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The Occurrence of Occupational Health Risk and Associated Factors Among Thai Nursing Students: A Cross-Sectional Study

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Abstract **:** Nursing students are exposed to health hazards during their clinical practice. This analytic cross-sectional study assessed such risks and the examined related factors in 219 nursing students. Participants were selected through cluster random sampling, and data were gathered via self-administered questionnaires that covered socio-demographic characteristics, occupational health literacy, support from teachers and healthcare personnel, clinical practice safety behaviors, and occupational health risks. Descriptive statistics and binary logistic regression analysis were used to analyze the data. Results indicated that psychosocial hazards were the most common risk (37.4%), followed by biological hazards (26.15%) and ergonomic factors (12.8%). Female gender (AOR = 4.15, 95% CI = 1.28−13.47), low clinical safety behaviors (AOR = 1.80, 95% CI = 1.03−3.14), and low occupational health literacy (AOR = 2.54, 95% CI = 1.13−5.74) were significantly associated with higher risks. This study highlights the need for targeted interventions to improve safety behaviors and occupational health literacy, emphasizing enhancements in training programs, support systems, personal protective equipment (PPE) adequacy, and ergonomic practices.

Keywords **:** occupational health risk, nursing students, safety behaviors, occupational health literacy.

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Introduction

Nursing students are required to engage in a variety of nursing activities during their clinical training, which inherently carry the risk of infection from patients. Studies have reported varying rates of needlestick injuries in student nurses, ranging from 18.2 to 88.6% [1−3]. The prevalence of blood and secretion exposures was found to be 8.3% [2], with a notably high rate of underreporting of such injuries and exposures [4]. In addition to risks of infection, nursing students may also be exposed to various other occupational hazards, including chemical, physical, ergonomic, and psychosocial health threats, akin to the risks

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faced by practicing nurses [5].

Despite being supervised by instructors during clinical practice, the complexity of nursing services often makes it challenging for instructors to provide immediate attention. Students may also encounter verbal, non-verbal, or physical aggression from healthcare personnel, nursing teachers, patients, and the families of patients [6]. Nursing students' lack of clinical knowledge and experience, coupled with limited exposure to clinical settings, exacerbates these risks. Previous studies have indicated that approximately 95.7% of students have low levels of awareness regarding occupational health and safety [7], and 37.7% have poor knowledge of occupational hazards [8]. This knowledge gap often results in unsafe nursing behaviors and a low level of needle-stick safety practices, with between 58.4% and 96% of students not wearing gloves during body fluid exposure risk, and between 44% and 92.8% failing to wear protective glasses during such exposures. Additionally, a significant proportion of students, ranging from 36.1% to 57.6%, recap needles after use [9], they often exhibit unsafe nursing behaviors as well as a low level of needle-stick safety practices [1, 2], between 58.4% and 96% do not wearing gloves during body fluid exposure risk, and between 44% and 92.8% fail to wear protective glasses during such exposures. Moreover, a significant proportion of students, ranging from 36.1% to 57.6%, recap needles after use.

An analysis of empirical evidence indicates that the majority of them possess only a moderate level of health knowledge. Their clinical safety practices are at an even lower level, and there is no significant correlation between their health knowledge and their practices [10]. Exposure to occupational health threats during clinical training arises from the interaction between various components of the work system, including rules, protocols, medical equipment, social support, interpersonal relationships, and individual characteristics. A review of the literature identifies several factors associated with occupational health risks in nursing students, including age, educational level [4, 11], sex, previous injury experience [12], and knowledge of and adherence to safe work practices [1, 11].

The SHELL model, which highlights the interactions between "Software, Hardware, Environment, Liveware (individual), and Liveware (interaction with others)," serves as a comprehensive framework for addressing occupational exposures in nursing students [13, 14]. This study focuses on the Liveware (individual) component, examining personal characteristics; the Hardware component, exploring the availability and adequacy of personal protective equipment (PPE); the Software component, assessing safety behaviors in nursing practices guided by infection control and safety protocols as well as seeking safety-related information and occupational health literacy; the Environment component, evaluating occupational exposure risks; and the Liveware (interaction with others) component, analyzing support systems from peers, teachers, and healthcare personnel. By utilizing this model, the study identifies and addresses key factors contributing to risks associated with exposure to blood and body fluids during clinical practice, providing a basis for targeted interventions to enhance safety and well-being in nursing students.

Previous studies have primarily been descriptive, focusing on the perception of occupational health hazards in nursing students, with limited research examining the factors associated with the actual occurrence of such risks. A deeper understanding of these exposures would enable nursing students to manage occupational health risks more effectively during practical training, thereby enhancing workplace safety and reducing the likelihood of injury or illness.

The data on exposure to health threats obtained from this study can be used to develop more targeted and effective preventive measures and enhanced support systems to mitigate these risks, ensuring the safety and well-being of nursing students. This study aims to investigate the occupational health risks in nursing students and examine the influencing factors.

Methods and materials

1. The Study Design, Setting, and Period

The present study, with an analytic cross-sectional design, was conducted at a university in the eastern region of Thailand from July to September 2023.

2. Study population and sample

The population was composed of all the nursing stu-

dents (n=338) in the 3rd and 4th year in the faculty of nursing.

2.1 Sample size determination

The sample size was calculated by the formula $Z^2pq/d2$ (p = 88.4%, q = 11.6%) for estimating a single population proportion using the prevalence of exposure to occupational hazard in nursing students as 88.4% [8]. The margin of error was 5%, and the sample size for the study was 199. By adding 10% of non-response rate, the final total number of nursing students was 219.

The inclusion criteria was nursing students in the third- and fourth- years who have been in clinical practice and agreed to participate in the study.

2.2 Sampling Method and Sampling Procedure

Cluster random sampling was employed to select the sample groups, categorized by the academic year of the nursing students. Each academic year consisted of three groups. In the third academic year, each group included 58 to 60 students, while in the fourth academic year, each group included 56 to 58 students. The random selection process involved choosing two groups from the third academic year and two groups from the fourth academic year. All students in the selected groups were included as participants for ethical reasons. As a result, 116 third-year students and 114 fourth-year students were included, totaling 230 students. However, only 222 students returned completed questionnaires, accounting for a response rate of 96.5%. Among these, three questionnaires were incomplete, leaving a total of 219 valid questionnaires for data analysis.

3. Data Collection Tool and Technique

Data were gathered using a structured, self-administered questionnaire adapted from existing literature. The questionnaire was divided into five sections:

1) Socio-demographic Characteristics: This section includes variables such as age, academic year, history of vaccination, health checkups as chest x-rays, experience of needle-stick injuries or sharp object cuts, and incidents of blood/body fluid exposure in the past year.

2) Occupational Health Risks: This section evaluates nursing students' perceptions of occupational hazards encountered during clinical practice, encompassing physical, chemical, biological, ergonomic, and psychosocial risks. It also examines the availability and adequacy of PPE and identifies symptoms or conditions that students attribute to their clinical training experiences. The section comprises 15 items, formatted as "Yes" or "No" responses.

3) Seeking Safety Practice Information: This section consists of six questions evaluating the search for information on disease and injury prevention during clinical practice. It includes various sources such as online platforms, textbooks, television/radio, inquiries from teachers and/or healthcare personnel, and discussions with peers. Responses are measured on a 4-point Likert scale, ranging from "never done" (1) to "always done" (4). The mean score for all questions is calculated, with higher scores indicating more frequent safety information-seeking behaviors.

4) Support from Teachers and Healthcare Personnel: This section consists of six questions that assess the support provided by teachers or healthcare personnel during clinical training. It covers areas such as provision of knowledge and information regarding safety behaviors in clinical practice, reminders to follow safety protocols, assistance in obtaining necessary immunizations, and provision of personal protective equipment. Responses are measured on a 4-point Likert scale, ranging from "did not receive support" (1) to "received the highest level of support" (4). The mean score was calculated, with higher scores indicating greater levels of support from healthcare personnel, reflecting significant assistance in disease and injury prevention during clinical training.

5) Occupational Health Literacy: This section covers three dimensions: basic health knowledge, health-related communication and interaction skills, and health reasoning. It includes 17 questions rated on a 4-point scale, ranging from "no knowledge" (1) to "high level of knowledge" (4). A higher mean score indicates a greater level of occupational health literacy, signifying a strong capacity to make informed decisions, promote and maintain personal health, and analyze health-related information effectively.

6) Clinical Safety Behaviors: This section encompasses various aspects of nursing practice, such as adherence to standards, infection prevention, hand hygiene, correct use of personal protective equipment, and maintaining a safe working environment. It contains 33 questions assessed on a 4-point Likert scale, ranging from "never practiced" (1) to "practiced regularly" (4).

A higher mean score reflects a higher commitment to safe practice behaviors during clinical training, demonstrating substantial engagement in maintaining a safe healthcare environment.

3.1 Quality of instruments

The validity and reliability of the questionnaire were established through the opinions of experts in the field of occupational health nursing. The content validity index was 0.85. Reliability was evaluated using Cronbach's alpha, with coefficients for sections 2−6 being 0.80, 0.85, 0.84, 0.90, and 0.76, respectively.

4. Ethical consideration

The study was approved by the Institutional Ethics Committee (IRB1-068/2566 date 26 June 2023). A consent form was also provided in the survey, and participants were asked to provide consent before participating in the survey. The survey questionnaire refrained from obtaining any personal and confidential information of the participants.

5. Data Analysis

The questionnaires retrieved from the student nurses were screened for completeness, coded and analyzed using IBM SPSS Statistics Version 27 Statistical Software (IBM Corp., Armonk, NY, USA). A descriptive statistics analysis was done to explore the distribution of all the variables. A binary logistic regression analysis was done to test the association between the demographic characteristics, health personal support, clinical safety practice information seeking, occupational literacy, safety behaviors and occupational health risks. Multiple logistic regression analysis was done to determine the effect of occupational literacy and clinical safety behaviors on the occupational health risks of nursing students, while other variables were controlled. The level of significance was set at $P < 0.05$ at a confidence interval of 95%.

Results

General Characteristics of the Samples

The sample consisted of 91.8% females, with an average age of 20.91 years (SD = 0.73), ranging from 19 to 23 years. Approximately half of the participants were in their third (49.8%) or fourth year (50.2%) of study (Table 1). In the past year, 20.5% of students had reported experiencing needle-stick injuries or cuts from sharp objects, with the most common incidents occurring during the preparation of medical tools (0.9%) and medication (6.8%). Additionally, 6.4% reported exposure to blood or body fluids, primarily through eye contact (2.3%), skin contact (1.4%), and other means (2.7%), with suctioning sputum (2.7%) and handling used medical instruments (1.8%) being the main activities associated with exposure, as detailed in Table 2.

Table 1. General characteristics of the nursing students (n = 219)

Characteristics	Number (person)	%
Gender		
Male	18	8.2
Female	201	91.8
Age		
19−20 years	65	29.7
21−23 years	154	70.3
mean 20.91 years (S.D. 0.73) min 19, max 23		
Year of study		
Third-year	109	49.8
Fourth-year	110	50.2

Seeking safety practice information, occupational health literacy, and clinical practice safety behavior

The average score for seeking safety practice information was moderate, with a mean of 2.61 (SD = 0.56). The most frequently utilized source was the internet, with a mean score of 3.26 (SD = 0.831). Support from healthcare personnel and nursing lecturers was also at a moderate level, with a mean score of 2.87 (SD = 0.56). The highest level of support was received through reminders during training, followed by advice or counseling on disease and injury prevention (mean = 3.60, SD = 0.59; mean 3.51, SD = 0.60, respectively). However, support for PPE, particularly safety goggles, face shields, and hair caps, was notably lower (mean = 1.65, SD = 1.0; mean = 2.11, SD = 1.16; mean = 2.39, SD = 1.12, respectively).

Occupational health literacy was at a moderate level (mean = 3.34, SD = 0.38). Students had an understanding of their own risks in nursing practice and methods to mitigate these risks (mean = 3.68, SD = 0.49). They were confident about selecting reliable sources for information on disease and injury preven-

Table 2. Experience of Needle-stick Injuries or sharp object cuts and exposure to blood/body fluid within past year (n = 219)

Experiences	Number (person)	%
Needle-stick Injuries or sharp object cuts		
No	174	79.5
Yes	45	20.5
Activities leading to injury		
Needle re-capping	3	1.4
Passing sharp instruments to others	2	0.9
Blood draws/IV catheter insertion	22	10.0
Preparation of medical tools/equipment	2	0.9
Handling/cleaning used medical equipment	4	1.8
Preparation/mixing of medications	5	6.8
Exposure to blood/body fluids		
No	205	93.6
Yes	14	6.4
Routes of exposure		
Eye exposure	5	2.3
Skin contact (ulcer)	3	1.4
Other (mouth, nose, skin no ulcer)	6	2.7
Activities Leading to Blood Exposure		
Assisting in childbirth	2	0.9
Suctioning sputum	6	2.7
Wound care	1	0.5
Handling blood-stained linens/body fluids	3	1.4
Handling used medical instruments	4	1.8
Cleaning instruments	1	0.5
Other	4	1.8

tion (mean = 3.51, SD = 0.58; mean = 3.51, SD = 0.57, respectively).

Clinical practice safety behaviors were similarly at a moderate level (mean 3.48, SD = 0.29). Consistently high-rated behaviors included explaining information to patients and seeking their cooperation before providing care (mean = 3.74, SD = 0.51; mean = 3.63, SD = 0.62, respectively). While most behaviors for preventing sharp injuries were rated highly, the behavior of not using hands to assist in needle threading during suture removal required improvement (mean = 2.89, SD = 1.23). Infection prevention behaviors needing enhancement included the use of PPE during suctioning of patients, specifically wearing goggles and hair caps (mean = 2.89, SD =1.23; mean = 1.98, SD = 1.11, respectively). Additionally, the use of aprons during nursing procedures involving potential exposure to blood or bodily fluids was infrequent (mean = 2.77, SD = 1.18). Despite all students wearing masks consistently during training, the average score for not touching the outside of the mask was 2.23 (SD = 1.26). Ergonomic behaviors that required improvement included stretching muscles and performing eye exercises during lunch breaks or when experiencing fatigue (mean = 1.91, SD = 1.23).

Occupational health risk

The most prevalent occupational health risk encountered by nursing students was psychosocial hazards, with 37.4% of students reporting experiences of being spoken down to by teachers, healthcare staff, patients, or relatives of patients in the patient ward. Biological hazards followed, particularly needle-stick and sharp injuries, representing 22.55% of reported cases. Among these, 13.3% (6 individuals) involved needles that had come into contact with patients, including two students who recapped needles, one student involved in blood sampling/injection, and three students responsible for cleaning medical equipment.

A significant proportion of needle-stick injuries, 48.89% (22 students), occurred due to equipment that had not yet come into contact with patients, primarily during equipment preparation or medical device handling. The second most common risk was related to medication preparation, involving 28.89% (13 students). Additionally, 3.65% (8 students) experienced exposure to blood or secretions from patients splashing into their eyes or onto injured skin.

Ergonomics-related hazards, such as lifting or moving heavy patients single-handedly, accounted for 12.8% of the risks. Physical hazards due to dim lighting constituted 9.6%, while chemical hazards from exposure to chemicals were reported by 6.8% of the students. Additionally, 10% of the students reported latex glove allergies. Overall, 51.4% of the students faced some level of occupational health risk, as detailed in Table 3.

This comprehensive analysis underscores the multifaceted nature of occupational health risks encountered by nursing students, highlighting the need for targeted interventions and enhanced support systems to ensure their safety and well-being during clinical

training.

Table 3. Number and percentage of the nursing students exposed to occupational health risks categorized by risk type (n = 219)

occupational health risks	Number (person)	%
Physical hazards		
Dim light	21	9.6
Chemical hazards		
Chemical expose	15	6.8
Allergic to latex gloves	22	10.0
Allergic to alcohol-based solution	4	1.8
Biological hazards		
Needle-stick, sharp injuries	45	22.5
Blood and blood and secretion exposures	8	3.65
Ergonomics		
Lifting/moving heavy patients single-handedly	28	12.8
Psychosocial hazards		
Mentally harmed by derogatory remarks made by nursing teachers, healthcare staff, patients, or relatives	82	37.4
Total of those who have encountered at least one risk factor	110	51.4

Comparison of Occupational Health Risk Exposure Between Fourth- and Third-Year Nursing Students

A comparative analysis of occupational health risk exposure between fourth- and third-year nursing students revealed that fourth-year students face significantly higher risks in several areas. Specifically, fourth-year students reported insufficient PPE more frequently when providing care, with an odds ratio (OR) of 2.350 (95% CI: 1.18−4.67). They also experienced higher rates of physical or psychological abuse, such as being demeaned by instructors (OR = 5.14, 95% CI: 1.68−15.72) and by nurses (OR = 2.76, 95% CI: 1.32−5.77), compared to third-year students, as shown in Table 4. This analysis underscores the heightened occupational health risks faced by fourth-year nursing students compared to third-year students, highlighting the need for enhanced protective measures and supportive environments, especially for those in their final year of training. Addressing issues such as insufficient PPE and incidents of abuse can significantly improve the safety and well-being of nursing students during their clinical education.

Factors associated with occupational health risk

In the sample group, 110 individuals (51.4%) were identified as having at least one occupational health risk factor. Univariate analysis revealed several factors associated with occupational health risks. These included gender, with females at higher risk compared to males (OR = 3.38, 95% CI = 1.17−11.56, $P = 0.03$), safety behaviors during training (compared to those exhibiting very good behaviors, OR = 2.09, 95% CI = 1.19−3.69, $P = 0.04$), occupational health knowledge (compared to those with good knowledge, OR = 2.79, 95% CI = 1.26−6.19, $P = 0.02$), and information-seeking behavior regarding disease and injury prevention (compared to those with high knowledge, OR = 2.09, 95% CI = 1.19−3.69, $P = 0.01$).

Multivariate analysis using the forward conditional method, controlling for other factors, further identified significant associations. Safety behaviors during professional practice were significantly associated with occupational health risks (compared to those with very good behavior, with an adjusted odds ratio (AOR) = 1.80, 95% CI = 1.03−3.14, $P = 0.04$). Occupational health literacy was also a significant factor (compared to those with good health literacy, AOR = 2.54, 95% CI = 1.13−5.74, $P = 0.02$), as shown in Table 5.

Discussion

This study identified that the most prevalent occupational health risks among nursing students were psychosocial hazards (37.4%), followed by biological hazards (22.5%) and ergonomic hazards (12.8%). Psychosocial risks were notably significant, aligning with the Liveware-Liveware interaction in the SHELL model [13], which underscores the importance of human interactions within clinical settings and their impact on student well-being. Fourth-year nursing students face various challenges that require them to adapt to new roles and responsibilities, such as demonstrating greater autonomy in patient care, making clinical decisions under supervision, mentoring junior students, and collaborating effectively with the healthcare team. They must also manage increased workloads, adhere to safety protocols, and exhibit professionalism and compassion in their approach to patient care. Despite prior clinical training, these students

Table 4. Comparative analysis of occupational health risks between third- and fourth-year nursing students (n = 219)

Occupational health risk	Risk level	3rd yr. Students (n=109) n (%)	4th yr. Students (n=110) n (%)	OR (95%CI)	95% Confidence Interval (CI)
Exposure to secretions	Ever	7 (6.4%)	8 (7.3%)	1.14	(0.40−3.27)
	Never	102 (93.6%)	102 (92.7%)		
Chemical exposure	Ever	7 (6.4%)	8 (7.3%)	1.14	(0.40−3.27)
	Never	102 (93.6%)	102 (92.7%)		
Lifting/moving heavy patients single-handedly	Ever	12 (11.0%)	16 (14.5%)	1.38	(0.62−3.06)
	Never	97 (89.0%)	94 (85.5%)		
Slips and falls	Ever	1 (0.9%)	7 (6.4%)	7.34	(0.89−60.70)
	Never	108 (99.1%)	103 (93.6%)		
Insufficient PPE	Ever	15 (13.8%)	30 (27.3%)	2.350	(1.18−4.67)**
	Never	94 (86.2%)	80 (72.7%)		
Inadequate lighting	Ever	10 (9.2%)	11 (10.0%)	1.10	(0.45−2.71)
	Never	99 (90.8%)	99 (90.0%)		
Physical or Psychological abuse from instructors	Ever	4 (3.7%)	18 (16.4%)	5.14	(1.68−15.72)**
	Never	105 (96.3%)	92 (83.6%)		
Physical or Psychological abuse from nurses	Ever	12 (11.0%)	28 (25.5%)	2.76	(1.32−5.77)**
	Never	97 (89.0%)	82 (74.5%)		
Physical or Psychological abuse from patients or relatives	Ever	4 (3.7%)	8 (7.3%)	2.06	(0.60−7.05)
	Never	105 (96.3%)	102 (92.7%)		

**: $P< 0.5$

Table 5. Factors related to the occurrence of occupational health risks during nursing students' professional practice (n = 219)

Factors	Number	Risk		univariate analysis		multivariate analysis	
		yes n (%)	no n (%)	OR (95%)	*P*-value	AOR (95%)	*P*-value
Gender							
female	201	103 (51.2)	98 (48.8)	3.68	.03*	4.15	.018**
male	18	4 (22.2)	14 (77.8)	(1.17−11.56)		(1.28−13.47)	
Academic year level							
3rd	109	60 (55.0)	49 (45.0)	1.649.	.09		
4th	110	47 (42.7)	63 (57.3)	(0.96−2.80)			
Clinical safety behaviors							
Moderate to good	113	63 (55.8)	50 (44.2)	2.09	.04*	1.80	.04**
Very good	106	44 (41.5)	62 (58.5)	(1.19−3.69)		(1.03−3.14)	
Occupational health literacy							
low	33	23 (69.7)	10 (30.3)	2.79	.016*	2.54	.02**
high	186	84 (45.2)	102 (54.8)	(1.26−6.19)		(1.13−5.74)	
Support from teacher and health care personal							
low	117	56 (47.9)	61 (52.1)	1.32	.37		
high	102	46 (45.1)	56 (54.9)	(0.78−2.56)			
Seeking safety practice information							
low	141	78 (55.3)	63 (44.7)	2.09	.01*		
high	78	29 (37.2)	49 (62.8)	(1.19−3.69)			

*, **: $P< 0.5$

encounter the added complexity of new specialty areas, necessitating adaptation and multifaceted role execution, including being learners, knowledge providers, and trusted caregivers. This dynamic can lead to negative feedback from instructors, healthcare staff, and patients or their relatives, consistent with previous findings that psychosocial factors are a predominant hazard in nursing students [8, 11, 12].

Biological hazards primarily stem from needle-stick injuries and sharp injuries, which pose risks of pathogen transmission due to inadequate technical preparation or distractions during clinical practice. These injuries often occur during activities such as handling and preparing medical instruments and administering injections. The study's results align with the existing literature, which highlights the significant risks associated with needle-stick injuries and sharp object handling in clinical settings [1, 2, 15]. Ergonomic hazards, including the manual handling of heavy patients without proper assessment or adjustment to the bed height, were also significant. These issues reflect broader findings that frequent student incidents involve manual handling activities and workplace violence [6, 16].

Occupational health literacy among the students was moderate. While students received orientation on self-protection from diseases and accidents and had good support from healthcare personnel, their practical safety behaviors were suboptimal. Despite students' efforts to seek information on disease and injury prevention, their clinical safety behaviors were inconsistent with the recommended practices. This discrepancy indicates that while students possess theoretical knowledge, practical application remains a challenge. For instance, students often fail to evaluate their physical capabilities before patient handling, do not properly adjust bed heights, and sometimes neglect to use appropriate PPE during procedures. These practices align with previous studies that noted moderate adherence to standard precautions and safety behaviors [9, 17], though they contrast with other findings suggesting generally good safety behaviors in nursing students [2, 15].

This study identified significant factors associated with occupational health risks in nursing students, with 51.4% of the sample group experiencing at least one occupational health risk. Univariate analysis revealed that gender, safety behaviors during training, occupational health knowledge, and information-seeking behavior regarding disease and injury prevention were key factors. Multivariate analysis further confirmed that safety behaviors during professional practice (AOR = 1.80, 95% CI = 1.03−3.14, $P = 0.04$) and occupational health literacy (AOR = 2.54, 95% CI = 1.13−5.74, $P = 0.02$) remained significant, even when controlling for other factors. These findings underscore the urgent need for targeted interventions to enhance safety behaviors and occupational health literacy in nursing students.

The SHELL model offers a comprehensive framework to understand these findings by conceptualizing the interaction between Software, Hardware, Environment, Liveware (individual), and Liveware (interaction with others). The software component, which includes protocols and training programs, was highlighted by the significant impact of inadequate safety behaviors during training. This indicates a pressing need for improved training programs that emphasize practical safety skills and strict adherence to protocols. Evidence from previous research supports the critical role of robust training programs in reducing occupational hazards [11].

The Hardware component focuses on the physical equipment and tools used in clinical settings, such as PPE. The inadequacy of PPE was a notable risk factor, suggesting that ensuring sufficient and appropriate PPE is crucial for mitigating risks. Studies have shown that the proper use of PPE significantly reduces exposure to biological hazards [8]. The Environment component encompasses the physical clinical environment, including lighting and ergonomics, which are critical in mitigating occupational health risks. Poor lighting and ergonomic challenges, such as lifting heavy patients, were significant risk factors in this study. Enhancing the physical environment of clinical settings to meet ergonomic standards can reduce these risks [5].

The Liveware-Liveware components represent the individual nursing students and their interactions with others, such as instructors, healthcare personnel, and patients. The significant association between occupational health literacy and risk highlights the importance of enhancing individual knowledge and skills. Effective educational interventions are essential for improv-

ing health literacy and promoting safe practices [10]. Gender as a significant risk factor, with females being more at risk, could reflect broader social and interpersonal dynamics within clinical settings. Ensuring supportive and respectful interactions can reduce psychosocial hazards [6].

This study highlights significant occupational hazards faced by nursing students, analyzed through the framework of the SHELL model. Psychosocial risks, the most prevalent, align with the Liveware-Liveware component, highlighting challenges in interpersonal dynamics among students, instructors, healthcare personnel, and patients. Biological risks, such as needlestick and sharp injuries, are closely tied to the Hardware component, emphasizing the need for appropriate and sufficient PPE and tools. Ergonomic risks, primarily related to manual handling tasks, reflect both Environmental factors, such as workspace design, and Liveware (individual) factors, including students' physical preparedness and adherence to safety behaviors.

While students demonstrated moderate occupational health literacy, representing the Software component, gaps in adherence to safety protocols and infection control practices suggest the need for enhanced training and practical reinforcement. These findings underscore the importance of addressing all SHELL model components to provide a comprehensive strategy for minimizing risks and enhancing safety during clinical practice.

Addressing these hazards requires targeted interventions across the SHELL model components. For the Software component, safety training programs should be strengthened to focus on practical applications of infection control and occupational health protocols, and should include workshops and simulations to reinforce safety practices. The Hardware component necessitates ensuring the consistent availability and adequacy of PPE and ergonomic tools that reduce physical strain during manual tasks. The Environment must enhance clinical settings by addressing ergonomic challenges, improving lighting, and streamlining workflows to reduce exposure to occupational hazards.

The Liveware (Individual) component should promote occupational health literacy and encourage self-assessment of risks through tailored educational initiatives that support safe practices. The Liveware (Interactions) component should foster supportive interpersonal relationships by implementing mentorship programs and collaborative frameworks between nursing students, teachers, and healthcare personnel, reducing psychosocial risks and creating a safer clinical environment. By integrating these recommendations into nursing education and clinical practice, institutions can address the multifaceted occupational hazards nursing students face, ensuring their safety and well-being while enhancing the overall quality of clinical training.

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Conflicts of Interest

All contributing authors have no financial conflicts of interest to disclose.

Data Availability Statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

1. Al Qadire M, Ballad CAC, Al Omari O, Aldiabat KM, Shindi YA & Khalaf A (2021): Prevalence, student nurses' knowledge and practices of needle stick injuries during clinical training: a cross-sectional survey. BMC Nursing 20 (1): 187
2. Krugkraipetch, N (2019). Factors affecting safety behavior in nursing practice among nursing students in The Eastern Region. J Prapokklao Hosp Clin Med Educat Center, 36 (3):193−201 (in Thai)
3. Xu X, Yin Y, Wang H & Wang F (2022): Prevalence of needle-stick injury among nursing students: A systematic review and meta-analysis. Frontiers in Public Health 10: 937887
4. Kaya A & Gok Ugur H (2019): The knowledge and experience of nursing students about occupational health and safety. Middle Black Sea Journal of Health Sci-

ence 5 (3): 212−220
5. Boucaut R & Cusack L (2016): 'Sometimes your safety goes a bit by the wayside' ... exploring occupational health and safety (OHS) with student nurses. Nurse Education in Practice 20: 93−98
6. Mohamed Nabil N, Sorour A & Ahmed F (2018): Occupational health hazards among faculty of nursing students in Zagazig University, Zagazig Nursing Journal 14 (1), 133−145
7. Eyi S & Eyi İ (2020): Nursing students' occupational health and safety problems in surgical clinical practice. Sage Open 10 (1): 2158244020901801
8. Amare TG, Tesfaye TT, Girmay B & Gebreagziabher TT (2021): Exposure to occupational health hazards among nursing and midwifery students during clinical practice. Risk Manag Healthc Policy 14: 2211−2220
9. Bouget Mohammedi S & Landelle C (2023): Review of literature: Knowledge and practice of standard precautions by nursing student and teaching techniques used in training. Am J Infect Control 51 (5): 574−581
10. Munangatire T, Tomas N & Mareka V (2022): Nursing students' understanding of health literacy and health practices: a cross-sectional study at a university in Namibia. BMC Nursing 21 (1): 8
11. Huang H, Yi Q, Tang S & An R (2016): Occupational exposure among Chinese nursing students: Current status, risking factors and preventive interventions 9: 16578−16586
12. Türen S, Ateş S, Bülbül E, Yeni T, Yildiz Ayvaz M & Atakoğlu R (2022): Occupational risk perception of nursing students, affecting factors and their association with occupational accidents: A crosssectional, multicenter studyHemşirelik öğrencilerinin mesleki risk algısı, etkileyen faktörler ve mesleki kazalar ile ilişkisi: Kesitsel, çok merkezli bir çalışma. Journal of Contemporary Medicine 12: 923−929
13. Hawkins FH (1993): Human Factors in Flight. Ashgate, Hampshire 384pp
14. Wiegmann DA & Shappell SA (2003): A human error approach to aviation accident analysis : the human factors analysis and classification system. Ashgate, Aldershot 165pp
15. Qaraman AFA, Elbayoumi M, Kakemam E & Albelbeisi AH (2022): Knowledge, attitudes, and practice towards occupational health and safety among nursing students in Gaza Strip, Palestine. Ethiop J Health Sci 32 (5): 1007−1018
16. Boucaut R & Knobben L (2020): Occupational health and safety incidents at a university school of nursing: A retrospective, descriptive appraisal. Nurse Education in Practice 44: 102776
17. Brosio F, Kuhdari P, Stefanati A *et al* (2017): Knowledge and behaviour of nursing students on the prevention of healthcare associated infections. Journal of preventive medicine and hygiene 58 (2): E99−E104