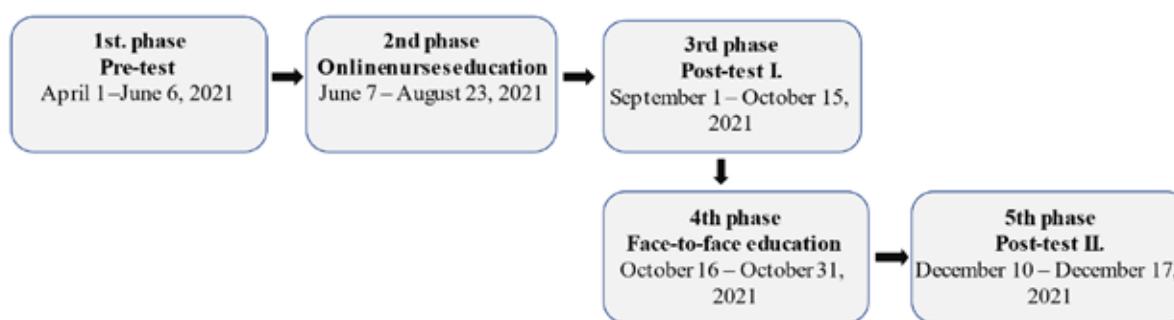


Figure 1. Phases of the knowledge validation and education

Table 1. Demographic characteristics of Czech nurses participating

Variable	Outcome	Pretest	Post-test I	Post-test II
		(n = 117)	(n = 106)	(n = 145)
Gender	Female	112 (95.7%)	102 (96.2%)	137 (94.5%)
	Male	5 (4.3%)	4 (3.8%)	8 (5.5%)
Age	≤ 39 years old	54 (46.2%)	56 (52.8%)	75 (51.7%)
	> 39 years old	63 (53.8%)	50 (47.2%)	70 (48.3%)
Experience (years of professional career)	≤5 years	27 (23.1%)	23 (21.7%)	38 (26.2%)
	6–10 years	10 (8.5%)	14 (13.2%)	16 (11%)
	11–15 years	10 (8.5%)	11 (10.4%)	13 (9%)
	16–20 years	19 (16.2%)	16 (15.1%)	21 (14.5%)
	21–30 years	32 (27.4%)	32 (30.2%)	37 (25.5%)
	≥31 years	19 (16.2%)	10 (9.4%)	20 (13.8%)
Education	Secondary School for Nurses Education—Practical nurse/Healthcare assistant	12 (10.3%)	6 (5.7%)	13 (9%)
	Secondary School for Nurses Education—General Nurse *	43 (36.8%)	39 (36.8%)	52 (35.9%)
	Higher professional education—General Nurse—DiS. (Diploma specialist)	16 (13.7%)	12 (11.3%)	18 (12.4%)
	University education—General Nurse BSc.	30 (25.6%)	33 (31.1%)	43 (29.7%)
	University education—General Nurse MSc.	16 (13.7%)	16 (15.1%)	19 (13.1%)
Workplace	Surgical Department	58 (49.6%)	58 (54.7%)	43 (29.7%)
	Internal Department	35 (29.9%)	14 (13.2%)	59 (40.7%)
	Anesthesiology Department	24 (20.5%)	34 (32.1%)	43 (29.7%)

\*Until 2004, there was an opportunity to graduate as a general nurse at the Secondary School

Figures 2–5 show a pairwise comparison of knowledge in all tests according to individual areas where the average rank of the correct answers of a specific test in the monitored areas is shown. Except for the part focusing on knowledge of PU risk assessment, knowledge in all three areas was increased after face-to-face education. However, it should be emphasised here that in the items focused on PU risk assessment, the nurses had sufficient knowledge in all tests, and the result of post-test II was affected by the higher number of nurses.

Even though the average results of the entire Post Test II showed a 93.3% correct response rate, 11 items did not achieve the required 90% correct response rate. Table 3 shows the problematic items that, although there was a significant increase in correct responses, did not reach the cut-off point.

The item from the Post-test II with the lowest score of correct answers (60%) was "Pressure ulcers cannot be documented in a patient that is not classified by category (so-called unclassifiable); the category must always be stated." The other two items

Table 2. Knowledge score in each phase by battery/questionnaire part

The assessed field in the PUKT	Knowledge median scores			p.
	Pre-test (n = 117)	Post-test I (n = 106)	Post-test II (n = 145)	
Knowledge of PU risk assessment	5.70 ± 0.56	5.70 ± 0.56	5.70 ± 0.50	0.891
General knowledge of PUs and IAD	13.44 ± 1.80	13.51 ± 1.42	15.26 ± 1.05	<0.001
Knowledge of PU classification	3.99 ± 1.03	4.12 ± 1.08	5.36 ± 0.79	<0.001
Knowledge of nursing interventions	13.21 ± 2.42	12.98 ± 1.83	19.50 ± 2.79	<0.001
Total	36.33 ± 4.34	36.27 ± 3.19	45.81 ± 4.15	<0.001

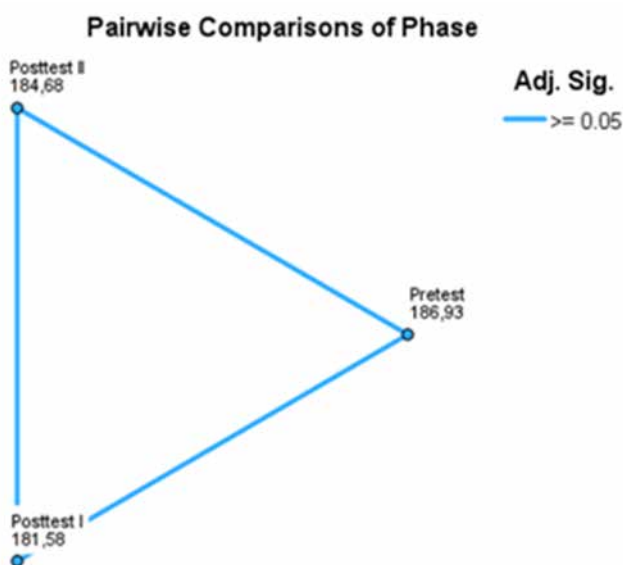


Figure 2. Knowledge of PU risk assessment

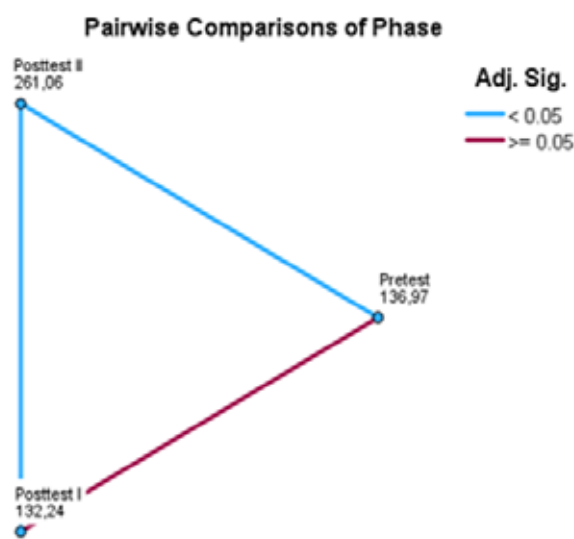


Figure 3. General knowledge of PUs and IAD

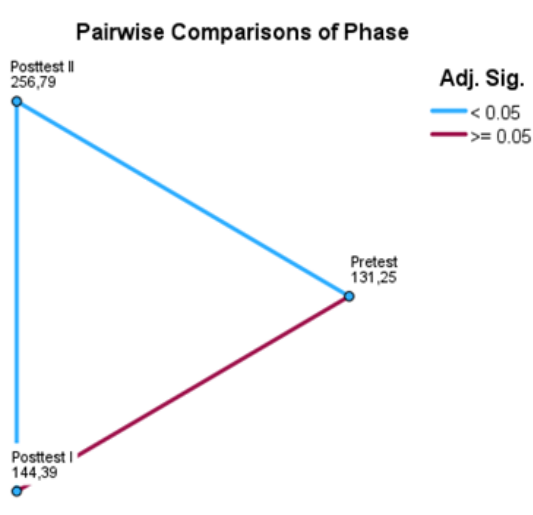


Figure 4. Knowledge of PU classification

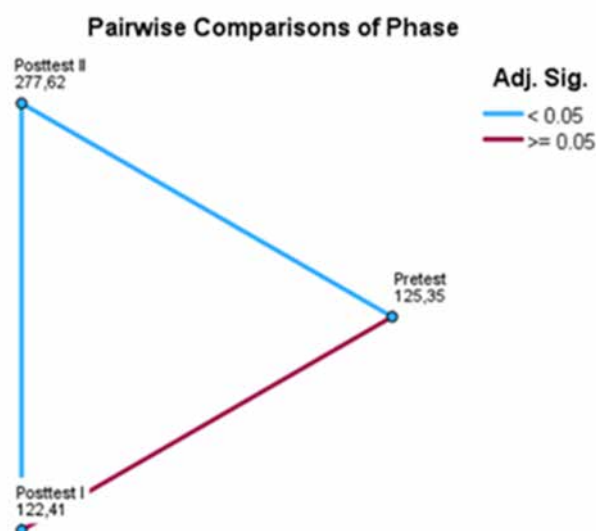


Figure 5. Knowledge of nursing interventions

with insufficient correct response scores were also related to diagnosing and determining the PUs category. The item "A pressure ulcer in stage III is a partial skin loss involving the epidermis" scored 85.5%, and the item dealing with the differential diagnosis "A pressure ulcer and a moist lesion (IAD) differ only in the cause but not in symptoms" scored only 64.8% correct answers.

Other items with insufficient scores of correct answers were related to the field of nursing interventions. Two items, "Bedridden people should be repositioned every 3 hours" and "A person who cannot move should be repositioned while sitting in bed every 2 hours" reached a borderline score (89%) of correct answers. In the item "Immobile persons who are conscious and capable of education and partial mobility should change position every 30 minutes to relieve the pressure of sitting in a chair" 84.8% correct answers were achieved. The item "Heel protectors relieve pressure on the heel" had the largest increase in correct responses over the pretest at 84.8%. The item "Donut or ring pads help prevent pressure ulcers" had 86.9% correct answers. In the item "It is important to massage bony processes if they are red" 83.4% correct answers were achieved and, in the item, "Low humidity can increase susceptibility to pressure ulcers", 86.2% correct answers were achieved.

The analysis of all responses confirmed that the workplace was related to the respondent's level of knowledge of PU prevention and care interventions. Nurses in the Anesthesiology Department demonstrated better knowledge than Surgical and Internal Department nurses ( $p < 0.001$ ). Respondent's education had an effect on the better level of knowledge in only two of the areas studied, namely PU classification ( $p = 0.005$ ) and PU risk assessment ( $p = 0.022$ ), where the level of knowledge was higher among university-educated nurses. Older nurses demonstrated better knowledge than younger nurses, but only in the classification of PUs ( $p = 0.031$ ). The length of work experience and gender do not relate to the level of knowledge of respondents on PU preventative measures, see Table 4.

Table 3. Items with low correct response scores

Item	Pretest n (%)	Post-test I n (%)	Post-test II n (%)	p
It is important to massage the bony prominences if they are reddish. (F*)	37 (31.6%)	16 (15.1%)	121 (83.4%)	<0.001
A pressure ulcer in category III is a partial skin loss involving epidermis. (F)	32 (27.4%)	37 (34.9%)	124 (85.5%)	<0.001
Bedridden people should be repositioned every 3 hours. (F)	36 (30.8%)	33 (31.1%)	129 (89%)	<0.001
Heel protectors relieve pressure on the heel. (F)	7 (6%)	5 (4.7%)	123 (84.8%)	<0.001
Donut-shaped or ring-shaped cushions help with the pressure ulcer prevention. (F)	16 (13.7%)	21 (19.8%)	126 (86.9%)	<0.001
A person who cannot move should be repositioned while sitting in bed every 2 hours. (F)	26 (22.2%)	10 (9.4%)	129 (89%)	<0.001
Immobile persons who are conscious and capable of education and partial mobility should change position every 30 minutes to relieve the pressure of sitting in a chair. (F)	18 (15.4%)	16 (15.1%)	123 (84.8%)	<0.001
Low-humidity environments can increase susceptibility to decubitus ulcers. (F)	61 (52.1%)	54 (50.9%)	125 (86.2%)	<0.001
A blister on the heel does not indicate a serious condition to be feared. (F)	94 (80.3%)	82 (77.4%)	109 (75.2%)	<0.001
Pressure ulcers cannot be documented in a patient that is not classified by category (so-called unclassifiable); the category must always be stated. (F)	38 (32.5%)	43 (40.6%)	87 (60%)	<0.001
A pressure ulcer and a moist lesion (IAD) differ only in cause but not in symptoms. (F)	26 (22.2%)	25 (23.6%)	94 (64.8%)	<0.001

\*F= false (the correct answer is NO), the percentage shows the number of correct answers

## DISCUSSION

Analysis of the pretest I data revealed only 74.2% correct answers, which does not reach the cut-off point of the PUKT questionnaire. The respondent's lack of knowledge of PUs was predicted based on the authors' previous analysis, where nurses' mean score of correct answers was 75.5%.<sup>11</sup> Also, international studies investigating nurses' level of knowledge in PU management showed very similar results for the PUKT questionnaire: The Portuguese study reported an overall mean of 71.2% correct answers ( $n=221$ )<sup>17</sup>; the Cyprus study reported 77% correct answers ( $n=102$ )<sup>18</sup>; the Turkish study reported 70% correct answers ( $n=158$ )<sup>19</sup>; and the Brazil study reported 63.4% correct answers ( $n=40$ ).<sup>20</sup>

Due to the unfavorable epidemiological situation and the inability to conduct face-to-face education directly at the nurses' clinical workplace, online education was chosen as an alternative to increase knowledge. During the online education training, we encountered collaborating clinics with high nurse caseloads during the COVID-19 pandemic, which affected their motivation to engage in PU management education. Considering these challenges, online education did not effectively increase nurses' knowledge of the material discussed, as the post-test I scores were comparable to the pre-test. However, to accurately monitor PU treatment costs, it was essential to have educated staff in the collaborating clinics with a strong understanding of PU classification, preventive interventions and treatment. This ensured the data collected would be valid for further economic analyses. Once the epidemiological situation improved, we resumed in-person training.

Face-to-face education supplemented by online tutorial presentations significantly affected the level of correct answers in post-test II, with the percentage of correct answers (93.5%) reaching the cut-off point set for PUKT. An Iranian intervention study showed that face-to-face education supported by educational videos significantly increased the

level of critical care nurses' knowledge compared to a group without educational activities.<sup>12</sup> Another intervention study in Saudi Arabia demonstrated that education in a clinical setting significantly affects nurses' knowledge level in the management of PUs. The study aimed to determine the effect of a pressure ulcer prevention educational protocol on nurses' knowledge. Before the educational phase, the results of the PUKT questionnaire had an overall mean of 74.04% correct responses, which improved to 96.37% immediately after the educational sessions. In the second post test, two weeks after the educational sessions, the overall mean was 95.28%, and in the third post test, one month after education, the overall mean of correct responses was 95.03%.<sup>13</sup> Our study showed very similar results in the pretest and second post

test. This phased, adaptive structure was necessary to ensure appropriate targeting of training resources and their timely use, especially given the constraints imposed by the pandemic.

Diagnosis and categorisation of PUs still pose challenges to nurses in clinical practice. Still, it is very important to determine not only the correct treatment strategy but also other interventions such as surveillance and determining the cost of treatment. In the area PUs classification, nurses in the lower age group ( $\leq 39$  years old) with a university degree and working in the Anesthesiology Department, had significantly better knowledge than nurses of higher age, working in other departments (Surgical and Medical) and with a lower level of education. Also, the Turkish study showed that the average scores of nurses working in intensive care

Table 4. Demographic characteristics to the level of correct answer scores

Variable	Outcome	PU classification	p.	General knowledge	p.	Nursing interventions	p.	Risk assessment	p.
		(0–6 points)		(0–16 points)		(0–21 points)		(0–6 points)	
Gender	Female	4.57 ± 1.15	0.841	14.17 ± 1.66	0.624	15.59 ± 3.96	0.669	5.69 ± 0.54	0.846
	Male	4.53 ± 1.18		14.18 ± 2.07		16.29 ± 3.93		5.65 ± 0.61	
Age	≤39 years old	4.69 ± 1.17	0.031	14.22 ± 1.74	0.314	15.80 ± 4.08	0.320	5.69 ± 0.52	0.972
	>39 years old	4.45 ± 1.12		14.13 ± 1.61		15.44 ± 3.83		5.68 ± 0.56	
Experience (years of professional career)	0–5 years	4.66 ± 1.08	0.115	14.08 ± 1.88	0.782	15.81 ± 4.11	0.545	5.66 ± 0.54	0.683
	6–10 years	4.93 ± 1.00		14.35 ± 1.58		16.20 ± 3.75		5.78 ± 0.42	
	11–15 years	4.35 ± 1.45		14.35 ± 1.65		15.97 ± 4.14		5.62 ± 0.55	
	16–20 years	4.73 ± 1.10		14.27 ± 1.57		15.23 ± 4.16		5.75 ± 0.51	
	21–30 years	4.45 ± 1.13		14.17 ± 1.66		15.38 ± 3.71		5.65 ± 0.62	
	≥31 years	4.33 ± 1.18		13.96 ± 1.56		15.51 ± 4.11		5.71 ± 0.46	
Education	Secondary School for nurses' education — Practical Nurse/ Healthcare Assistant	4.29 ± 1.19	0.005	13.52 ± 2.31	0.106	15.65 ± 4.49	0.653	5.55 ± 0.51	0.022
	Secondary School for nurses' education — General Nurse	4.32 ± 1.18		13.99 ± 1.67		15.27 ± 4.04		5.72 ± 0.50	
	Higher professional education — General Nurse -DiS. (Diploma specialist)	4.63 ± 1.18		14.28 ± 1.82		15.78 ± 3.81		5.70 ± 0.70	
	University education — BSc.	4.79 ± 1.03		14.41 ± 1.47		15.81 ± 3.97		5.62 ± 0.54	
	University education — MSc.	4.86 ± 1.11		14.47 ± 1.39		15.98 ± 3.58		5.82 ± 0.48	
Workplace	Surgical Department	4.38 ± 1.18	<0.001	13.74 ± 1.58	<0.001	14.61 ± 3.74	<0.001	5.58 ± 0.59	<0.001
	Internal Department	4.47 ± 1.05		14.25 ± 1.94		16.63 ± 4.11		5.83 ± 0.40	
	Anesthesiology Department	4.97 ± 1.12		14.78 ± 1.28		16.13 ± 3.78		5.70 ± 0.56	

regarding the correct response to wound description, staging, and assessment was found to be significantly higher than nurses working in surgical and internal departments.<sup>19</sup> Other studies also confirm the higher knowledge of nurses working in intensive care than in standard wards.<sup>21,22</sup>

The most problematic items with low scores of correct answers were statements related to heel care. Therefore, part of the training activities was focused specifically on the specific prevention of PUs on heels. The item *"Donut-shaped or ring-shaped cushions help with pressure ulcer prevention"* increased the percentage of correct answers from 13.7% in the pre-test to 86.9% in the post-test II. Only 6% of respondents answered the item *"Heel protectors relieve pressure on the heel"* correctly in the pre-test, and 84.8% of respondents answered correctly in the post-test II. This item saw the largest increase in correct answers. Previous studies in the Czech Republic and other foreign studies have confirmed the insufficient level of nurses' knowledge on the issue of heel PUs.<sup>10,23,24</sup> In clinical practice, the local custom of workplaces of using the so-called donut pad as a possible solution to prevent heel PUs persists, but according to professional societies, it is not recommended and should not be used. The elevation of the legs is strongly recommended at the level of evidence B1.<sup>25,26</sup> Change in the established routines of nursing staff is a long-term process that depends on the motivation of nursing staff as well as on the management of healthcare facilities. Nurses need to understand how and why pressure ulceration of the heel can occur, how to assess the risk of pressure ulceration of the heel, and what preventive measures they should implement. Appropriately selected and implemented techniques (for example, floating legs) and aids can reduce the effects of pressure, shear, and friction on patients' heels and prevent the development of PUs, thereby helping to preserve patients' quality of life.<sup>27</sup> We believe that in other typical localisations, caregivers have become quite accustomed to the correct preventive procedures, but we can perceive issues that are underestimated in practice.

Another area of concern, where nurses did not have the required score of correct responses, was related to the frequency of patient position changes in the prevention of pressure ulcers. This may be influenced by both workplace practice<sup>26,28</sup> and nurses' uncertainty about how often to perform patient repositioning in different cases and with varying types of mattresses.

The study demonstrated the insufficient level of nurses' knowledge in specific areas of management of PUs before education. We assumed that targeted online educational tools focused on areas of low knowledge in PU prevention and care would help increase nurses' knowledge. However, it was confirmed that the online tools did not improve nurses' knowledge, primarily due to the afore mentioned barriers. It is essential to focus on selecting appropriate strategies for implementing education and clinical practice changes in challenging situations, such as the COVID-19 pandemic, which was marked by high nurse turnover, extreme workloads, and low motivation among nursing staff. Validating nurses' level of knowledge in the management of PUs is important not only for identifying potential risks in care but also for further interventions such as the right strategy of targeted education to increase professional knowledge and skills and their application in clinical practice. As a result of these changes, a

realistic quantification of the cost of care of PU prevention and treatment is also possible.

### Limitations

This study has several limitations. We did not conduct a cross-sectional study due to the high nurse turnover at the involved clinics, as a consequence of the COVID-19 pandemic. The use of a pre-test, first post test (following online education), and second post test (following F2F education) allowed the research team to monitor progress and the effectiveness of both forms of education in the majority of educated nurses as we needed to reflect nursing fluctuation. This structure provided the flexibility to adapt training delivery as the situation evolved without the potential biases of a crossover design, such as carryover effects, which could distort true knowledge gains.

We consider a high level of nurse's knowledge in the identification, prevention, and treatment of PUs as a basic prerequisite for accurately determining the cost of care for patients with PUs. Therefore, this study was part of a project evaluating PU costs across three departments, in which we assessed nurses' knowledge globally, which influenced the study's results. During the study, there was not only turnover among nurses, leading to varying numbers of nurses in different phases of data collection but also low motivation due to their heavy workload. There is a potential for bias in the results, as participants were not observed while completing the online questionnaire and may have consulted information sources when answering questions. Additionally, the sample size from one healthcare facility cannot be generalised to the entire population. On the other hand, the main benefit of our study is that it relates to the abovementioned project activities and thus we assume nurses were aware of the importance of proper PUs monitoring as part of the economic model development in their hospital.

### CONCLUSION

The study investigated the knowledge level of nurses related to PU management before and after online and face-to-face education. Before the educational activities, a questionnaire survey was conducted, verifying nurses' insufficient knowledge in the PU management field, while only 74.2% of respondents answered correctly. Online education did not increase the nurse's knowledge of the given issue, and the results of the post test I (74.1%) were at the same level as in the pre-test. After a targeted face-to-face training phase, correct results increased in post-test II to 93.3%.

It is clear from studies that have focused on increasing the level of knowledge in PU management that a change in the established routine nursing practice and maintaining the required level of knowledge in this area is a long-term process that depends on the motivation of nursing staff and also on the management of health care facilities. A sufficient level of knowledge is necessary for the subsequent construction of economic models to generate valid data and implement measures at the national level. Repeated education is necessary to maintain a sufficient level of PU knowledge in nurses, including about new findings in this field. Adequate knowledge of general nurses in the field of PU prevention and treatment is a prerequisite for ensuring quality and safe care, given that PUs are highly preventable adverse events. When general nurses are aware of the importance of their actions

in preventing potential patient harm, risks for patients are reduced. This influences the cost of care, and reduces the often long-term and serious consequences for patients.

## IMPLICATIONS FOR CLINICAL PRACTICE

Nurses' competence in PU management depends on knowledge acquisition, which influences attitudes towards skill performance. When it comes to the prevention and management of PUs as a whole, a nurse's knowledge consists of empirical and factual knowledge, ethical and moral attitudes, and reflection on each patients' needs. Nurses' motivation is an important part of education in the management of PUs and depends on the interest and attitude of the healthcare organisation. Local management in a healthcare facility can substantially impact the quality of care provided to patients at risk of, or with, PUs by implementing appropriate strategies for nurse education and fostering motivation. Thereby supporting a proactive and effective approach to PU management.

## FURTHER RESEARCH

Based on the results and analysis of this paper, we suggest that future research with significant implications would be a content analysis of approaches of healthcare facilities in educating nursing staff in the management of PUs. Although there are a number of international studies on nurses' knowledge of PU management, it is not always possible to use their results or apply the proposed interventions in an international context. Given that there may be differences in sociocultural context, we believe that there is a need to conduct similar studies in European countries, as well as in the Czech Republic.

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## CONFLICT OF INTEREST

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

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## AUTHOR CONTRIBUTIONS

Conception and design (SS, AP); data analysis and interpretation (SS, AP, PB, LK, AR); manuscript draft (SS, PB), critical revision of the manuscript (LK, AP), final approval of the manuscript (SS, AP). All the authors have read and approved the final version of the manuscript.

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