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Ratios and Nurses' Perceived Caring Behaviors

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Abstract

The Philippine nursing workforce continues to face challenges from increasing patient demands and persistent staffing shortages, which strain healthcare delivery. This study examined the relationship between nurse–patient ratios and nurses' perceived caring behaviors in selected public hospital wards in Laguna, Philippines. Utilizing a descriptive-correlational design, 117 registered ward nurses were purposively sampled from three public hospitals and surveyed using the Caring Behaviors Inventory-16-FIL, a validated instrument measuring self-assessed caring practice. Ethical clearance was secured prior to data collection. Results revealed that most respondents were female, aged 31–40 years, and working under staffing conditions that exceeded the Department of Health's recommended 1:12 ratio, consistent with typical ratios of 1:15–1:20 in similar hospitals. Despite these constraints, nurses consistently reported high levels of caring behavior, particularly in maintaining patient confidentiality ($M = 5.71$, $SD = 0.75$), demonstrating confidence ($M = 5.67$, $SD = 0.78$), and providing patient education ($M = 5.65$, $SD = 0.78$). Lower ratings were observed in empathy ($M = 5.26$, $SD = 0.89$), responsiveness ($M = 5.29$, $SD = 0.88$), and meeting holistic needs ($M = 5.39$, $SD = 0.82$), reflecting workload pressures. Statistical analyses using independent t-tests, one-way ANOVA, and Pearson correlation showed no significant differences in caring behavior across demographic variables, nor a significant correlation between nurse–patient ratio and caring behavior, although a positive but non-significant trend was noted ($r = 0.172$, $p = 0.063$). Findings affirm that caring is a professional attribute embedded in nursing identity, resilient across diverse groups and workloads. The persistence of excessive ratios emphasizes risks to responsiveness, holistic care, and patient safety. The study calls for policy reforms, improved staffing standards, and institutional support to sustain compassionate care and strengthen workforce resilience.

Keywords: Caring behavior; Nurse–patient ratio; Staffing adequacy; Nursing workforce; Public hospitals

1. Introduction

Nurses are central to the healthcare system, with their caring nature forming the foundation of the profession. Their ability to deliver effective, efficient, and quality care is shaped not only by individual competence but also by institutional policies and staffing levels. Maintaining an optimal nurse–patient ratio is essential to sustaining high-quality care, as comprehensive care management requires adequate staffing to address diverse patient needs (Bautista et al., 2025). Previous studies emphasize the influence of practice environments and hospital policies on nursing care strategies, emphasizing the challenges nurses encounter when faced with heavy workloads (Alibudbud, 2023). Insufficient staffing has been consistently identified as a critical threat to nurses' performance and well-being (Artificion et al., 2020).

Although the Department of Health (DOH, 2018) recommends a 1:12 nurse–patient ratio in general wards, studies show that many Philippines public hospitals go beyond this standard. Nurses often care for 15 to 20 patients per shift, and sometimes even 25 to 30 patients. This situation is linked to staff shortages, heavy patient demand, and nurse migration abroad (Alibudbud, 2023; Bautista, 2025). National reports confirm that most government hospitals continue to exceed the recommended staffing levels, showing a clear gap between policy and practice (Caballero & Estillore, 2023; Oducado, 2024).

In lieu of this, the present study examines nurse–patient ratios and caring behavior in public hospitals in Laguna. Local findings mirror the same challenges seen nationwide, making the study significant in showing how staffing affects nurses' ability to provide compassionate care and how this impacts patient safety and global healthcare quality.

Further, this study is anchored in Jean Watson's Unitary Caring Science (2018), which views nursing as a holistic and transpersonal practice. Caring is understood as a transformative process that integrates mind, body, spirit, and environment, expressed through *caritas* processes, intentional acts of compassion and authentic presence that go beyond technical duties.

Thus, the study situates nurse–patient ratio as the independent variable, caring behaviors as the dependent variable, and Watson's Unitary Caring Science (2018) as the guiding theory, the present study examines how nurse–patient ratios influence caring behaviors in public hospitals in Laguna. Watson's framework provides the lens to understand how institutional factors such as staffing levels affect nurses' ability to sustain compassionate, holistic care and protect patient well-being.

This study examined the relationship between nurse–patient ratios and nurses' caring behavior in selected public hospitals in Laguna, offering a local perspective on care rationing due to staff shortages. The findings help determine optimal nurse–patient ratios and their link to caring behavior, with implications for better nursing care, faster patient recovery, and policy reforms. For the College of Nursing, the study enriches curriculum development, strengthens research and training, and supports the integration of Watson's Theory of Human Caring, preparing future nurses for compassionate and evidence-based practice.

2. Objectives

This study was conducted to describe the demographic profile of nurses in selected public hospital wards in Laguna, Philippines, with emphasis on age, sex, marital status, socio-economic status, years of experience, and nurse–patient ratio. It further sought to determine the level of nurses' self-perception of their caring behavior, recognizing caring as a central dimension of nursing practice. The study also examined whether significant differences in caring behavior exist when nurses are grouped according to demographic profile, thereby providing insights into how personal and professional attributes may shape caring practices. Moreover, it aimed to establish the relationship between nurse–patient ratio and caring behavior, contributing evidence-based understanding of how staffing adequacy influences caring practices. These objectives provide implications for nursing education, hospital administration, and policy development within the Philippine healthcare setting.

3. Materials and Methods

This study utilized a descriptive–correlational **design** to investigate the relationship between nurse–patient ratios and nurses' caring behavior in selected public hospital wards in Laguna, Philippines. As a quantitative approach, it enabled systematic collection and analysis of numerical data, ensuring objectivity in measuring variables (Creswell and Creswell, 2022). The correlational component examined the strength and direction of associations without manipulation, identifying patterns that may influence caring practices.

The Filipino version of the Caring Behaviors Inventory-16 (CBI-16 FIL), translated and validated by Tamayo et al. (2022), served as the primary tool in this study. It consists of 16 items rated on a six-point Likert scale (1 = Very Low to 6 = Very High). The instrument demonstrated high internal consistency (Cronbach's $\alpha = 0.95$), confirming its reliability in assessing nurses' self-perceived caring behaviors. This adapted tool is well-suited to the study as it captures caring practices within the Filipino nursing context while ensuring cultural relevance and methodological rigor.

The study population consisted of 145 ward nurses from three public hospitals in Laguna, as identified through official hospital records. To ensure that the sample reflected nurses directly involved in bedside care, inclusion criteria required active registration and assignment to medical, surgical, or general wards with direct patient care responsibilities. Conversely, nurses in administrative or supervisory positions were excluded, as they were not engaged in routine ward duties.

After applying these criteria, all eligible nurses were invited to participate through purposive sampling. Of the 145 qualified nurses, 117 consented and completed the survey, representing the final sample size. The reduction from 145 to 117 was therefore due to non-participation or declined consent, a common occurrence in survey-based research. This process ensured that the final sample

was composed only of nurses who both met the inclusion criteria and voluntarily agreed to participate, thereby maintaining methodological rigor and ethical compliance.

Data collection adhered to approved ethical protocols. Objectives and procedures were explained, informed consent was obtained, and confidentiality was assured. Questionnaires were distributed to the identified respondents following the approved protocol. Upon completion, the instruments were retrieved and checked for completeness to ensure accuracy of responses. Valid questionnaires were then tallied, encoded, and tabulated systematically. The data were subsequently organized and prepared for statistical analysis using appropriate software, ensuring reliability and validity of results. **Descriptive statistics** summarized demographic characteristics and caring behavior scores. **Independent t-tests** were applied to variables with two categories, **one-way ANOVA** to those with more than two, and **Pearson correlation** to assess the relationship between nurse–patient ratio and caring behavior.

Ethical approval was obtained from the Institutional Ethics Review Committee of UPH–Dr. Jose G. Tamayo Medical University, and an ethics clearance certificate was issued prior to data collection. Hospital authorities also granted permission for the conduct of the study.

Confidentiality and anonymity were strictly maintained, and participation was voluntary with the right to withdraw at any time. The principle of beneficence was observed by ensuring that no harm came to respondents.

4. Results

Demographic Profile of Respondents

The majority of respondents were aged 31–40 years (57.2%), followed by those aged 41–50 years (21.4%), 30 years and below (15.5%), 51–60 years (5.1%), and 60 years and above (0.9%). Most were female (70.9%), while 29.1% were male. In terms of marital status, 59% were single, 39.3% were married, and 1.7% were widowed or separated.

Socio-economic data showed that 88% of nurses earned between PHP 21,914 and PHP 43,828, while 12% reported incomes ranging from PHP 43,828 to PHP 76,669. With respect to professional experience, the largest group (42.7%) had more than 10 years of practice, followed by 26.5% with 5–10 years, 23.1% with less than 3 years, and 7.7% with 3–5 years.

In terms of workload, most respondents (36.7%) reported handling 12–13 patients per shift. Other nurse–patient ratios included 1:14–15 (24%), 1:20 (15.4%), 1:11 or below (10.3%), 1:21–25 (4.3%), and 1:30 or more (9.4%).

Table 1. Demographic Profile of Respondents

Variable	Classification	Percentage
Age	30 years and below	15.5
	31–40 years	57.2
	41–50 years	21.4
	51–60 years	5.1
	60 years and above	0.9
Sex	Female	70.9
	Male	29.1
Marital Status	Single	59.0
	Married	39.3
	Widowed/Separated	1.7
Socioeconomic Status	PHP 21,914–43,828	88.0
	PHP 43,828–76,669	12.0
Years of Experience	Less than 3 years	23.1
	3–5 years	7.7
	5–10 years	26.5

Variable	Classification	Percentage
Nurse-Patient Ratio	More than 10 years	42.7
	1:11 or below	10.3
	1:12–13	36.7
	1:14–15	24.0
	1:20	15.4
	1:21–25	4.3
	1:30 and above	9.4

Table 2 presents the perceived level of caring behavior among nurses in selected public hospitals in Laguna, Philippines. The highest-ranked item was Treating patient information confidentially ($M = 5.71$, $SD = 0.75$), reflecting strong adherence to ethical standards and patient privacy. This was followed by Being confident with the patient ($M = 5.67$, $SD = 0.78$), underscoring the role of professional assurance in fostering trust. The third highest-ranked item was Giving instructions or teaching the patient ($M = 5.65$, $SD = 0.78$), emphasizing the importance of patient education in quality care.

Lower ratings were observed in Being empathetic or identifying with the patient ($M = 5.26$, $SD = 0.89$), Responding quickly to the patient's call ($M = 5.29$, $SD = 0.88$), and Meeting the patient's stated and unstated needs ($M = 5.39$, $SD = 0.82$). These findings suggest challenges in sustaining emotional connection, responsiveness, and holistic care under demanding work conditions.

Further, the results indicate that while nurses consistently demonstrated high levels of caring behavior, aspects related to empathy, responsiveness, and meeting holistic needs were relatively less emphasized compared to confidentiality, confidence, and patient teaching.

Table 2. Respondents' Perceived Level of Caring Behavior

		Mean	SD	VD	Rank
1	Attentively listening to the patient. <i>Nakikinig sa pasyente ng may buong atensyon.</i>	5.59	0.79	High	5
2	Giving instructions or teaching the patient. <i>Binibigyan ng paalala o tinuturuan ang pasyente.</i>	5.65	0.78	High	3
3	Treating the patient as an individual. <i>Pinakikitunguhan ang pasyente bilang isang indibidwal na tao.</i>	5.59	0.89	High	5
4	Spending time with the patient. <i>Naglalaan ng oras sa pasyente.</i>	5.40	0.85	High	13
5	Supporting the patient. <i>Nagbibigay suporta sa pasyente.</i>	5.43	0.81	High	11
6	Being empathetic or identifying with the patient. <i>Dinadamayan o nakikiisa sa pasyente.</i>	5.26	0.89	High	16
7	Being confident with the patient. <i>May kumpiyansa sa sarili sa harap ng pasyente.</i>	5.67	0.78	High	2
8	Demonstrating professional knowledge and skill. <i>Nagpapakita ng propesyonal na kaalaman at kasanayan.</i>	5.63	0.77	High	4
9	Including the patient in planning his or her care. <i>Isinasama ang pasyente sa pagpapalano ng pag-aalaga sa kanya.</i>	5.50	0.83	High	8
10	Treating patient information confidentially. <i>Itinuturing na kompidensyal ang impormasyon ng pasyente.</i>	5.71	0.75	High	1
11	Returning to the patient voluntarily. <i>Kusang-loob na bumabalik sa pasyente.</i>	5.50	0.84	High	8
12	Talking with the patient. <i>Nakikipag-usap sa pasyente.</i>	5.57	0.81	High	7
13	Meeting the patient's stated and unstated needs.				

		Mean	SD	VD	Rank
	<i>Natutugunan ang mga nababanggit at hindi nababanggit na pangangailangan ng pasyente.</i>	5.39	0.82	High	14
14	Responding quickly to the patient's call. <i>Natutugunan kaagad ang tawag ng pasyente.</i>	5.29	0.88	High	15
15	Giving the patient's treatments and medication on time. <i>Naibibigay sa pasyente ang mga gamot sa tamang oras.</i>	5.45	0.81	High	10
16	Relieving the patient's symptoms. <i>Naiibsan ang mga nararamdamang sintomas ng pasyente.</i>	5.41	0.79	High	12
Mean		5.50			

The analysis of differences in caring behavior across demographic groups was conducted using independent t-tests for two-category variables and one-way ANOVA for variables with more than two categories. Results of the independent t-test revealed that sex ($t = 1.18$, $p > 0.05$) and socio-economic status ($t = 0.92$, $p > 0.05$) did not yield significant differences. This indicates that caring behavior scores were comparable across male and female nurses, as well as across income groups, suggesting that caring practices are consistently upheld regardless of gender or economic standing.

For variables with more than two categories, one-way ANOVA showed that age ($F = 1.34$, $p > 0.05$), marital status ($F = 0.87$, $p > 0.05$), years of experience ($F = 1.42$, $p > 0.05$), and nurse–patient ratio ($F = 1.26$, $p > 0.05$) did not produce significant differences in caring behavior. These findings suggest that caring behavior remained stable across demographic profiles and patient load, reinforcing the notion that caring is a professional attribute embedded in nursing identity rather than contingent on personal background or workload.

The statistical treatment confirmed that caring behavior among nurses was not significantly influenced by demographic profile or nurse–patient ratio. Accordingly, the null hypothesis was accepted, affirming that caring behavior is a consistent professional practice sustained across diverse groups and conditions.

It is noteworthy, however, that the mean scores for caring behavior were uniformly high (**overall mean = 5.50 on a six-point scale**). This pattern indicates a possible **ceiling effect**, where responses cluster near the upper limit of the scale, reducing variability and limiting the ability to detect significant differences. Such ceiling effects may be attributed to the strong professional identity of Filipino nurses, cultural norms that emphasize caring as a core nursing value, and the influence of social desirability bias in self-report measures. Moreover, while the CBI-16 FIL is validated and reliable, its broad items may capture caring behaviors generally but may not differentiate subtle variations across demographic groups or workload conditions.

Table 3. Differences in Caring Behavior by Demographic Variables

Variables	t-value	Interpretation	Decision
Sex	1.18	Not Significant ($p > 0.05$)	Accept H_0
Socioeconomic Status	0.92	Not Significant ($p > 0.05$)	Accept H_0
Variables	F-value	Interpretation	Decision
Age	1.34	Not Significant ($p > 0.05$)	Accept H_0
Marital Status	0.87	Not Significant ($p > 0.05$)	Accept H_0
Years of Experience	1.42	Not Significant ($p > 0.05$)	Accept H_0
Nurse–Patient Ratio	1.26	Not Significant ($p > 0.05$)	Accept H_0

Table 4 presents the relationship between nurse–patient ratio and caring behavior was examined using Pearson correlation analysis. Results revealed a positive correlation coefficient ($r = 0.172$), suggesting that as the nurse–patient ratio increases, caring behavior tends to improve slightly. However, this relationship was not statistically significant ($p = 0.063$) at the 0.05 level of significance. The findings therefore indicate that while workload may exert some influence on caring practices, it does not serve as a decisive factor in determining the quality of nurse–patient interactions.

Based on these results, the null hypothesis stating that there is no significant relationship between nurse–patient ratio and perceived caring behavior was accepted. This outcome emphasizes that caring behavior is a professional attribute embedded in nursing identity, rather than being solely dependent on staffing adequacy. Nonetheless, the presence of a positive though non-significant correlation emphasizes the importance of monitoring nurse–patient ratios, as excessive workloads may compromise responsiveness, holistic care, and patient safety.

Table 4. Relationship Between Nurse-Patient Ratio and Caring Behavior

Hypothesis	Significance Level	Critical Value	Interpretation	Decision
H0: There is no significant relationship between the nurse-patient ratio and the perceived caring behavior	$\alpha=0.05$ $p=0.063$	$r=0.172$	No Significant	Accepted

5. Discussions

The nursing workforce in public hospitals in Laguna, Philippines, is relatively young, with the majority of respondents aged 31–40 years. This age distribution reflects sustainability and long-term professional commitment, as younger nurses are positioned to contribute to the profession for many years (Alibudbud, 2021). The profession remains female-dominated, consistent with global trends (World Health Organization, 2021), though the presence of male nurses adds diversity and broadens perspectives in care delivery.

A large proportion of nurses were single, a pattern that may be shaped by demanding schedules and the challenges of balancing personal and professional responsibilities. Economically, most respondents fell within the lower- to middle-income bracket, emphasizing financial strain and stressing the need for improved compensation and institutional support systems (Department of Health, 2021). In terms of professional experience, a significant proportion had more than ten years in practice, strengthening mentorship opportunities and providing stability in care delivery (Govasli & Solvoll, 2021).

Despite systemic challenges, nurses demonstrated consistently high levels of caring behavior. The strongest emphasis was placed on confidentiality, confidence, and patient teaching, reflecting ethical commitment and professional competence (Oducado, 2024). However, relational aspects such as empathy, responsiveness, and holistic care were rated lower, constrained by workload and staffing pressures. These affective dimensions are most vulnerable to stress and time demands, particularly in resource-limited settings.

No significant differences in caring behavior were observed across demographic groups, affirming that caring is a professional attribute embedded in nursing identity rather than dependent on personal background. The nurse–patient ratio showed a positive but non-significant correlation with caring behavior, suggesting that workload alone does not fully determine caring practices. Nevertheless, excessive ratios remain a concern, as they compromise responsiveness, holistic care, and patient safety (Caballero & Estillore, 2023).

Filipino nurses uphold professionalism and patient-centered values across demographic groups. Yet systemic challenges such as staffing adequacy and workload management must be addressed to sustain holistic, compassionate care. Strengthening institutional support, improving nurse–patient ratios, and investing in emotional intelligence training are essential strategies to ensure that caring behaviors remain central to nursing practice in public hospitals (Balay-Odao et al., 2024). Future research may employ longitudinal designs to examine how sustained staffing interventions influence caring outcomes and patient satisfaction, thereby contributing to evidence-based policy development in nursing administration.

6. Conclusion

This study examined the relationship between nurse–patient ratios and nurses’ perceived caring behaviors in selected public hospital wards in Laguna, Philippines. Nurses consistently demonstrated

high levels of caring behavior, particularly in confidentiality, confidence, and patient education, even when staffing conditions exceeded the Department of Health's recommended 1:12 ratio. No significant differences were found across demographic variables, confirming that caring is a professional attribute rooted in nursing identity.

Although the relationship between nurse–patient ratio and caring behavior was positive but non-significant, the findings emphasize that excessive workloads may gradually reduce empathy and holistic care. The results emphasize that **staffing adequacy** is essential to sustain quality nursing practice, as **heavier workloads** challenge nurses' ability to balance technical tasks with compassionate care. Despite these pressures, Filipino nurses continue to uphold professionalism and compassion, showing resilience in maintaining **caring behaviors**.

Sustaining these behaviors requires institutional commitment to adequate staffing, supportive work environments, and continuous professional development. Strengthening nurse–patient ratios, enhancing emotional resilience, and integrating caring competencies into hospital policy and nursing education are vital to ensure quality care, patient safety, and improved health outcomes.

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Pain Discomfort in Jeepney Drivers and Their Work Performance

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Abstract

Jeepney drivers in the Philippines perform physically demanding work that involves prolonged sitting, repetitive pedal use, whole-body vibration, and continuous passenger handling, all of which expose them to musculoskeletal pain. Despite their critical role in public mobility, no prior study has jointly described task-level pain discomfort and work performance in this population, nor examined how occupational adaptation mediates the relationship between pain and performance. This descriptive-correlational study recruited 30 active drivers along the Calamba to Balibago route in Laguna using purposive quota sampling and an expert-validated questionnaire. Frequency, weighted mean, and Pearson's r were applied. All drivers (100%) reported pain, and 40% experienced onset after four to five hours of driving. The back (27.69%), shoulder (13.85%), and knee were the most affected sites, with pain ranging from mild to moderately severe. Overall work performance remained adequate ($M = 3.29$), and the correlation between pain and performance was weak and non-significant ($r = -0.182$, $p = 0.335$). These findings suggest that occupational adaptation, coping strategies, and income pressure sustain driver performance despite ongoing pain. The results carry direct implications for ergonomic intervention, occupational therapy practice, and driver welfare policy in the Philippine transport sector.

Keywords: jeepney drivers, pain discomfort, work performance, musculoskeletal pain, occupational adaptation, PEO model, occupational therapy

1. Introduction

Jeepney drivers are among the most visible and economically vulnerable members of the Philippine transport workforce. Their work demands prolonged driving, navigation of congested urban routes, repeated gear shifting, and continuous passenger and fare management across long shifts—all of which expose the body to sustained physical strain. Musculoskeletal discomfort is a well-documented consequence of these conditions (World Health Organization, 2018; International Labour Organization, 2020).

The scale of this concern in the Philippines is significant. Data from the Department of Labor and Employment (DOLE, 2022) show that musculoskeletal complaints—including back pain, joint strain, and upper extremity fatigue—are among the most frequently recorded occupational health issues among land transport workers. The Philippine Statistics Authority (PSA, 2020) estimates that over 400,000 jeepney drivers are actively employed nationwide, many operating vehicles that pre-date modern ergonomic standards. With no universal mechanism for occupational health monitoring in the informal transport sector, the burden of musculoskeletal pain among jeepney drivers remains largely unquantified and poorly addressed at the policy level.

Local research supports this concern. Estember and Espinosa (2020) documented high rates of back pain, shoulder strain, and upper extremity fatigue among Filipino public utility vehicle drivers. Seva et al. (2011) similarly identified prolonged vibration exposure and static postures as primary contributors to musculoskeletal complaints in Metro Manila transport workers. Internationally, Siddiqui et al. (2024) found a 77% prevalence of musculoskeletal pain among bus drivers in Pakistan, while Chen et al. (2022) reported that over 82% of urban bus drivers in China experienced pain in the preceding month. These figures underscore a global pattern of occupational risk in professional driving that is likely replicated—and possibly amplified—among jeepney drivers who operate under ergonomically substandard conditions.

What distinguishes jeepney drivers from other professional drivers is the nature of their occupational tasks. Unlike bus or truck drivers, they stop frequently to board and alight passengers, reach across the cabin to collect fares, navigate narrow roads through dense urban traffic, and perform

repeated manual gear changes throughout the shift. These task patterns create a unique occupational context for discomfort that has not been adequately described in existing literature.

Purposive quota sampling was used to recruit 30 active drivers along the Calamba–Balibago route, a judgment-based approach appropriate when the target population has defined characteristics and access is limited to a specific operational site (Creswell, 2014). This approach ensures representativeness within the study boundary while allowing systematic data collection from an otherwise hard-to-reach occupational group. The study's small sample size ($n = 30$) and single-route scope are acknowledged limitations; generalizability is restricted, and findings should be interpreted as context-specific descriptive evidence pending replication across broader samples.

2. Framework and Method

This paper is anchored on the Person–Environment–Occupation–Performance (PEOP) Model (Baum et al., 2015), a practical framework for understanding occupational performance. Rather than assuming that a single factor—such as pain—determines how well someone performs their work, the PEOP Model recognizes that performance is shaped by the interaction of personal factors, environmental conditions, and the specific tasks involved. Applied to jeepney drivers, the Person component refers to physical capacity and the driver's experience of pain; Environment encompasses road conditions, vehicle ergonomics, and the economic pressures of meeting daily income targets; Occupation covers the core tasks of driving and managing passengers and fares; and Performance reflects how well drivers are able to execute these tasks under their actual working conditions.

This article advances three interrelated objectives: (1) characterizing jeepney working conditions and their ergonomic consequences within the Philippine transport sector; (2) situating Filipino jeepney drivers within international evidence on musculoskeletal pain distribution, intensity, and onset; and (3) examining the pain–performance relationship through a PEOP lens, arguing that occupational adaptation, coping strategies, and economic necessity mediate this relationship.

This descriptive-correlational study recruited 30 active drivers along the Calamba to Balibago route in Laguna using purposive quota sampling and an expert-validated questionnaire. Frequency, weighted mean, and Pearson's r were applied. All drivers (100%) reported pain, and 40% experienced onset after four to five hours of driving. The back (27.69%), shoulder (13.85%), and knee were the most affected sites, with pain ranging from mild to moderately severe. Overall work performance remained adequate ($M = 3.29$), and the correlation between pain and performance was weak and non-significant ($r = -0.182$, $p = 0.335$).

3. Results

Pain Discomfort and Work Performance Among Jeepney Drivers

3.1 Jeepney Transportation and Driver Working Conditions

Despite the rise of alternative transport modes, jeepneys remain among the most cost-effective and culturally significant means of public mobility in the Philippines. Most units currently in service are locally fabricated or rebuilt assemblies designed primarily for commercial viability rather than ergonomic function (Coz et al., 2015). Seat dimensions, pedal placement, steering column height, and cabin ventilation frequently fall outside recommended ergonomic parameters, placing drivers at structural risk for musculoskeletal strain from the outset of each shift.

Drivers along the Calamba–Balibago route operate under conditions that compound these ergonomic deficits: congested urban traffic requiring frequent braking, repeated start-stop cycles during passenger boarding, prolonged shifts driven by daily boundary income targets, and limited access to rest facilities. These conditions position musculoskeletal discomfort not as an incidental by-product but as a structurally embedded feature of the occupation.

Figure 1 illustrates the PEOP Model applied to the jeepney driver context, mapping each component to the study's specific findings. The Person component (pain, physical capacity, coping strategies) interacts with Environmental demands (traffic, vehicle design, income pressure) and Occupational tasks (driving, fare handling, passenger management) to produce the observed Performance outcomes—drivers maintaining adequate function despite universal pain.

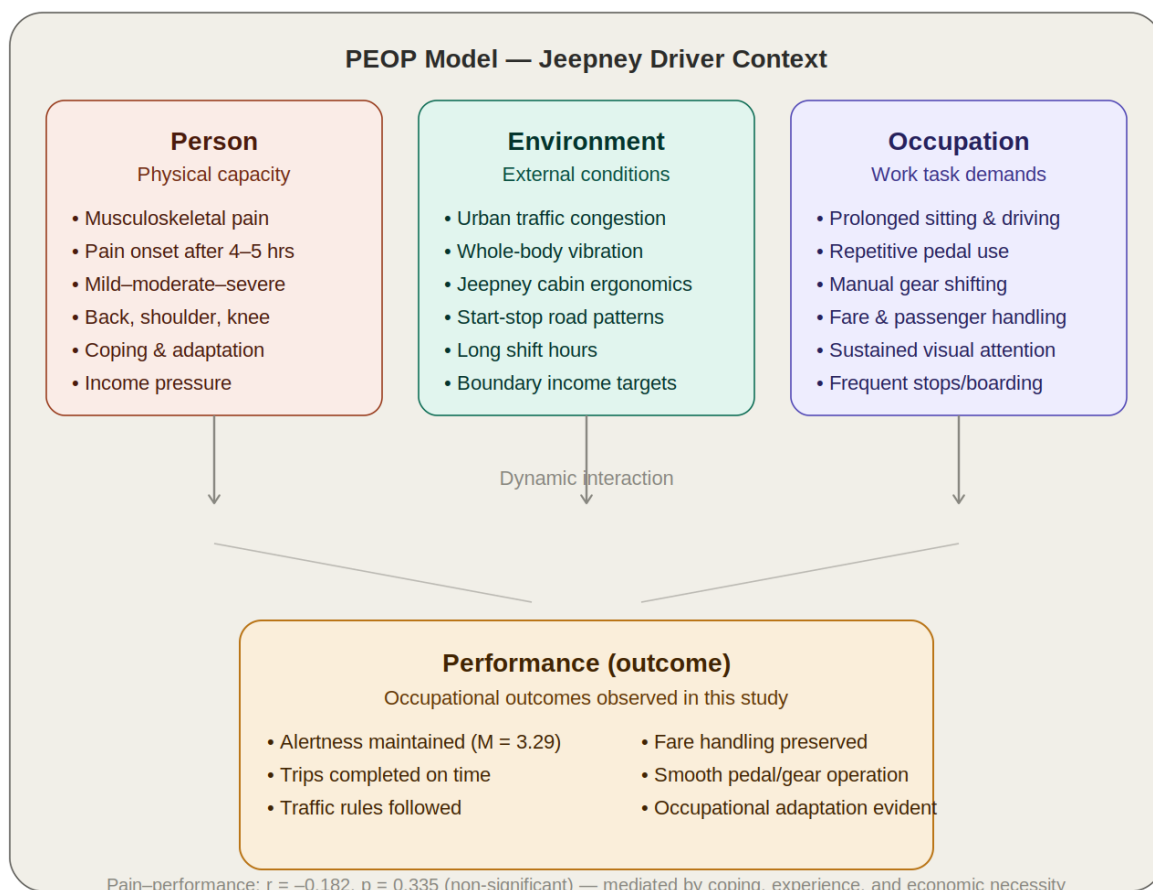


Figure 1. PEOP Model applied to jeepney drivers in the Calamba–Balibago study context. The Person component (pain experience, physical capacity, coping strategies) interacts with Environmental factors (road conditions, vehicle design, income pressure) and Occupational tasks (driving, gear shifting, fare handling) to produce the observed Performance outcomes. Arrows indicate bidirectional, dynamic interaction among all components, with performance as the emergent product rather than a simple downstream effect of pain. [Figure to be inserted by authors; a conceptual diagram mapping each PEOP component to study-specific variables is recommended.]

3.2 Musculoskeletal Pain Among Professional Drivers

Musculoskeletal pain is a consistent occupational finding among professional drivers worldwide. Estember and Espinosa (2020) documented high pain rates among Filipino jeepney drivers, attributing them to repetitive pedal use, prolonged sitting, and trunk rotation during fare interactions. Seva et al. (2011) identified back pain as the predominant complaint among Metro Manila public transport drivers, linked to whole-body vibration and static postures maintained over long shifts.

International evidence shows the same pattern across driver populations. Siddiqui et al. (2024) reported that 77% of Bus Rapid Transit drivers in Peshawar experienced musculoskeletal pain in the preceding 12 months, concentrated in the neck, upper back, lower back, and shoulders. Chen et al. (2022) found that 82.1% of Shanghai bus drivers experienced musculoskeletal pain in the past month, with 41.2% rating it as moderate and 20.1% as severe. Kumar and Varghese (2022) identified the lower back (48.5%), neck (37.2%), and shoulders (33.9%) as the most affected regions among South Indian urban bus drivers. Across all studies, the same risk factors recur: prolonged sitting, continuous steering, suboptimal seat ergonomics, and inadequate rest breaks.

Findings from the present study aligned with this body of evidence, as summarized in Tables 1 through 4. All 30 respondents (100%) reported pain discomfort while driving (Table 1), confirming pain as a universal occupational feature rather than an isolated complaint. Table 2 showed that 40% of drivers experienced pain onset after 4–5 hours of continuous driving, suggesting a predictable

threshold of physical strain. Table 3 indicated that 43% reported mild pain and approximately 48% reported moderate-to-severe pain. Table 4 showed that pain was multi-site: the most frequently reported locations were the back (27.69%), shoulder (13.85%), and knee (12.31%), consistent with international data on body-region distribution.

Table 1 Presence of pain discomfort among jeepney drivers (N = 30)

Pain Discomfort	Frequency	Percentage (%)
Yes – pain experienced while driving	30	100.0
No	0	0.0
Total	30	100.0

Table 2 Hours of continuous driving before pain onset (N = 30)

Hours before pain onset	Frequency	Percentage (%)
Less than 1 hour	3	10.0
1–2 hours	5	16.7
2–3 hours	4	13.3
3–4 hours	6	20.0
4–5 hours	12	40.0
More than 5 hours	0	0.0
Total	30	100.0

Table 3 Level of pain discomfort using standardized pain scale (N = 30; multiple responses allowed)

Pain level	Frequency*	Percentage (%)
Mild (1–3)	13	43.3
Moderate (4–6)	10	33.3
Moderate-severe (7–8)	4	13.3
Severe (9–10)	3	10.0

Table 4 Frequency and percentage of pain locations (N = 30; multiple responses allowed)

Pain location	Frequency	% of responses
Back / lower back	18	27.69
Shoulder	9	13.85
Knee	8	12.31
Neck	7	10.77
Wrist / arm	6	9.23
Legs / feet	5	7.69
Others	12	18.46
Total responses	65	100.0

3.3 The Relationship Between Pain Discomfort and Work Performance

Pain discomfort has been associated with reduced attention, slower decision-making, and diminished reaction time among professional drivers (ILO, 2020). Persistent discomfort increases cognitive load and may compromise a driver's ability to respond to road hazards. Pain can also reduce driving endurance, prompt more frequent rest breaks, and shorten productive shift hours (WHO, 2018). These mechanisms point toward a negative relationship between pain and performance.

However, the evidence suggests this relationship is neither direct nor deterministic. De Vries et al. (2012) found that workers with chronic musculoskeletal pain often maintained moderate self-reported work performance, indicating that pain does not automatically translate into functional decline. Machin and Hoare (2008), in a study of 159 Australian bus drivers, showed that workload did not directly predict physical symptoms or negative affect; rather, the need for recovery acted as a mediator, and adaptive coping strategies preserved positive functioning. These findings point to a set of mediating variables—income pressure, years of experience, sleep quality, and coping style—that shape how pain ultimately influences performance. These mediators have not been examined in prior Filipino jeepney driver research, constituting a gap the present study begins to address.

Table 5 presented work performance scores across six indicators. Despite universal pain, respondents maintained adequate performance overall ($M = 3.29$, interpreted as Often). Drivers consistently reported staying alert on the road, following traffic rules, handling fares accurately, completing trips on time, and operating pedals and gear shift smoothly while experiencing discomfort.

Table 5 Level of work performance while experiencing pain discomfort (N = 30; 4-point scale: 1 = Never, 2 = Sometimes, 3 = Often, 4 = Always)

Performance indicator	Weighted mean	Interpretation
Stays alert and focused while driving	3.40	Often
Follows traffic rules consistently	3.47	Often
Handles fare transactions accurately	3.33	Often
Completes trips on time	3.27	Often
Operates pedals and gear shift smoothly	3.20	Often
Manages passengers efficiently	3.07	Often
Overall weighted mean	3.29	Often

Pearson correlation analysis yielded $r = -0.182$, $p = 0.335$ —a weak negative, statistically non-significant association between pain discomfort and work performance. The direction of this relationship was consistent with the hypothesis that higher pain corresponds to lower performance, but the size of the correlation was too small to draw a firm conclusion. The non-significant result is best understood through the concept of occupational adaptation—the ability people develop over time to keep doing their work even when their bodies are under strain. Drivers appeared to sustain performance through long-practised motor habits built up over years of driving, economic motivation to meet daily income targets, and coping strategies that reduced the practical impact of pain on task execution. Future studies with larger samples should employ multiple regression or ANOVA-based designs to test whether pain level, body region, or pain duration differentially predict performance outcomes, and to examine coping style and sleep quality as formal mediating variables.

Within the PEO Model (Baum et al., 2015), these results illustrated how the Person (pain, physical capacity), Environment (traffic, vehicle ergonomics, income pressure), and Occupation (driving tasks, fare handling) work together to shape Performance. In this model, performance is not simply the result of how much pain a person feels; it emerges from the interaction of personal, environmental, and task-related factors. The weak and non-significant pain–performance correlation found in this study directly supports that view: even when physical capacity was reduced by pain, drivers maintained their occupational performance by drawing on experience, habit, and the practical necessity of earning a daily income.

4. Conclusion

This paper has advanced three arguments. First, the working conditions of jeepney drivers along Philippine routes are structurally demanding: locally fabricated vehicles with suboptimal ergonomics, congested traffic, and income-driven shift lengths embed physical strain into the occupation itself. Second, musculoskeletal pain among the jeepney drivers studied was universal (100%), multi-site, and consistent with international evidence, with onset typically after 4–5 hours of driving and concentration in the back, shoulders, and knees. Third, pain does not automatically reduce work performance: despite persistent pain, drivers maintained adequate work performance ($M = 3.29$), and the correlation was weak and non-significant ($r = -0.182$, $p = 0.335$), mediated by occupational adaptation, coping, and economic pressure.

These findings position jeepney driving within global discourse on driver ergonomics and musculoskeletal health. The Philippine context shares risk patterns with professional driver populations in Pakistan, China, India, and Australia, yet differs in the structural informality of the sector, the ergonomic inadequacy of locally fabricated vehicles, and the absence of regulatory health monitoring. Addressing musculoskeletal health among jeepney drivers is therefore not only a clinical concern but a transport policy priority.

Practical Implications

For occupational therapists, the findings support community- and worksite-based programs targeting posture correction, stretching routines, and ergonomic body mechanics adapted to the jeepney cabin environment. Specific interventions with potential to reduce pain burden include: (1) lumbar support cushions or seat padding fitted to existing jeepney seat dimensions; (2) structured micro-break protocols mandating a minimum 10–15 minute rest after every 3–4 hours of driving; (3) driver education programs on posture awareness, load management, and early pain recognition; and (4) referral pathways for drivers experiencing moderate-to-severe pain to access musculoskeletal assessment and management services. These interventions are consistent with occupational therapy's role in enabling participation through modification of person, environment, and occupation—the three interacting domains of the PEO Model.

For policymakers and transport regulators, the near-universal prevalence of pain in this sample constitutes evidence for integrating musculoskeletal health standards into driver welfare provisions under the Land Transportation Franchising and Regulatory Board (LTFRB) framework. Mandated pre-employment and periodic musculoskeletal screening, ergonomic seat specifications in franchise renewal requirements, and access to affordable occupational health services are actionable policy directions supported by the study's findings. The Department of Transportation (DOTr) and Department of Labor and Employment (DOLE) may use these findings to inform updating of occupational health guidelines for the informal transport sector.

Limitations and Recommendations for Further Study

This study is limited by its small sample ($n = 30$), single-route scope, reliance on self-report, and cross-sectional design, all of which restrict causal inference and generalizability. Mediating variables—sleep quality, income pressure, coping style, and years of experience—were not measured.

Future research should expand to multiple routes and provinces to capture variability in road conditions and vehicle types. Longitudinal designs are needed to track how pain accumulates across a driving career and how coping strategies evolve over time. Mixed-method approaches combining self-report with ergonomic measurement (posture analysis, vibration exposure), fatigue assessment, and direct task observation would strengthen the evidence base. Multiple regression and ANOVA-based analyses in larger samples would clarify whether pain level, duration, or body region differentially predicts performance outcomes. Intervention studies evaluating ergonomic seat modifications, structured micro-break protocols, and community-based occupational therapy programs are needed to move from description to validated practice. Comparative studies across Philippine public transport modalities (UV Express, tricycle, bus) could identify which occupational characteristics most strongly drive musculoskeletal risk.

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Wound Healing Activity of Busbusilak (*Tabernaemontana pandacaqui*) Ethanollic Leaf Extract Ointment in Wistar Albino Rats

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Abstract

Wounds are a common health concern, particularly in areas with limited access to affordable treatments. This study investigated the wound healing potential of Busbusilak (*Tabernaemontana pandacaqui*) ethanollic leaf extract formulated into ointments, using an excision wound model in Wistar albino rats. Specifically, it assessed the characteristics of the ointments based on quality control parameters, stability under various storage conditions, and wound healing efficacy compared with a positive control (Povidone-Iodine, 10% w/w ointment) and a negative control (no treatment). This experimental study began with the authentication of Busbusilak leaves by the Bureau of Plant Industry. The leaves were shade-dried, extracted using ethanol, and formulated into ointments at 8%, 10%, and 12% concentrations. Stability tests were conducted at ambient, refrigerated, and accelerated conditions. Five healthy male Wistar albino rats (180–250 g) were individually housed under standard laboratory conditions and subjected to full-thickness excision wounds. Ointments were applied topically once daily for 14 days. Wound healing was evaluated through wound contraction measurements on days 2, 4, 6, 8, 10, 12, and 14, and documented with photographs. The results showed that among the experimental treatments, the 8% formulation exhibited the most significant wound-healing effect, while the 10% formulation exhibited superior physical stability, including homogeneity, consistent organoleptic quality, stable pH across various storage conditions, and satisfactory washability, despite lower spreadability. Histopathological findings supported these results, with the 8% ointment displaying active healing features, such as complete re-epithelialization and angiogenesis. These findings suggest that Busbusilak ointment is a promising natural alternative for wound management. Further research is recommended to optimize its formulation and explore its potential for broader therapeutic use.

Keywords: Busbusilak; *Tabernaemontana pandacaqui*; Herbal ointment; Wound healing; Wound Contraction.

1. Introduction

A wound is a mechanical interruption or discontinuity of the skin, organ tissue, or mucous surface brought about by disrupting its normal physiological structure. It may be accidental, incidental, or disease-conditioned (Chinko & Precious-Abraham, 2024). Scrapes, scratches, or cuts are examples of wounds that occur anywhere in the body. Therefore, proper care for these injuries will ensure that they do not acquire additional complications by infection and facilitate healing (Srivastava et al., 2024). The various modes of treatment include antiseptics, antibiotics, debridement, irrigation, and wound dressings. However, these treatment approaches are often costly and may lead to unwanted side effects such as contact dermatitis, bacterial resistance, bleeding, and delays in wound healing (G/giorgis et al., 2022). In the Philippines, the cost of branded drugs is 22 times higher than international reference prices, while generic drugs are four times more expensive (Maramba-Lazarte, 2020). This makes access to wound care limited for individuals in lower-income brackets. Moreover, antibiotic resistance continues to pose a significant crisis in health care, primarily driven by the overuse and inappropriate use of antibiotics. Implementing wound treatments that do not involve the use of antibiotics, antimicrobials, or antiseptics is essential to promote antimicrobial stewardship practices (Rippon et al., 2021). One of the plants that has long been valued in some parts of the Philippines due to its notable wound-healing activity is Busbusilak (*Tabernaemontana pandacaqui*) (Sicalan et al., 2023).

Busbusilak (*T. pandacacui*), or banana bush, is an evergreen shrub or small tree with ornamental flowers and fruits. It falls under the Apocynaceae family and is present in every tropic, although it has the highest prevalence in Southeast Asian countries, such as the Philippines (Galanta et al., 2022; Sicalan et al., 2023). Morphologically, *T. pandacacui* leaves are elliptical to narrowly elliptical in shape. It is widely used as an herbal medicine and an ornamental plant. Reviews of *T. pandacacui* indicate that it possesses a range of pharmacological properties, including antiprotozoal, anti-inflammatory, antipyretic, antinociceptive, cardiovascular, antibacterial, and anthelmintic properties. Additionally, a phytochemical analysis of the ethanolic extract of *T. pandacacui* conducted by (Galanta et al., 2022) revealed the presence of secondary metabolites, which include alkaloids, flavonoids, saponins, glycosides, tannins, phytosterols, carbohydrates, and reducing sugars. Furthermore, a study by (Aslam et al., 2018) stated that the presence of flavonoids in *T. pandacacui* influences the wound healing activity of the plant. Catechin, apigenin, luteolin, and rutin are classes of flavonoids found in many medicinal plants that possess wound healing activities. Numerous studies have explored the wound healing activity of *T. pandacacui*. However, the development of pharmaceutical products, such as ointments derived from this plant, remains largely unexplored. Such exploration of this plant could lead to the development of affordable, effective, and locally available alternatives to wound care treatments corresponding to global and regional health policies, such as the Traditional and Alternative Medicine Act of (TAMA) 1997.

Moreover, the excision wound model in rats has not yet been utilized in any wound healing study involving *T. pandacacui*. This model is commonly used to investigate various aspects, such as hemorrhage, inflammation, granulation tissue formation, re-epithelialization, angiogenesis, and tissue remodeling. Rats are frequently used in wound healing studies due to their size, wide availability, and tractable nature (Grada et al., 2018). Hence, this study aimed to evaluate the wound healing activity of Busbusilak (*T. pandacacui*) ethanolic leaf extract ointment, employing an excision wound model in Wistar albino rats (*Rattus norvegicus*).

2. Objectives

Generally, this study aimed to evaluate the wound healing activity of Busbusilak (*Tabernaemontana pandacacui*) ethanolic leaf extract ointment in Wistar albino rats. Specifically, it aimed to characterize the formulated ointment based on key quality control parameters, including accelerated stability studies, organoleptic evaluation, homogeneity test, pH, spreadability test, and washability test. Furthermore, the study sought to determine if there was a significant difference in the rate of wound contraction in Wistar albino rats on the 14th day following the administration of five distinct treatments: a positive control using 10% w/w Povidone-iodine ointment, a negative control with no treatment, and three experimental formulations containing 8% w/w, 10% w/w, and 12% w/w Busbusilak ethanolic leaf extract ointments. Lastly, the research aimed to assess the histopathological characteristics of the wounds in the test subjects following the administration of the different treatments.

2. Materials and Methods

Chemicals and Reagents

The materials used in this study were 95% Ethanol, Petrolatum Ointment, Distilled water, 2% Lidocaine hydrochloride, 10% w/w Povidone-Iodine ointment, 10% Formalin, Xylene, Paraffin wax, Hematoxylin, and Eosin.

Plant Material

The plant material of Busbusilak (*Tabernaemontana pandacacui*) was gathered at Peñablanca, Cagayan, Philippines. The plant sample was subsequently submitted and authenticated at the Bureau of Plant Industry in Malate, Manila, Philippines, to ensure accurate identification of the genus and species used in the study.

Animal Ethics

The animal ethics of the study adhered strictly to the prioritization of the humane treatment and well-being of the Wistar albino rats used in the experiments. The study protocol was officially reviewed and granted ethical clearance by the University of Saint Louis Research Ethics Board

(USLREB) under USLREB Code: 15-2025-01. The animal subjects were housed at the animal facility of the Department of Health (DOH)-Philippine Institute of Traditional and Alternative Health Care (PITAHC)-Cagayan Valley Herbal Processing Plant [PITACH-CVHPP] under standard laboratory conditions ($25\pm 3^{\circ}\text{C}$, 50-60% humidity, and a 12-hour light-dark cycle). The animals were kept in polypropylene cages. They were provided with free access to food and water ad libitum. The cages were cleaned daily with water and detergent, and the wooden shavings bedding was replaced at the same interval. The procedures in the experimentation were reviewed and verified by the veterinarian-in-charge at PITAHC. The rat carcasses were appropriately disposed of at the designated disposal area at the Animal Housing Facility at PITAHC.

Subjects of the Study

Five (5) healthy male Wistar albino rats at 2-3 months of age, weighing 180-250 g, were sourced from a licensed breeder in Malvar, Santiago City. To adhere to ethical guidelines on minimizing animal use, each animal served as its own internal control, with multiple independent excision wounds created per rat, corresponding to the different experimental groups. Statistical analyses were performed using these replicated data ($n = 5$ wounds per treatment group), rather than individual biological replicates. These animals were housed at the Philippine Institute of Traditional and Alternative Health Care (PITAHC) Animal Housing Facility. They were kept individually in separate propylene cages and maintained under standard laboratory conditions of $25\pm 3^{\circ}\text{C}$, 50-60% humidity, and a 12-hour light-dark cycle (Cauilan et al., 2021). The animals were provided with free access to food and water ad libitum.

Experimental Methods

Plant Material Preparation and Extraction

The fresh leaves of Busbusilak (*Tabernaemontana pandacaqui*) were thoroughly washed with distilled water to remove dust, dirt, and other contaminants. The leaves were shade-dried at room temperature ($20\text{--}25^{\circ}\text{C}$) for 14 days. The dried plant was crushed using an electric blender. The powdered leaves were placed in an amber, airtight container and macerated in 95% ethanol at a 1:3 w/v sample-to-solvent ratio for three days, with occasional stirring. The macerate was filtered through filter paper (Whatman No. 1). The solvent was removed using a rotary evaporator at 40°C . The extract was kept at $2\text{--}8^{\circ}\text{C}$ in the refrigerator until usage (Galanta et al., 2022).

Preparation of Busbusilak Ointment

Three (3) ointment formulations were prepared with the following concentrations of Busbusilak ethanolic extract: 8% w/w, 10% w/w, 12% w/w. Ethanolic extracts weighing 8 g, 10 g, and 12 g were mixed with 92 g, 90 g, and 88 g of ointment base, respectively (Mulisa et al., 2015). Table 1 provides a summary of the formulation for the Busbusilak ointment. The incorporation method of ointment preparation was employed to achieve a uniform, smooth consistency of the mixture using a stainless-steel spatula and an ointment slab (Allen, 2018). The ointments were packaged in clean plastic jars with a net weight of 50 g. The labels on the ointment container include the following information in accordance with Administrative Order No. 2016-0008 of the Food and Drug Administration (FDA): Product name, Dosage Form and Strength, Formulation, Indication, Dosage and Mode of Administration, Storage Conditions, Net Content, Name and Address of Manufacturer, Expiration Date, and Date of Manufacture (Food and Drug Administration (FDA), 2016).

Table 1 Formulation of *T. pandacaqui* Ethanolic Leaf Extract Ointment

Ingredients	Formula		
	8%	10%	12%
<i>T. pandacaqui</i> ethanolic extract	4 g	5 g	6 g
Petrolatum Ointment	46 g	45 g	44 g
Total	50 g	50 g	50 g

Evaluation of the Busbusilak Ointment Formulation

To ensure the safety, efficacy, and consumer acceptability of the Busbusilak ointment, each formulation was subjected to a rigorous battery of physicochemical evaluations. These assessments were designed to monitor the integrity of the semi-solid system and were conducted in accordance with the quality control standards for topical preparations. Evaluation parameters included organoleptic properties (color, odor, and texture), homogeneity, pH level, spreadability, and washability. To quantify these qualitative observations, a standardized 5-point Likert scale was employed, where a score of 5 represented optimal pharmaceutical quality and 1 represented poor quality. The detailed rubric, including the specific ranges and descriptors for each score, is provided in Appendix A.

Accelerated Stability Studies

The ointment formulations were subjected to stability testing under various conditions: refrigerated ($t = 5 \pm 3^\circ\text{C}$), ambient ($t = 25 \pm 2^\circ\text{C}$), and accelerated ($t = 40 \pm 2^\circ\text{C}$) conditions for 1 month. The stability assessments were conducted at specified intervals: immediately after preparation, after 14 days, and one month. At each test interval, samples were evaluated using the parameters for ointment formulation evaluation, including organoleptic evaluation, homogeneity test, pH measurement, spreadability, and washability (Zdoryk et al., 2014).

Organoleptic Evaluation

The ointment formulations were assessed for color, odor, and texture to ensure consistency and quality. The desirable properties include a brown color, along with a distinct aroma of the extract, and a smooth, semi-solid texture (Prasopsom et al., 2024).

Homogeneity Test

A sample of ointment was applied to a glass slide to check whether it is evenly blended. An appropriate mixture of ointment should have an even color and texture, with no clumps present (Wijianto & Pratiwi, 2024).

pH Measurement

A solution was prepared by dispersing 1 g of ointment in 100 ml distilled water. The pH of the herbal ointment was measured using a digital pH meter. A pH range of 4.5 to 6.5 was considered optimal since it aligns with the normal pH of the skin (Sekar & Abdul Jalil, 2017).

Spreadability

An ointment sample of 0.5 g was placed in the center of a round glass plate. Another round glass plate was placed on top, and a 100 g weight was applied. The spreadability setup was left undisturbed for 2 minutes. The diameter of the spread of the ointment was measured using a vernier caliper. The optimal spreadability range is 5-7 cm (Maesaroh et al., 2020).

Washability

The ointment formulations were applied to the hand, and their ease of washing under the running tap water was observed. Good washability was achieved when the applied ointment was easily removed with minimal effort, leaving the skin free from greasy residue (Shaikh et al., 2018).

Wound Infliction

The excision wound model was induced in Wistar albino rats following the procedures described by (Cauilan et al., 2021), with modifications. The excision wound model is the most commonly employed method to study wound healing (Remoué et al., 2020). The entire process was carried out under the supervision of the veterinarian-in-charge at the Philippine Institute of Traditional and Alternative Health Care (PITAHC). Appropriate Personal Protective Equipment (PPE) was worn to ensure safety and maintain aseptic conditions during the procedures. The animals were anesthetized with SC Lidocaine hydrochloride 2% dosed at 2.5 mg/kg before wound infliction. The dorsal skin was shaved with a razor and cleaned with ethyl alcohol 70% prior to wound infliction. A 6-mm biopsy punch was used to excise a full-thickness circular skin biopsy from the depilated

back. The ointments were applied topically with a sterile cotton-tipped applicator (Namunana et al., 2018).

Ointment Administration

Appropriate Personal Protective Equipment (PPE) was worn to ensure safety and maintain aseptic conditions. Prior to each application, the wound area was gently dabbed with a cotton swab moistened with distilled water to ensure a clear surface for optimal ointment application. The ointments were administered topically to the animals in the respective treatment groups once daily at 12:00 P.M. using a sterile cotton-tipped applicator. The application began on the day of wound infliction and continued through the 14th day. Povidone-Iodine 10% w/w ointment served as the positive control, as it has been widely recognized as a potent antiseptic for decades. Its broad-spectrum antimicrobial activity, rapid action, and favorable risk-benefit profile make it a highly effective therapeutic agent for both acute and chronic wound management (Bigliardi et al., 2017). The treatment groups are as follows: Treatment 1 (T1): Positive control (PC) (Povidone-Iodine, 10% w/w ointment), Treatment 2 (T2): Negative control (NC) (No treatment), Treatment 3 (T3): 8% w/w Busbusilak ethanolic leaf extract ointment, Treatment 4 (T4): 10% w/w Busbusilak ethanolic leaf extract ointment, and Treatment 5 (T5): 12% w/w Busbusilak ethanolic leaf extract ointment.

Evaluation of Wound Healing Activity

Wound Contraction Rate

Wound contraction indicates the rate of reduction of the unhealed area during the healing process. Thus, a faster rate of wound closure indicates better efficacy of medication (Ghosh et al., 2012), as cited in (G/giorgis et al., 2022). Wound area was measured using a vernier caliper on days 2, 4, 6, 8, 10, 12, and 14. Additionally, the wound area was photographed on these days using a cellular phone camera for documentation and visual comparison (Cauilan et al., 2021). The wound contraction rate was calculated using the formula:

$$\% \text{ of wound contraction} = \frac{\text{Wound area on day 0} - \text{Area of wound on nth day}}{\text{Wound area on day 0}} \times 100$$

Histopathological Evaluation

The histology slide preparations were conducted at the Histopathology Laboratory of St. Paul Hospital, Tuguegarao City, Inc. After the rats were euthanized at the end of the experiment, tissue samples from each treatment group were collected. The samples were preserved in 10% Formalin. The samples were dehydrated in 95% Ethanol. The tissues were treated with xylene, serving as a clearing solution. The tissue samples were embedded in paraffin wax. The processed tissues were cut into thin sections, each measuring 5 millimeters. Staining of the thin sections was performed using hematoxylin and eosin to facilitate histopathological evaluation. The processed histopathological tissue slides were evaluated and interpreted by a licensed veterinary pathologist. Labeled slide samples were provided directly to the pathologist for analysis. The pathologist performed a descriptive morphological analysis focusing on features such as re-epithelialization, polymorphonuclear leukocytes (PMNs), tissue macrophages (TMs), fibroblasts, neovascularization, and new collagen formation to ensure a thorough comparative assessment across all treatment groups (Udegbumam et al., 2022).

Data Analysis

Ointment formulations were evaluated by three independent assessors at three time intervals: immediately post-preparation, at 14 days, and at 30 days. Quality control was assessed based on organoleptic properties, homogeneity, pH, spreadability, and washability using standardized criteria (Appendix A). Each parameter was scored on a 5-point Likert scale (1 = Poor, 5 = Excellent). Data were expressed as mean $\pm$ standard deviation (SD) and subjected to Two-Way Analysis of Variance (ANOVA). Statistical significance was set at $p < 0.05$.

4. Results and Discussion

Evaluation of the Busbusilak Ointment Formulations

Table 2 Evaluation of the Busbusilak (*Tabernaemontana pandacacui*) Ointment Formulations Immediately After Preparation

Immediately After Preparation			
Parameters	Sample	Mean	Criteria
Organoleptic	8%	5	Excellent
	10%	5	Excellent
	12%	5	Excellent
Homogeneity Test	8%	5	Excellent
	10%	5	Excellent
	12%	5	Excellent
pH	8%	5	Excellent
	10%	5	Excellent
	12%	5	Excellent
Spreadability Test	8%	3	Good
	10%	1	Poor
	12%	1	Poor
Washability Test	8%	2	Fair
	10%	2	Fair
	12%	1	Poor

Table 2 shows the initial evaluation results for the Busbusilak ointment formulations at concentrations of 8%, 10%, and 12% immediately after preparation, as assessed by the three independent evaluators. The results were guided by the criteria provided by the researchers. All samples scored “Excellent” in Organoleptic, Homogeneity, and pH tests. However, spreadability and washability varied with concentration. Lower concentration (8%) consistently demonstrated better spreadability and washability compared to higher concentrations (10% and 12%). This finding is supported by the study conducted by (Maru & Lahoti, 2019), which showed that ointments containing lower concentrations of active ingredients exhibited improved spreadability and washability.

Table 3 Evaluation of the Busbusilak (*Tabernaemontana pandacacui*) Ointment Formulations After 14 Days under Refrigerated Temperature

After 14 Days				
Temperature	Parameters	Sample	Mean	Criteria
Refrigerated Temperature ($t = 5 \pm 3^\circ\text{C}$)	Organoleptic	8%	3.67	Very Good
		10%	4.33	Very Good
		12%	3	Good
	Homogeneity Test	8%	4.33	Good
		10%	4	Very Good
		12%	4	Very Good
	pH	8%	5	Excellent
		10%	5	Excellent
		12%	5	Excellent
	Spreadability Test	8%	2	Fair
		10%	1	Poor
		12%	2	Fair
	Washability Test	8%	2.67	Good
		10%	3.67	Very Good
		12%	3	Good

Table 3 presents the evaluation of Busbusilak ointments after 14 days at refrigerated temperature ($5 \pm 3^\circ\text{C}$). All samples were rated “Excellent” for pH. Organoleptic ratings were “Very Good” for 8% and 10%, and “Good” for 12%. Homogeneity scored “Very Good” for 10% and 12%, and “Good” for 8%. Spreadability was “Poor” for 10%, and “Fair” for 8% and 12%. Washability rated

“Very Good” for 10%, and “Good” for 8% and 12%. Overall, the ointments maintained acceptable physical and chemical properties under refrigerated conditions, with minor differences in organoleptic and spreadability depending on concentration.

Table 4 Evaluation of the Busbusilak (*Tabernaemontana pandacahui*) Ointment Formulations After 14 Days under Ambient Condition

After 14 Days				
Temperature	Parameters	Sample	Mean	Criteria
Ambient Condition (t = 25±2°C)	Organoleptic	8%	2	Fair
		10%	3.33	Good
		12%	3.67	Very Good
	Homogeneity Test	8%	2	Fair
		10%	4.33	Very Good
		12%	2.67	Good
	pH	8%	5	Excellent
		10%	5	Excellent
		12%	4	Very Good
	Spreadability Test	8%	1	Poor
		10%	2	Fair
		12%	1	Poor
	Washability Test	8%	4	Very Good
		10%	2.67	Good
		12%	1.67	Fair

Table 4 shows the evaluation results of the Busbusilak ointment formulations at various concentrations after 14 days under ambient conditions (25±2°C). The pH test rated 8% and 10% as “Excellent” and 12% as “Very Good.” Organoleptic ratings were “Fair” (8%), “Good” (10%), and “Very Good” (12%). Homogeneity scored “Very Good” for 10%, “Good” for 12%, and “Fair” for 8%. Spreadability was “Poor” for 8% and 12%, and “Fair” for 10%. In the Washability, the ointment was rated “Very Good” (8%), “Good” (10%), and “Fair” (12%). Overall, these findings indicate that the ointment formulations exhibited acceptable stability at ambient conditions, although the performance in terms of homogeneity, organoleptic properties, and spreadability varied with concentration.

Table 5 Evaluation of the Busbusilak (*Tabernaemontana pandacahui*) Ointment Formulations After 14 Days under Accelerated Condition

After 14 Days				
Temperature	Parameters	Sample	Mean	Criteria
Accelerated Condition (t = 40±2°C)	Organoleptic	8%	4.33	Good
		10%	4	Very Good
		12%	4	Very Good
	Homogeneity Test	8%	5	Excellent
		10%	5	Excellent
		12%	5	Excellent
	pH	8%	5	Excellent
		10%	5	Excellent
		12%	3	Good
	Spreadability Test	8%	1	Poor
		10%	1	Poor
		12%	1	Poor
	Washability Test	8%	4.33	Very Good
		10%	3.67	Very Good
		12%	3	Good

Table 5 shows the evaluation of Busbusilak ointments (8%, 10%, and 12%) after 14 days at accelerated conditions (40±2°C). The pH test rated 8% and 10% as “Excellent” and 12% as “Good.” All formulations scored “Excellent” in homogeneity. Organoleptic ratings were “Very Good” for 10%

and 12%, and “Good” for 8%. Spreadability was rated “Poor” across all formulations. Washability was “Very Good” for 8% and 10%, and “Good” for 12%. Overall, the ointments remained stable under accelerated conditions, with spreadability consistently identified as a weakness.

Table 6 Evaluation of the Busbusilak (*Tabernaemontana pandacacui*) Ointment Formulations After 1 month under Refrigerated Temperature

After 1 Month				
Temperature	Parameters	Sample	Mean	Criteria
Refrigerated Temperature (t = 5±3°C)	Organoleptic	8%	4.33	Good
		10%	4.67	Very Good
		12%	5	Excellent
	Homogeneity Test	8%	3	Good
		10%	4.67	Excellent
		12%	4	Very Good
	pH	8%	2	Fair
		10%	2	Fair
		12%	2	Fair
	Spreadability Test	8%	1	Poor
		10%	1	Poor
		12%	3	Good
	Washability Test	8%	4	Very Good
		10%	3.33	Good
		12%	3.33	Good

Table 6 presents the evaluation of Busbusilak ointments (8%, 10%, and 12%) after one month at refrigerated temperature (5±3°C). All formulations received a “Fair” rating for pH. Organoleptic ratings were “Excellent” (12%), “Very Good” (10%), and “Good” (8%). Homogeneity was rated “Excellent” (10%), “Very Good” (12%), and “Good” (8%). Spreadability was “Poor” for 8% and 10%, but “Good” for 12%. Washability was rated “Very Good” for 8%, and “Good” for both 10% and 12%. The ointment formulations showed acceptable stability under refrigerated conditions but had fair pH ratings and poor spreadability.

Table 7 Evaluation of the Busbusilak (*Tabernaemontana pandacacui*) Ointment Formulations After 1 month under Ambient Condition

After 1 Month				
Temperature	Parameters	Sample	Mean	Criteria
Ambient Condition (t = 25±2°C)	Organoleptic	8%	4.67	Excellent
		10%	4.67	Excellent
		12%	4	Very Good
	Homogeneity Test	8%	3.67	Very Good
		10%	4	Very Good
		12%	4	Very Good
	pH	8%	5	Excellent
		10%	5	Excellent
		12%	5	Excellent
	Spreadability Test	8%	3	Good
		10%	1	Poor
		12%	1	Poor
	Washability Test	8%	3	Good
		10%	3	Good
		12%	3.33	Good

Table 7 shows the evaluation of Busbusilak ointment formulations (8%, 10%, and 12%) after one month at ambient conditions (25±2°C). All formulations scored “Excellent” in pH and “Very Good” in homogeneity. The 8% and 10% formulations received “Excellent” ratings for organoleptic properties, while the 12% scored “Very Good.” Spreadability was rated “Good” for 8%, but “Poor” for 10% and 12%. Washability was “Good” across all formulations. The 8% Busbusilak ointment demonstrated the best overall physical properties, including excellent pH, homogeneity, organoleptic

quality, and good spreadability and washability. The 10% and 12% formulations maintained good stability but had poorer spreadability.

Table 8 Evaluation of the Busbusilak (*Tabernaemontana pandacaqui*) Ointment Formulations After 1 month under Accelerated Condition

After 1 Month				
Temperature	Parameters	Sample	Mean	Criteria
Accelerated Condition (t = 40±2°C)	Organoleptic	8%	1.67	Fair
		10%	2.3	Fair
		12%	2.33	Fair
	Homogeneity Test	8%	4.67	Excellent
		10%	4.67	Excellent
		12%	5	Excellent
	pH	8%	3	Good
		10%	3.67	Very Good
		12%	2.33	Fair
	Spreadability Test	8%	1	Poor
		10%	1	Poor
		12%	3	Good
	Washability Test	8%	2.67	Good
		10%	4.33	Very Good
		12%	3.33	Good

Table 8 shows the evaluation of Busbusilak ointments (8%, 10%, and 12%) after one month at accelerated conditions (40±2°C). All formulations were rated “Fair” in organoleptic tests, while homogeneity was consistently “Excellent.” pH ratings varied, with 8% rated “Good,” 10% “Very Good,” and 12% “Fair.” Spreadability was “Poor” for 8% and 10%, but “Good” for 12%. Washability was “Good” for 8% and 12%, and “Very Good” for 10%. Overall, the ointment formulations maintained good homogeneity and washability under accelerated conditions, though organoleptic and spreadability ratings were generally lower.

Based on a comprehensive evaluation of organoleptic properties, homogeneity, pH stability, spreadability, and washability across different concentrations (8%, 10%, and 12%) of Busbusilak (*Tabernaemontana pandacaqui*) ointments under refrigerated, ambient, and accelerated conditions, the 10% formulation stored at ambient temperature for one month demonstrated the most favorable overall profile. Although the 8% concentration exhibited superior spreadability, its limitations in washability and sustained pH stability reduced its overall performance. Conversely, the 12% concentration displayed commendable homogeneity, organoleptic properties, and washability but was compromised by suboptimal pH stability under accelerated conditions and poor spreadability. The 10% formulation achieved a balance of excellent homogeneity, consistent organoleptic quality, stable pH across various storage conditions, and satisfactory washability despite showing lower spreadability.

Table 9 Average Percent Wound Contraction of the Samples After Administration of Treatment Groups

Treatment Group	Percentage Wound Contraction (%)						
	Day 2	Day 4	Day 6	Day 8	Day 10	Day 12	Day 14
T1 (PC)	30.17	33.63	39.50	44.11	55.47	93.08	100
T2 (NC)	32.85	37.42	39.61	44.41	57.03	77.71	88.45
T3 (8%)	29.38	32.31	39.65	48.98	55.36	80.36	90
T4 (10%)	34.08	36.81	36.51	36.95	39.27	60.60	77.49
T5 (12%)	18.79	18.57	23.66	24.45	40.36	52.79	72.78

Table 9 shows that the positive control achieved the highest wound contraction, reaching 100% by Day 14. The 8% Busbusilak ointment followed with 90%, outperforming both the 10% (77.49%) and 12% (72.78%) concentrations. The negative control reached 88.45%. Among the Busbusilak treatments, 8% showed the best wound healing effect, suggesting it may be the most effective concentration tested.

Table 10 Paired T-Test for Time-Related Effects on Wound Contraction (Within-Subjects Effects)

Treatment Group	Within Subjects Effects (%)				
	Mean (Day 2)	Mean (Day 14)	Mean Difference	p-value	Description
T1 (PC)	30.2	100	-69.8	<0.001	Significant
T2 (NC)	32.8	88.5	-55.6	0.003	Significant
T3 (8%)	29.4	90	-60.6	0.015	Significant
T4 (10%)	34.1	77.5	-43.4	0.065	Not Significant
T5 (12%)	18.8	72.8	-54.0	0.064	Not Significant

Table 10 presents the results for the paired t-test for the time-related effects on wound contraction within subjects. The table shows that the mean wound contraction rate increased for T1 (Positive Control) ($p < 0.001$), T2 (Negative Control) ($p < 0.003$), and T3 (8%) ($p < 0.015$). The table also showed that it was not evident that both T4 (10%) ($p > 0.065$) and T5 (12%) ($p > 0.064$) were able to increase the wound contraction rate. Their wound contraction rates increased by 69.8%, 55.6%, 60.6%, 43.4%, and 54.0%, respectively. The results show that wound contraction over time was significant in the positive control, negative control, and 8% ointment groups, but not in the higher concentrations (10% and 12%) of the Busbusilak ointment over the 14-day period.

This finding supports the concept of a therapeutic threshold, in which increasing concentrations beyond an optimal level do not necessarily enhance efficacy and may even reduce it (Boateng & Catanzano, 2015). Similar dose-dependent effects were also observed in a study on *Centella asiatica*, where optimal wound healing was seen at moderate extract concentrations, while higher doses slowed epithelialization (Arribas-López et al., 2022). Additionally, a study by (Elhosari et al., 2022) investigated the cytotoxic potential of fungal endophytic extracts isolated from *T. pandacaqui* leaves. The findings indicated that these extracts exhibit significant cytotoxicity, suggesting that compounds derived from the leaves can be toxic to cells at elevated concentrations.

Table 11 Analysis of Variance for Treatment-Related Effects on Wound Healing on Day 14 (Between-Subjects Effects)

Between Subjects Effects on Day 14							
	Sum of Squares	df	Mean Square	F	p	Description	Decision
Treatment	2324	4	581.1	0.823	0.526	Not Significant	Accept Ho
Residual	14120	20	706.0				

Table 11 presents the ANOVA results for treatment-related effects on wound healing on Day 14. The analysis shows no difference between treatment groups ($F = 0.823$, $p = 0.526$), indicating that there is no significant difference in the wound healing activity based on the rate of wound contraction in Wistar albino rats after the administration of Treatment 1, Treatment 2, Treatment 3, Treatment 4, and Treatment 5. This result indicates that both the control and experimental groups produced similar effects, suggesting that all treatment groups are equally effective.

Figure 1 shows the photographic progression of wound contraction across the various treatment groups throughout the observation period. The images illustrate how each treatment influenced the rate and extent of wound healing over time. Noticeable differences in wound size and closure are evident between groups.

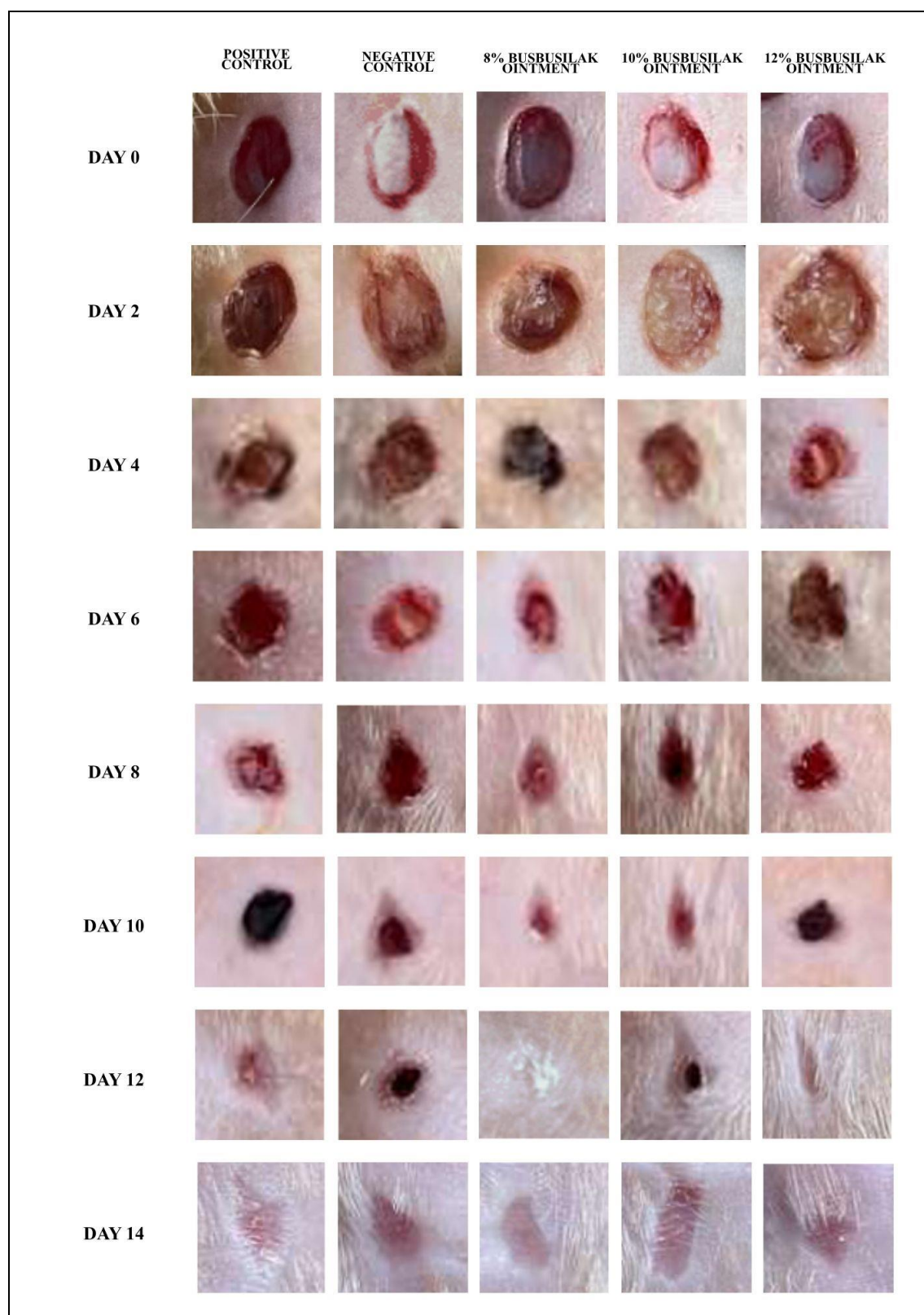


Figure 1 Photographic representation of the wound contraction across different treatment groups over the observation period.

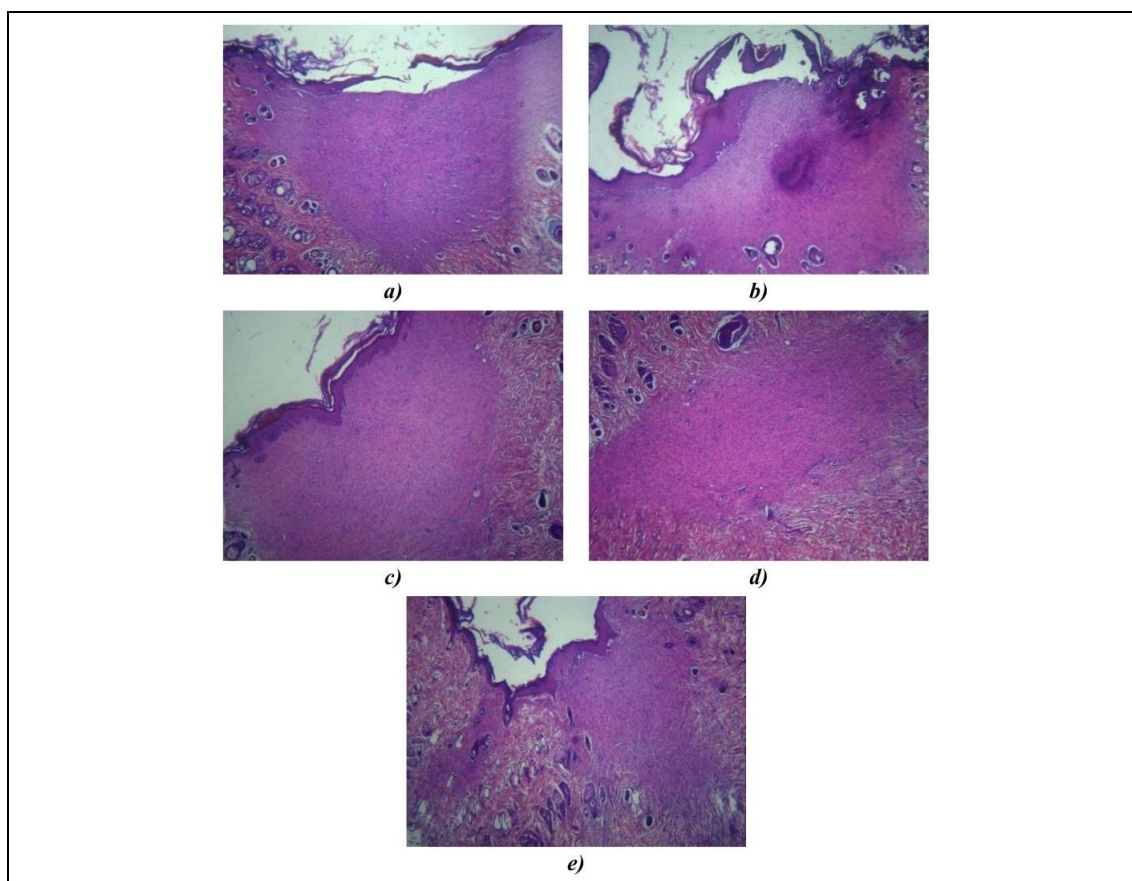


Figure 2 Microscopic view of the histopathological characteristics of the tissue samples from the test animals at the end of the experiment.

Figure 2 presents the microscopic view of the histopathological characteristics of tissue samples taken from the wounds of test animals at the end of the experiment. The samples are categorized as follows: (a) T1 (Positive Control) – Povidone-Iodine 10% w/w ointment, (b) T2 (Negative Control), (c) T3 – 8% Busbusilak ointment, (d) T4 – 10% Busbusilak ointment, and (e) T5 – 12% Busbusilak ointment.

Table 12 Histopathological Evaluation of the Wounds of Test Subjects after the Administration of Different Treatments

Treatment Groups	Histopathologic Description
T1 (PC)	Complete re-epithelialization above the well-defined granulation tissue composed of fibroblast and collagen supporting multiple sites of angiogenesis.
T2 (NC)	Complete re-epithelialization with marked parakeratosis above the well-defined granulation tissue composed of fibroblast and collagen supporting multiple sites of angiogenesis. Inflammatory cell infiltrations still present beneath the immature epidermis.
T3 (8%)	Complete re-epithelialization with parakeratosis above the well- defined granulation tissue composed of fibroblast and collagen supporting multiple sites of angiogenesis. Part of the wound scab still intact.
T4 (10%)	Well-defined granulation tissue composed of fibroblast and collagen supporting multiple sites of angiogenesis.
T5 (12%)	Complete re-epithelialization with parakeratosis above the well- defined granulation tissue composed of fibroblast and collagen supporting multiple sites of angiogenesis. Wound scab was detached.

Table 12 presents the histopathological evaluation of the wounds after administration of different treatments. The positive control (Povidone-iodine, 10% w/w ointment) showed complete re-epithelialization, mature granulation tissue with fibroblasts and collagen, and strong angiogenesis. The negative control also had re-epithelialization but showed parakeratosis and residual inflammation, indicating delayed healing. The 8% Busbusilak ointment showed complete re-epithelialization with parakeratosis, well-defined granulation tissue, and partial scab retention. The 10% concentration had granulation tissue and angiogenesis but lacked full re-epithelialization. The 12% ointment showed complete re-epithelialization with parakeratosis, well-defined granulation tissue, and scab detachment, indicating more advanced histological healing than 8%, though parakeratosis suggested ongoing maturation.

However, despite this apparent histological progress, the 12% ointment was less effective at promoting wound contraction over time than the 8% concentration, which showed a significant increase in the contraction rate, as observed in Table 16. This discrepancy may be due to higher concentrations causing delayed functional healing through prolonged inflammation or cytotoxic effects that impair efficient wound contraction and closure. Thus, while 12% Busbusilak ointment shows advanced tissue changes under the microscope, it may hinder the coordinated cellular processes necessary for timely wound contraction. Lower concentrations, like 8%, appear to better balance tissue regeneration and functional repair. Recent studies support this concentration-dependent effect; for example, (Shafeie et al., 2015) found that moderate doses of *Calendula officinalis* extract enhanced wound contraction better than higher doses, which induced inflammation and delayed healing. Similarly, (Arribas-López et al., 2022) reported that optimal concentrations of *Centella asiatica* promoted fibroblast proliferation and angiogenesis, while excessive doses impaired wound closure. These findings emphasize the importance of dose optimization in herbal wound therapies and support the superior functional healing observed with 8% Busbusilak ointment in this study.

5. Conclusion

Based on the findings of this study, the wound healing potential of Busbusilak (*Tabernaemontana pandacaqui*) ethanolic leaf extract ointment was successfully demonstrated using an excision wound model in Wistar albino rats. The 10% concentration showed the highest overall stability after one month, particularly under ambient storage conditions. However, the 8% concentration showed a superior wound contraction rate compared to the 10% and 12% concentrations.

Histopathological analysis revealed that the 12% ointment led to complete re-epithelialization, mature granulation tissue formation, and scab detachment, indicating advanced structural repair. However, its limited wound contraction rate suggests that higher concentrations may disrupt coordinated healing processes, possibly due to cytotoxic effects. On the other hand, the 8% formulation demonstrated effective tissue regeneration and a higher wound contraction rate, despite showing parakeratosis and partial scab retention. This suggests that the 8% concentration may offer a more favorable therapeutic profile by supporting both structural and functional aspects of wound healing.

The presence of flavonoids in the extract is likely responsible for the enhanced wound healing effects, acting through antioxidant, anti-inflammatory, and antimicrobial mechanisms. This study confirms the therapeutic potential of Busbusilak as a natural alternative for wound management and encourages further exploration of its other pharmaceutical applications.

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The Integration of AI-Assisted Learning Tools: Impacts on Critical Thinking Skills and Academic Integrity of Radiologic Technology Students

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Abstract

Radiologic technology education enhances learning, critical thinking, and academic integrity. This study aimed to determine the levels of AI-assisted learning tool integration, critical thinking, and academic integrity among radiologic technology students and examine the relationships among these variables. A descriptive-correlational research design was employed. Data were collected through a validated questionnaire that underwent pilot testing for reliability before administration to undergraduate radiologic technology students and were analyzed using descriptive and inferential statistics. The findings revealed high AI-assisted learning tool integration, high critical thinking, and high academic integrity among the respondents. AI-assisted learning tool integration was significantly associated with enhanced critical thinking; however, neither AI-assisted learning tool integration nor critical thinking was significantly related to academic integrity. The study concludes that AI-assisted learning tools can strengthen students' critical thinking but do not necessarily influence ethical academic behavior. The findings are limited by the use of a single institution, a cross-sectional design, and self-reported data, which may limit the generalizability of the results.

Keywords: Artificial Intelligence, AI-Assisted Learning Tools, Critical Thinking, Academic Integrity, Radiologic Technology

1. Introduction

In a world where information is everywhere, AI becomes more than just a helper; it becomes a personalized learning companion, turning frustration into curiosity and study time into something far more engaging and dynamic. Imagine having a smart study partner available 24/7, one that can explain difficult concepts, generate essay ideas, help debug code, summarize lengthy readings, and even quiz you before exams.

Effective integration goes beyond just using these tools. It requires thoughtful and responsible application. From writing assistants that help improve grammar and style to research tools that condense hours of reading into key insights, AI is making learning more efficient and personalized than ever (Malik et al., 2023). Instead of replacing effort, these tools enhance students' ability to concentrate on understanding imaging protocols and diagnostic practices rather than being burdened by repetitive tasks. However, with great power comes great responsibility. Knowing how to integrate AI effectively and ethically in learning and clinical practice is becoming an essential skill for radiologic technology students.

When utilizing AI, learners should be taught to consider whether the information is credible. Does it make sense? Do I need to take into account any additional viewpoints? AI can offer opportunities, but it is the student's responsibility to confirm facts, make connections between concepts, and apply knowledge in meaningful ways. It is where critical thinking comes in, helping students challenge, analyze, and evaluate the information AI offers rather than taking it at face value. According to Lawasi et al. (2024), critical thinking turns AI from a quick fix into a potent learning tool. It gives students the ability to solve complex problems, make well-informed judgments, and develop stronger understanding skills that are crucial regardless of how advanced technology becomes. When students actively interact with the material, exercise critical thought, and generate original ideas, learning takes place.

As AI technologies become increasingly accessible, students may be tempted to use them for assignments without fully understanding the subject matter. However, submitting AI-generated work as one's own is academic dishonesty. (Mathivanan and Rao, 2026). Even when utilizing AI, academic integrity prioritizes truthfulness, equity, and accountability. Students uphold these principles by

adhering to school policies and appropriately acknowledging AI aid. Building trust, honing skills, and preparing for long-term success in an AI-driven environment are all facilitated by academic integrity.

Previous studies emphasized the value of AI-assisted tool integration, critical-thinking skills, and academic integrity. However, it did not focus on the specific context of radiologic technology students. Moreover, no studies have examined the integration of AI, critical thinking, and academic integrity together in this field. This research aimed to explore how AI tools can be effectively integrated into radiologic technology education, assess the impact on students' critical-thinking skills, and examine how academic integrity is maintained when using these tools in academic tasks.

2. Objectives

The study aims to determine the levels of integration of AI-assisted learning tools, critical thinking skills, and academic integrity among third-year radiologic technology students. Furthermore, it seeks to examine the relationships among these variables to better understand how they influence one another.

3. Materials and methods

This study employed a non-experimental, quantitative research design using a descriptive-correlational approach to examine the impact of integrating AI-assisted learning tools on critical thinking skills and academic integrity among radiologic technology students. This method enables the researcher to describe variables and examine relationships among them without manipulating any variables. Descriptive-correlational research is commonly used to determine associations between variables as they naturally occur (Creswell & Creswell, 2023). The descriptive component assessed the integration of AI-assisted learning tools and respondents' critical thinking skills and academic integrity, while the correlational component examined whether significant relationships existed among these variables.

Primary data were collected through a structured survey questionnaire administered to radiologic technology students at the University of Perpetual Help—Dr. Jose G. Tamayo Medical University during the second semester of AY 2025–2026. A random sampling technique was used to select 181 respondents from a population of 338, based on a 95% confidence level and 5% margin of error. Proportional allocation resulted in (70) first-year, (50) second-year, (42) third-year, and (19) fourth-year students. Inclusion criteria required that participants be currently enrolled radiologic technology students with exposure to AI-assisted learning tools.

The instrument used in this study was a researcher-developed questionnaire composed of three parts: integration of AI-assisted learning tools, critical thinking skills, and academic integrity among radiologic technology students. The questionnaire employed a four-point Likert scale ranging from 1 (Strongly Disagree) to 4 (Strongly Agree). The instrument underwent expert validation and pilot testing, with reliability assessed using Cronbach's alpha. The results revealed that Part I (Level of Integration of AI-Assisted Learning Tools) obtained a reliability coefficient of 0.73 (Acceptable), Part II (Critical Thinking Skills) gained 0.90 (Excellent), and Part II (Academic Integrity) had 0.93 (Excellent), making it a reliable tool for data collection. Data gathering was conducted online after securing institutional permission and informed consent, with strict confidentiality observed.

Responses were measured using a four-point Likert scale, with mean and weighted mean used to determine the levels of AI-assisted learning tool integration, critical thinking skills, and academic integrity. Mean scores were interpreted as Very High (3.25–4.00), High (2.50–3.24), Low (1.75–2.49), and Very Low (1.00–1.74). Ranking was likewise employed to arrange the indicators according to their mean scores, allowing the researcher to identify which aspects of AI-assisted learning tool integration, critical thinking skills, and academic integrity were rated highest or lowest by the respondents. This facilitated the interpretation of the findings by highlighting the relative strengths and areas that may require further attention.

The Pearson product-moment correlation coefficient (r) was used to assess the significant relationships among the level of integration of AI-assisted learning tools, critical thinking skills, and academic integrity. All hypotheses were tested at a 0.05 level of significance.

4. Results

Table 1 Integration of AI-assisted learning tools among radiologic technology students

Indicators	Weighted Mean	Interpretation	Rank
1. AI-assisted tools (e.g., generative pre-trained transformer tools and AI-based apps) are regularly used to support academic tasks.	3.16	High	5
2. AI-assisted tools are integrated into daily study routines.	2.95	High	14
3. AI tools are used to enhance understanding of complex concepts in radiologic technology.	3.30	Very High	3
4. AI-assisted learning tools are accessible whenever needed.	3.34	Very High	1
5. AI tools are relied upon to review lessons and prepare for examinations.	3.12	High	7
6. Instructors encourage the use of AI-assisted learning tools in coursework.	2.55	High	15
7. AI tools are incorporated into academic activities (e.g., assignments, research, case analysis).	3.00	High	11
8. AI-assisted tools are used to enhance problem-solving skills in radiologic technology subjects.	2.99	High	12
9. AI-assisted learning tools are easy to use and navigate.	3.33	Very High	2
10. AI tools are used to supplement information from textbooks and lectures.	3.02	High	10
11. AI-assisted tools are part of collaborative learning activities (e.g., group discussions, projects).	3.04	High	9
12. Students demonstrate confidence in using AI-assisted tools for academic work.	2.97	High	13
13. The use of AI tools has become common among classmates.	3.22	High	4
14. AI-assisted tools are used responsibly in completing academic requirements.	3.13	High	6
15. AI-assisted learning tools are effectively integrated into the overall learning experience.	3.07	High	8
Overall Weighted Mean	3.08	High	

Table 1 presented the level of integration of AI-assisted learning tools among radiologic technology students. Indicator 4, which referred to the accessibility of AI-assisted learning tools, obtained the highest rank with a weighted mean of 3.34 and was interpreted as very highly integrated. This finding suggested that students generally had consistent access to AI-assisted platforms and applications, allowing them to incorporate these tools into their academic tasks with relative ease. The high accessibility may also have reflected the widespread availability of digital devices and internet connectivity, which supported the use of such technologies in their learning environment.

In contrast, Indicator 6 received the lowest rank, with a weighted mean of 2.55, indicating that Instructors encourage the use of AI-assisted learning tools in coursework. This implied that, although AI-assisted tools were accessible, their use for deeper academic purposes, such as enhancing or extending course content, remained limited. Furthermore, this may have suggested that instructors did not strongly encourage or integrate the use of AI-assisted learning tools into coursework, which could have influenced how students perceived their academic value. Overall, the respondents demonstrated a high level of integration of AI-assisted learning tools, as reflected by the overall weighted mean of 3.08. This indicated that, in general, these tools were readily available and easy to use among the students. However, while accessibility was high, there was still an opportunity to further promote their effective academic application, particularly in supporting and enriching traditional learning materials.

These findings were supported by Acosta-Vargas et al. (2025), who emphasized that e-learning systems allowed students to access educational content anytime and anywhere. Their study also highlighted that AI-powered platforms provided continuous and convenient access to learning materials, further enhancing their usability. However, they also noted that the integration of AI features across platforms could be inconsistent, pointing to gaps in implementation. Similarly, Bond et al. (2025) found that there was still limited understanding and structured use of AI tools in higher education, which may have explained the uneven adoption and varying levels of support from educators.

Table 2 Level of critical thinking skills among Radiologic Technology students

Indicators	Weighted Mean	Interpretation	Rank
1. Radiologic problems are examined independently before consulting AI-assisted tools.	3.28	Very High	1
2. Complex radiologic concepts are broken down into smaller components during AI use.	3.12	High	10
3. AI-generated responses are compared with personal reasoning before acceptance.	3.14	High	7
4. Key elements of a problem are identified when interpreting AI-generated explanations.	3.17	High	4
5. Relationships between concepts and variables are analyzed when reviewing AI-generated information.	3.14	High	8
Analysis Skills (Mean)	3.17		
6. Information provided by AI-assisted learning tools is interpreted accurately	2.83	High	15
7. Unclear or ambiguous AI-generated responses are questioned and clarified.	3.21	High	2
8. AI-generated explanations are related to previously learned radiologic concepts.	3.07	High	12
9. Relevant information is distinguished from irrelevant details in AI outputs.	3.07	High	13
10. Meaning is accurately derived from AI-generated explanations in a radiologic context.	2.88	High	10
Interpretation Skills (Mean)	3.01		
11. The accuracy and reliability of AI-generated information are critically assessed.	3.13	High	9
12. Inconsistencies or errors in AI-generated responses are identified.	3.17	High	5
13. AI-generated answers are validated using	3.12	High	11

Indicators	Weighted Mean	Interpretation	Rank
textbooks, lectures, or credible sources.			
14. Informed judgments are made regarding the acceptance or rejection of AI outputs.	3.15	High	6
15. The relevance and appropriateness of AI-generated information to specific radiologic tasks are evaluated.	3.20	High	3
Evaluation Skills (Mean)	3.16		
Overall Weighted Mean	3.11	High	

Table 2 presents the level of critical thinking skills among radiologic technology students while using AI-assisted learning tools, with an overall weighted mean of 3.11, indicating a high level of critical thinking. This suggests that students are able to analyze, interpret, evaluate, and apply knowledge effectively in their learning activities. It may also imply that integrating AI tools does not hinder their ability to think critically; in fact, these tools may even support analysis, interpretation, evaluation, and informed decision-making within the context of radiologic technology studies.

Among the indicators, the statement “Radiologic problems are examined independently before consulting AI-assisted tools” ranked first. This shows that students most strongly demonstrate the ability to analyze and evaluate problems on their own before using AI as a supplementary resource. Conversely, the statement “Information provided by AI-assisted learning tools is interpreted accurately” ranked last. This suggests that students tend to critically analyze AI-generated content rather than accepting it at face value, reflecting a thoughtful and evaluative approach to learning.

These findings are supported by Feigerlova et al. (2025), who reported that AI applications in medical education were positively associated with critical thinking and clinical competency, indicating that students using AI tools continue to engage in higher-order cognitive skills. Similarly, Hamdan-Mansour et al. (2025) found that medical students using AI tools demonstrated higher levels of critical thinking, showing that AI can enhance students’ ability to analyze and evaluate information. However, interpreting AI outputs accurately requires critical evaluation of their accuracy, relevance, bias, and quality, making this an essential competency rather than a process of passive acceptance.

Table 3 Level of academic integrity in the College of Radiologic Technology

Indicators	Weighted Mean	Verbal Interpretation	Rank
1. Academic tasks are completed honestly without total reliance on AI-assisted tools.	3.03	High	15
2. AI-generated information is referenced properly to maintain academic integrity.	3.15	High	14
3. Answers are not copied directly from AI tools during quizzes or examinations.	3.31	Very High	9
4. Original work is submitted for all my assignments and projects.	3.25	Very High	12
5. Understanding and actively avoiding what constitutes plagiarism, fabrication, and the improper use of AI-assisted tools.	3.40	Very High	6
6. Institutional policies regarding academic honesty, including rules on the integration of AI-assisted tools, are followed.	3.35	Very High	8
7. Unauthorized materials, such as digital devices with access to AI, during examinations are not allowed during	3.50	Very High	2

Indicators	Weighted Mean	Verbal Interpretation	Rank
examinations.			
8.Responsibility and accountability are applied to maintain honesty when integrating AI tools into my academic work.	3.41	Very High	4
9.AI tools are avoided in ways that violate academic policies.	3.36	Very High	7
10. Use of AI-assisted tools is acknowledged when required by my instructor.	3.20	Very High	13
11. Students do not allow others to copy their work and revise it using AI tools.	3.27	Very High	10
12. Honesty is valued more than achieving high grades.	3.43	Very High	3
13. Dishonest academic practices are reported or discouraged when encountered.	3.26	Very High	11
14. All submitted work reflects the student's own understanding and effort.	3.41	Very High	5
15. Students are aware of the consequences of academic dishonesty and strive to avoid them.	3.51	Very High	1
Overall Weighted Mean	3.32	Very High	

Table 3 presents the level of academic integrity among radiologic technology students in the context of using AI-assisted learning tools, with an overall weighted mean of 3.32, indicating a very high level of academic integrity. This suggests that respondents generally demonstrate responsible and ethical behavior when using AI-assisted tools in their academic work. However, it is important to note that these findings are based on self-reported data, which may be subject to bias. This is particularly evident as the lowest-ranked indicator relates to completing academic tasks honestly without total reliance on AI-assisted tools.

Among the indicators, the statement “students are aware of the consequences of academic dishonesty and strive to avoid them” ranked first. This highlights that students’ awareness and understanding of the consequences associated with academic dishonesty play a significant role in maintaining ethical behavior. At the same time, the results show that while students continue to value honesty, there is an increasing reliance on AI-assisted tools in completing academic tasks, as reflected in the statement “Academic tasks are completed honestly without total reliance on AI-assisted tools” ranking last. This does not necessarily imply dishonest behavior; rather, it may indicate that students are gradually integrating AI into their usual learning practices, using it to generate ideas, clarify concepts, and improve their outputs.

These findings are supported by Cotton et al. (2024), who found that many students use AI tools responsibly, not primarily for cheating but as support for learning, reflecting their continued regard for academic integrity. Similarly, Kasneci et al. (2023) noted that AI tools are increasingly utilized as assistive technologies for idea generation, explanation, and feedback. Their use, therefore, reflects a shift in learning practices rather than an inherent form of academic misconduct.

Table 4 Relationship between the level of integration of AI-assisted learning tools and the level of critical thinking skills among Radiologic Technology students

Variables	Statistical Treatment	p-value	Decision	Interpretation
Relationship between the level of integration of AI-assisted learning tools and the level of critical thinking skills among Radiologic Technology students	Pearson-r r: 0.6244025946	0.00000	Null Hypothesis Accepted	Significant Relationship
Significant @ <0.05				

For the relationship between the level of integration of AI-assisted learning tools and the level of critical thinking skills among radiologic technology students, a p-value of 0.00000, which was lower than the test of significance at 0.05, showed a significant relationship between the integration of AI-assisted learning tools and critical thinking skills. The strength of the correlation is moderate ($r = 0.6244$), suggesting that higher integration of AI-assisted learning tools is associated with higher levels of critical thinking skills.

The findings reveal a notable correlation between the use of AI-assisted learning tools and the critical thinking abilities of students in radiologic technology. The moderate positive relationship implies that increased usage of AI tools corresponds with improved critical thinking; however, it's important to consider that additional factors may also play a role. This aligns with contemporary research, which emphasizes that AI tools when incorporated into thoughtfully designed instructional methods offer cognitive support through adaptive feedback, reflective prompts, and conversation simulations. These features promote reflective reasoning, self-directed learning, and evaluative thinking, thus aiding the enhancement of higher-order cognitive skills (Balart, Díaz, & Shryock, 2026; Li, 2025).

Similarly, Li (2025) claims that AI-enabled learning platforms improve students' metacognitive skills by encouraging them to examine their own thought processes through questions and real-time feedback. The student can develop advanced thinking abilities, such as analytical and problem-solving skills, through regular cognitive engagement.

Overall, present findings are consistent with prior findings, indicating that AI-supported educational apps have the potential to boost critical thinking abilities when used properly in teaching procedures. Nonetheless, given the modest relationship between factors, it is required to use not only AI, but also other ways to optimize educational processes.

Table 5 Relationship between the level of integration of AI-assisted learning tools and the level of academic integrity in the College of Radiologic Technology

Variables	Statistical Treatment	p-value	Decision	Interpretation
Relationship between the level of integration of AI-assisted learning tools and the level of academic integrity in the College of Radiologic Technology	Pearson-r r: -0.1443330508	0.05127	Null Hypothesis Rejected	No Significant Relationship
Significant @ <0.05				

For the relationship between the level of integration of AI-assisted learning tools and the level of academic integrity in the College of Radiologic Technology, a p-value of 0.05127, which was higher than the test of significance at 0.05, showed no significant relationship between the integration of AI-assisted learning tools and academic integrity. The strength of the correlation is very low ($r = -0.1443$), suggesting that the integration of AI-assisted learning tools and academic integrity are not strongly related.

Yusuf et al. (2024) focused on this argument, claiming that academic honesty does not exist in an environment where artificial intelligence plays a part in learning processes due to the default employment of such technologies. It is impacted by norms, regulations, academic culture, and, most notably, ethical education.

Similarly, Cotton, Cotton, and Shipway (2023) observed that, while generative AI raises concerns about academic dishonesty in higher education, the presence of AI does not ensure the occurrence of unethical behavior. This study demonstrates how evaluation methods, institutional procedures, and students' understanding of acceptable AI use all have a significant impact on academic integrity.

In general, the current findings are consistent with previous research, which indicates that academic integrity is mostly controlled by educational framework and ethical issues, rather than AI-assisted learning instruments.

Table 6 Relationship between the level of critical thinking skills and the level of academic integrity in the College of Radiologic Technology

Variables	Statistical Treatment	p-value	Decision	Interpretation
Relationship between the level of critical thinking skills and the level of academic integrity in the College of Radiologic Technology	Pearson-r r: 0.03417865554	0.64601	Null Hypothesis Rejected	No Significant Relationship
Significant @ <0.05				

For the relationship between the level of critical thinking skills and the level of academic integrity in the College of Radiologic Technology, a p-value of 0.64601, which was higher than the test of significance at 0.05, showed no significant relationship between critical thinking skills and academic integrity. The strength of the correlation is negligible ($r = 0.0342$), suggesting that critical thinking skills and academic integrity are not related.

This result suggests that critical thinking and academic integrity are separate phenomena. Critical thinking focuses on cognitive processes including information processing, interpretation, and assessment, whereas academic integrity is based on ethical decision-making and adherence to institutional standards. The weak link shows that improving cognitive skills alone does not automatically result in ethical conduct.

Yusuf, Pervin, and Román-González (2024) agree that academic integrity in higher education is not solely defined by students' cognitive capacities. According to their findings, institutional regulations, assessment design, and explicit teaching on correct academic conduct have a greater effect on ethical behavior than intellectual skills like critical thinking. This implies that even highly talented students may commit academic dishonesty if ethical frameworks are weak or ambiguous.

In the same way, it has been found by Cotton, Cotton, and Shipway (2023) that the integration of generative AI in educational settings has complicated the discourse around academic integrity. However, the researchers' findings indicate that ethical behavior cannot be considered as a function of an individual's intellectual capabilities or level of technological exposure. Rather, their research reveals that academic integrity relies heavily on the assessment process and the students' understanding.

Dawson (2023) also emphasizes that academic integrity is heavily context-dependent, impacted by assessment contexts, perceived pressure, and institutional culture. His research demonstrates that even individuals with superior reasoning skills may engage in academic dishonesty when external constraints outweigh ethical considerations, supporting the weak link between cognitive capacity and integrity.

Overall, the results are consistent with previous research indicating that critical thinking and academic integrity develop separately. While critical thinking improves academic achievement and reasoning, institutional frameworks, ethical instruction, and assessment design have a greater impact on academic integrity than cognitive aptitude.

5. Discussion

The findings of this study indicate that AI-assisted learning tools are well integrated into the academic environment of radiologic technology students, primarily due to their accessibility and ease of use. However, despite their widespread availability, these tools are less frequently utilized for deeper academic purposes, such as supplementing textbooks and lectures. This suggests that while students have incorporated AI into their study routines, there is still room to maximize its potential for meaningful learning. These findings are consistent with Acosta-Vargas et al. (2025), who emphasized

that AI-powered e-learning platforms provide continuous and convenient access to educational resources, although AI integration across platforms remains inconsistent. Similarly, Bond et al. (2025) reported that the limited understanding and structured implementation of AI in higher education contribute to its uneven adoption and use among students and educators.

Furthermore, the results demonstrate that students possess a high level of critical thinking skills, with many choosing to analyze radiologic problems independently before consulting AI. The significant moderate relationship between AI integration and critical thinking further implies that AI, when used appropriately, can support higher-order thinking processes. These findings are consistent with Feigerlova et al. (2025) and Hamdan-Mansour et al. (2025), who reported that AI applications in medical education enhance critical thinking and clinical competence by encouraging students to analyze and evaluate information. Likewise, Balart et al. (2026) and Li (2025) emphasized that AI promotes reflective reasoning, metacognitive awareness, and self-directed learning through adaptive feedback and interactive learning experiences.

In contrast, the study revealed that academic integrity remains largely independent of both AI integration and critical thinking skills. Despite students reporting a very high level of academic integrity, no significant relationship was found between academic integrity and the other variables, indicating that ethical behavior is influenced more by institutional policies, personal values and educational context rather than technological exposure to AI or cognitive ability alone. This finding reinforces the idea that while AI can enhance learning efficiency and thinking skills, it does not inherently determine whether students act ethically. These findings are consistent with Yusuf et al. (2024), who emphasized that academic integrity is shaped by academic culture, institutional regulations, and ethics instruction rather than the mere presence of AI in learning. Likewise, Cotton et al. (2024) and Dawson (2023) noted that while AI presents new challenges to academic integrity, ethical behavior depends primarily on assessment design, institutional policies, and students' understanding of responsible AI use. Therefore, the integration of AI in radiologic technology education should be accompanied by clear ethical guidelines, strengthened academic policies, and continuous reinforcement of integrity to ensure that students not only learn effectively but also uphold professional and ethical standards in both academic and clinical practice.

6. Conclusion

AI-assisted learning tools are highly integrated into the learning environment of radiologic technology students, being both available and readily accessible whenever needed. The accessibility of these learning tools facilitates students' daily educational activities, thereby enhancing learning efficiency and overall academic experience. The integration of AI tools further complements students' high-level critical thinking skills, enabling students to independently examine and analyze radiologic problems before consulting AI resources. Furthermore, radiologic technology students demonstrate a very high level of academic integrity, reflecting a strong awareness of the consequences of academic dishonesty and a commitment to upholding ethical standards in academic work while utilizing AI-assisted learning tools.

The findings indicate that greater integration of AI-assisted learning tools was associated with enhanced critical thinking skills among students, thereby promoting analytical and independent problem-solving abilities. However, both AI-assisted learning tool integration and critical thinking skills do not appear to influence students' academic integrity or adherence to academic honesty. This suggests that students with strong critical-thinking skills may not necessarily engage in ethical academic practices, highlighting that academic integrity is influenced more by other factors, like personal values and ethical awareness, than by the availability and integration of AI tools and critical thinking.

Educational institutions should encourage students to use AI-assisted learning tools not only for accessibility but also to supplement textbooks and classroom instruction, thereby promoting deeper learning. Instructional activities should continue to strengthen students' ability to critically evaluate AI-generated information while reinforcing responsible and independent use of AI in completing academic tasks. Future studies may include participants from multiple institutions and employ longitudinal or mixed-methods designs to further examine the relationships among AI-assisted learning tool integration, critical thinking, and academic integrity.

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Stain Removing Property of Eggshell Paste on Tooth Surface

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Abstract

Tooth discoloration is a common esthetic concern that may negatively affect perceptions of oral health and self-confidence. Although commercial oral prophylaxis pastes are widely used for stain removal, there is growing interest in sustainable and naturally derived alternatives. This study aimed to evaluate the effectiveness of duck eggshell prophylaxis paste in removing dental stains compared with a commercial oral prophylaxis paste. An experimental research design was employed in two phases: (1) evaluation of the abrasiveness of duck eggshell pastes and (2) assessment of its stain-removal efficiency on stained tooth surfaces. Paired and independent t-tests were used to compare stain reduction between groups, while effect sizes were calculated to determine the magnitude of treatment effects. Both the commercial and eggshell pastes significantly reduced stain scores. The mean stain score for the commercial paste decreased from 2.6520 (pre-treatment) to 1.3600 (post-treatment), while the eggshell paste decreased from 2.3840 to 1.3200. No statistically significant difference was observed between the two groups ($p = 0.356$), indicating comparable stain-removal effectiveness. The observed effect size using Hedges' correction ($g = 0.408$) indicated a small practical effect of the eggshell paste. These findings demonstrate that duck eggshell paste achieved effectiveness comparable to the commercial oral prophylaxis paste, with potential sustainability benefits from the use of recycled eggshell waste as an alternative biomaterial for oral care. Further studies are recommended to evaluate its long-term clinical performance, safety, and potential for large-scale production.

Keywords: Stain; Duck eggshell paste; Commercial oral paste; Granulation; Abrasiveness

1. Introduction

Oral health is a fundamental component of overall health and significantly influences an individual's quality of life. Poor oral health affects not only physical well-being but also appearance, communication, self-esteem, and social interactions. Despite advances in preventive dentistry and the widespread availability of oral hygiene products, oral diseases remain among the most prevalent noncommunicable diseases worldwide. Dental caries, periodontal diseases, and tooth loss continue to affect billions of people, disproportionately impacting individuals from low- and middle-income countries and underserved communities where access to affordable dental care and preventive oral health products remains limited. Socioeconomic inequalities limit oral health awareness, and inadequate access to preventive services contributes to persistent global oral health disparities. Lifestyle factors such as tobacco use, alcohol consumption, unhealthy dietary habits, and poor oral hygiene further increase the risk of oral diseases. Cigarette smoking has been identified as a major environmental risk factor associated with periodontitis and oral cancer. Consequently, preventive practices such as brushing twice daily with fluoride toothpaste, together with the regular use of dental floss and mouthwash, remain essential for maintaining oral health and preventing dental diseases (Subashri & Maheshwari, 2016).

Tooth discoloration is one of the most common aesthetic concerns affecting individuals and often influences self-confidence and social interactions. Stains may arise from intrinsic or extrinsic factors, including dietary habits, tobacco use, aging, medications, and developmental conditions. According to the *Glossary of Prosthodontic Terms*, tooth stain refers to the discoloration of tooth surfaces caused by ingested materials, bacterial activity, or other substances. Depending on their origin, stains may be classified as intrinsic, extrinsic, or internalized (Kapadia & Jain, 2018). Tooth color is influenced by several factors, including enamel and dentin composition, age-related changes, and the interaction of light with the tooth surface. Understanding the etiology of tooth discoloration is essential in selecting appropriate treatment approaches and achieving desirable esthetic outcomes.

Various methods have been developed to manage tooth discoloration, including professional dental cleaning procedures such as oral prophylaxis. This routine treatment involves scaling and

polishing to remove plaque, calculus, and surface stains, thereby improving oral health and tooth appearance. Commercial polishing pastes with varying abrasive particle sizes are widely used because of their effectiveness in stain removal. However, some commercially available products may contain abrasive or chemical components that could compromise enamel integrity with prolonged or excessive use. In addition, the cost and availability of commercial oral care products may limit their accessibility in resource-constrained communities. Historically, natural materials such as finely ground coral, eggshells, ginger, and salt were used as tooth polishing agents, as introduced by Pierre Fauchard, the Father of Modern Dentistry (Sawai et al., 2015). These traditional materials have recently gained renewed attention as sustainable and affordable alternatives for oral care.

Eggshells, commonly regarded as household waste, are composed primarily of calcium carbonate, and possess a mineral composition similar to that of human tooth enamel. Their high calcium content and mild abrasive properties suggest that eggshell-derived materials may effectively remove extrinsic stains while minimizing damage to the tooth surface. Furthermore, repurposing eggshell waste into oral care products supports environmental sustainability through waste valorization and the development of eco-friendly biomaterials.

Although interest in natural and sustainable oral care products has increased in recent years, limited research has evaluated the effectiveness of eggshell-based polishing agents for stain removal, particularly in comparison with commercially available oral polishing pastes. Moreover, there remains a lack of accessible, low-cost, and environmentally sustainable alternatives that could benefit communities with limited access to conventional oral hygiene products. Addressing these gaps may contribute to the development of innovative, affordable, and sustainable oral care materials. Therefore, this study aims to evaluate the stain-removing properties of eggshell paste on tooth surfaces and compare its effectiveness with that of a commercial oral polishing paste.

Tooth polishing is an integral component of preventive dentistry that aims to remove extrinsic stains, improve tooth aesthetics, and enhance patient comfort following prophylactic procedures. Commercial oral prophylaxis pastes are widely used because of their established cleaning efficiency and polishing properties. However, concerns have been raised regarding the abrasiveness of certain commercial formulations and their potential effects on enamel integrity with repeated use. These concerns have prompted increasing interest in the development of naturally derived polishing agents that combine effective stain removal with improved biocompatibility and environmental sustainability.

Recent studies have demonstrated the potential of eggshell-derived materials as alternative polishing agents due to their high calcium carbonate content and favorable abrasive characteristics. Mayta-Tovalino et al. (2021) formulated an experimental polishing paste using quail eggshells and reported measurable reductions in extrinsic tooth stains while also demonstrating antimicrobial properties. Similarly, Onwubu et al. (2020) found that nanosized eggshell particles exhibited low enamel abrasiveness while maintaining effective polishing performance, suggesting that eggshell-based materials may provide a balance between stain removal efficiency and enamel preservation.

Although previous studies consistently support the use of eggshell-derived materials in oral prophylaxis, they differ in terms of raw materials, formulation techniques, and outcome measures. Existing research has primarily focused on quail eggshells or nanosized eggshell particles, with emphasis on antimicrobial activity, abrasiveness, and surface roughness. Despite these promising findings, limited research has evaluated the use of duck eggshells as the primary material for an oral prophylaxis paste. Furthermore, few studies have directly compared duck eggshell prophylaxis paste with commercially available oral prophylaxis paste in terms of stain-removal effectiveness.

These gaps provide the rationale for the present study. By evaluating the stain-removing effectiveness of duck eggshell prophylaxis paste and comparing its performance with that of a commercial oral prophylaxis paste, this research contributes additional evidence regarding the use of locally available biomaterials as sustainable alternatives for preventive dental care. The study also explores the potential of utilizing agricultural waste as a value-added oral healthcare product, supporting environmentally sustainable practices while improving access to affordable preventive dental materials.

This study is founded on the premise that the type of oral prophylaxis paste influences the effectiveness of extrinsic stain removal from tooth surfaces. Duck eggshells are composed primarily of calcium carbonate, a naturally occurring mineral with mild abrasive properties capable of removing

surface stains while minimizing excessive enamel wear. Previous studies have demonstrated that eggshell-derived polishing materials can achieve measurable reductions in extrinsic tooth stains while maintaining acceptable abrasive characteristics, providing the basis for evaluating duck eggshell paste as an alternative oral prophylaxis material.

The independent variable in this study is the type of oral prophylaxis paste (duck eggshell prophylaxis pastes and commercial oral prophylaxis paste), whereas the dependent variable is the effectiveness of stain removal, measured by the reduction in stain scores following treatment. Standardized polishing procedures were employed to ensure consistency during application, and the effectiveness of each paste was evaluated by comparing pre-treatment and post-treatment stain scores using appropriate statistical analyses.

2. Objectives

The general objective of this study is to evaluate the effectiveness of duck eggshell oral prophylaxis paste as an alternative stain-removing agent on tooth surfaces.

Specifically, this study aims to:

1. Determine the abrasiveness of duck eggshell oral prophylaxis paste.
2. Compare the stain-removal effectiveness of duck eggshell oral prophylaxis paste and commercial oral prophylaxis paste.
3. Evaluate the effectiveness of duck eggshell oral prophylaxis paste in removing extrinsic stains from tooth enamel surfaces.

3. Materials and Methods

This study was conducted to evaluate the effectiveness of eggshell oral prophylaxis paste in removing extrinsic stains on tooth surfaces. The procedures and methodology were designed to allow reproducibility by other investigators.

Research Design

An experimental research design was employed to determine the stain-removing property of eggshell paste compared to commercial oral prophylaxis paste. The independent variable was the type of prophylaxis paste (eggshell-based and commercial), while the dependent variable was the level of extrinsic stain removal on tooth surfaces. This design was selected to establish a cause-and-effect relationship between the treatment applied and the observed outcomes. Qualitative validation through expert feedback was also incorporated.

Sources of Data

Duck eggshells were collected from a local duck farm in Pinaod, San Ildefonso, Bulacan, Philippines. Tooth specimens were obtained during a dental mission, "PROJECT RAGSAK (Restorative Activities for the Geriatric & Special Needs na may Aruga at Kalinga)," conducted at the Area 1 Vocational Rehabilitation Center in Bonuan, Pangasinan. Extracted teeth were selected as samples for the experimental procedures.

Preparation of Eggshell Prophylaxis Paste

Collected eggshells were thoroughly cleaned with water to remove debris and contaminants, then sun-dried for 24 hours. The dried shells were pulverized using a grinder until a medium particle consistency was achieved. A slurry was prepared by mixing one teaspoon of cornstarch with 1/4 cup of water. The pulverized eggshell was then combined with the slurry in a 2:1 ratio to produce the eggshell oral prophylaxis paste.

Sample Selection and Grouping

Ten extracted human tooth specimens were selected based on predefined clinical criteria, including the presence of visible extrinsic staining and the absence of extensive structural damage, such as severe caries or fractures. Given the quasi-experimental nature of this preliminary laboratory study, the sample size was considered sufficient to compare the stain-removal effectiveness of duck eggshell prophylaxis paste with that of a commercial oral prophylaxis paste and to estimate effect sizes for future confirmatory research.

The selected tooth specimens were randomly assigned into two groups:

1. Experimental group ($n = 5$), treated with duck eggshell oral prophylaxis paste; and
2. Control group ($n = 5$), treated with commercial oral prophylaxis paste.

Random allocation was performed to minimize selection bias and ensure comparable baseline characteristics between the two treatment groups.

Application Procedure

Before treatment, baseline stain levels were assessed within 24 hours post-extraction by a licensed dentist using visual examination. Stains were categorized according to severity levels.

Each tooth specimen was subjected to polishing using a low-speed handpiece operating at approximately 5000 rpm, fitted with a prophylaxis brush. The assigned paste (eggshell or commercial) was applied in circular motions across all tooth surfaces, including labial, buccal, lingual, palatal, proximal, incisal, and occlusal areas. Each surface was treated for 30 seconds. All procedures were standardized to ensure consistency between groups.

Post-treatment stain levels were evaluated using the same criteria applied during baseline assessment. In addition, qualitative feedback regarding the efficacy and usability of the eggshell paste was obtained from five licensed dentists through an online survey.

Survey Instrument

A researcher-developed online questionnaire was used to obtain qualitative feedback from five licensed dentists regarding the eggshell oral prophylaxis paste. The survey consisted of open-ended and structured questions that evaluated the paste in terms of its abrasiveness, stain-removal effectiveness, ease of application, consistency, and overall acceptability for clinical use. Before administration, the questionnaire was reviewed by faculty members with expertise in restorative and preventive dentistry to ensure the clarity and relevance of the questions. The survey was administered electronically using Google Forms, and responses were summarized descriptively to complement the quantitative findings of the experimental study.

Data Analysis

Quantitative data were analyzed using an independent samples t-test to compare the mean stain reduction between the experimental and control groups. This statistical method was selected to determine whether a significant difference existed between the two treatments. Descriptive statistics, including mean and standard deviation, were also computed. The level of significance was set to determine the acceptance or rejection of the null hypothesis.

Ethical Considerations

Ethical standards were strictly observed throughout the study. Participants involved in the dental mission were informed about the purpose and procedures of the research, and informed consent was obtained before sample collection. All collected data were treated with confidentiality, and no personal identifiers were disclosed. The study complied with the provisions of the Data Privacy Act of 2012 (Republic Act No. 10173).

4. Results

A. Application of Eggshell Oral Prophylaxis Paste

This section presents the findings on the stain-removing effectiveness of duck eggshell oral prophylaxis paste on tooth surfaces. The analysis included the evaluation of stained tooth specimens before and after treatment, statistical comparison of stain reduction, and qualitative feedback from licensed dentists. A commercial oral prophylaxis paste served as the control treatment for comparison. To ensure consistency in evaluating treatment outcomes, tooth discoloration was assessed using a standardized four-level stain severity scale before and after the application of each prophylaxis paste.

Table 1 Stain Severity Assessment Criteria

Stain Category	Score	Assessment Criteria
None	1	No visible extrinsic stain: natural tooth color is maintained.
Mild	2	Slight extrinsic stain that is barely visible, appearing as off-white to light yellow discoloration.
Moderate	3	Clearly visible extrinsic stain with yellow, orange, or light

Stain Category	Score	Assessment Criteria
		brown discoloration covering a noticeable portion of the tooth surface.
Severe	4	Extensive dark brown to black extrinsic stain covering a substantial area of the tooth surface.

The stain severity categories presented in Table 1 served as the standardized assessment criteria throughout the study. Baseline (pre-treatment) and post-treatment stain levels were independently evaluated by a licensed dentist using the same scoring system to ensure consistency in the assessment of stain removal effectiveness. A reduction in stain score following treatment indicated an improvement in tooth surface appearance and was used as the primary outcome measure for comparing the effectiveness of the duck eggshell and commercial oral prophylaxis pastes.

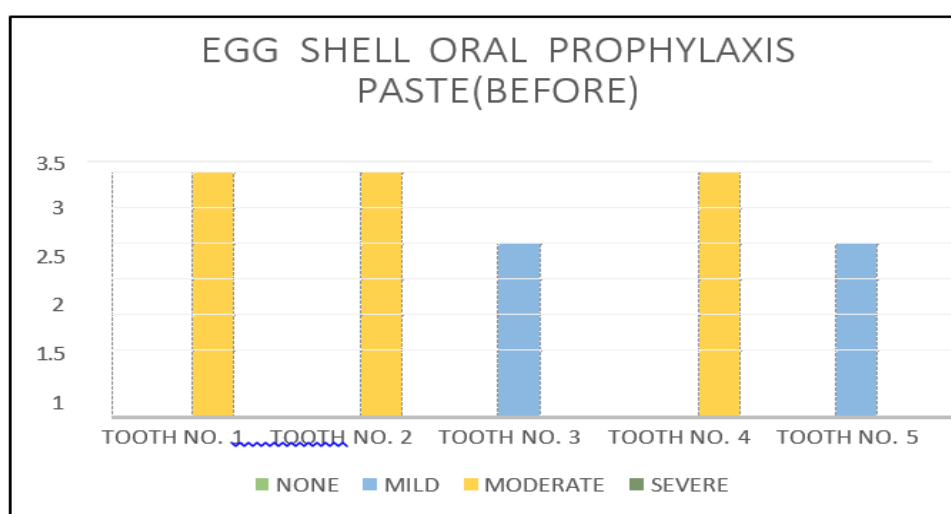


Figure 1 Eggshell prophylaxis paste pre-treatment average result

Figure 1 presents the baseline stain scores of the tooth specimens assigned to the duck eggshell prophylaxis paste group before treatment. The average stain score of 2.48 indicates that most specimens exhibited stain severity within the mild-to-moderate range before the application of the eggshell paste. Establishing comparable baseline stain levels is essential because it provides the reference point for evaluating the effectiveness of the treatment. The presence of visible extrinsic stains before polishing confirms that the specimens were appropriate for assessing the stain-removing capability of the eggshell prophylaxis paste. These baseline findings directly support the study objective of evaluating the effectiveness of duck eggshell paste in reducing extrinsic tooth stains.

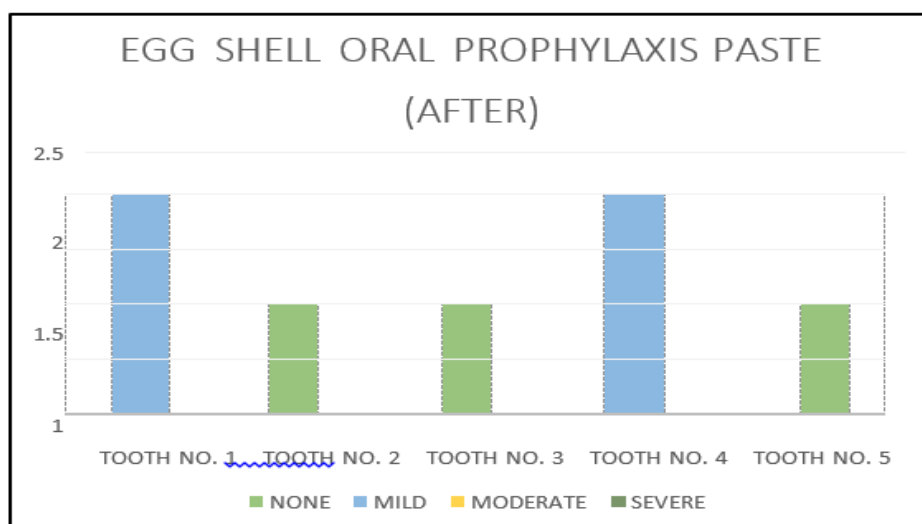


Figure 2 Eggshell prophylaxis paste post-treatment average result

The duck eggshell prophylaxis paste demonstrated effective stain-removal performance, producing a mean stain reduction of 1.064. Although the commercial oral prophylaxis paste achieved a slightly higher mean stain reduction (1.292), the difference between the two treatments was small. Furthermore, the duck eggshell prophylaxis paste exhibited lower variability in stain reduction, indicating more consistent treatment outcomes among the specimens.

The magnitude of the difference between the two prophylaxis pastes was evaluated using Hedges' correction, which yielded a small, standardized effect size ($g = 0.408$). Moreover, the corresponding 95% confidence interval (-1.694 to 0.608) included zero, indicating that the observed difference was not statistically meaningful. These findings suggest that the stain-removal effectiveness of the duck eggshell prophylaxis paste was comparable to that of the commercial oral prophylaxis paste under the conditions of the present study.

The comparable performance of the duck eggshell prophylaxis paste may be attributed to the abrasive properties of eggshell powder. According to Mayta-Tovalino et al. (2022), eggshell is composed predominantly of calcium carbonate and possesses favorable abrasive characteristics that effectively remove extrinsic stains while preserving tooth surface integrity. These properties make eggshell a promising material for oral prophylaxis. Consequently, the present findings support the potential of duck eggshell prophylaxis paste as an effective, sustainable, and cost-efficient alternative to commercially available prophylaxis pastes for the removal of extrinsic tooth stains.

B. Application of Commercial Oral Prophylaxis Paste

This section presents the findings on the stain-removing properties of eggshell oral prophylaxis paste on tooth surfaces. The analysis involved the examination of multiple tooth specimens, supported by statistical evaluation and qualitative insights from licensed dentists. A commercial oral prophylaxis paste was used as a comparative control to assess relative effectiveness. Tooth discoloration was evaluated based on varying levels of stain severity, acknowledging that differences in stain characteristics are critical considerations in determining appropriate and effective dental treatment approaches.

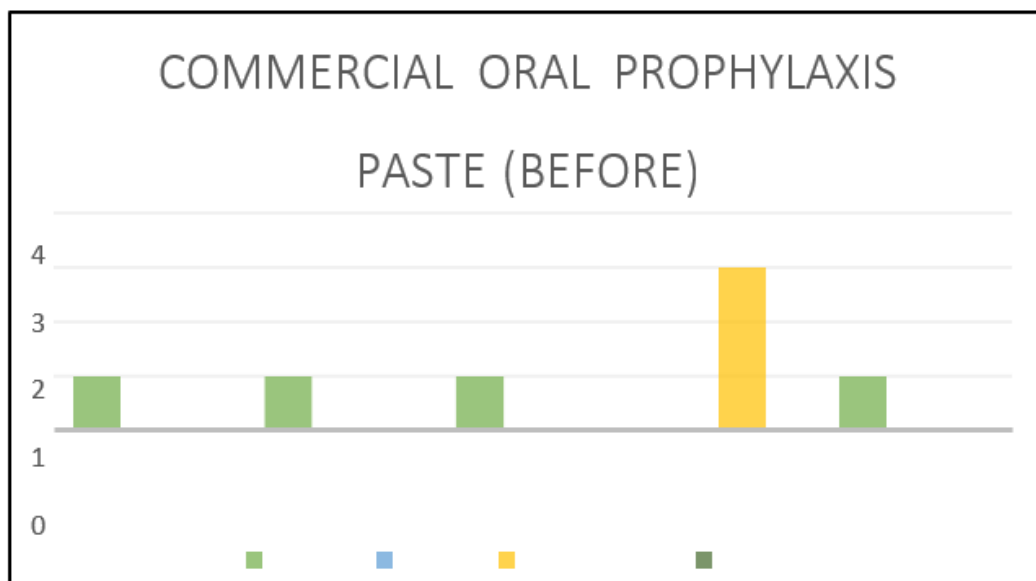


Figure 3 Commercial paste pre-treatment average result

Figure 3 shows the baseline stain scores of the specimens assigned to the commercial oral prophylaxis paste group before treatment. The average stain score of 2.65 indicates that the teeth exhibited predominantly moderate extrinsic staining before polishing. The similarity of the baseline stain levels between the commercial and eggshell groups provided an appropriate basis for comparing the effectiveness of the two prophylaxis pastes. This baseline assessment ensured that any reduction in stain scores could reasonably be attributed to the treatment applied.

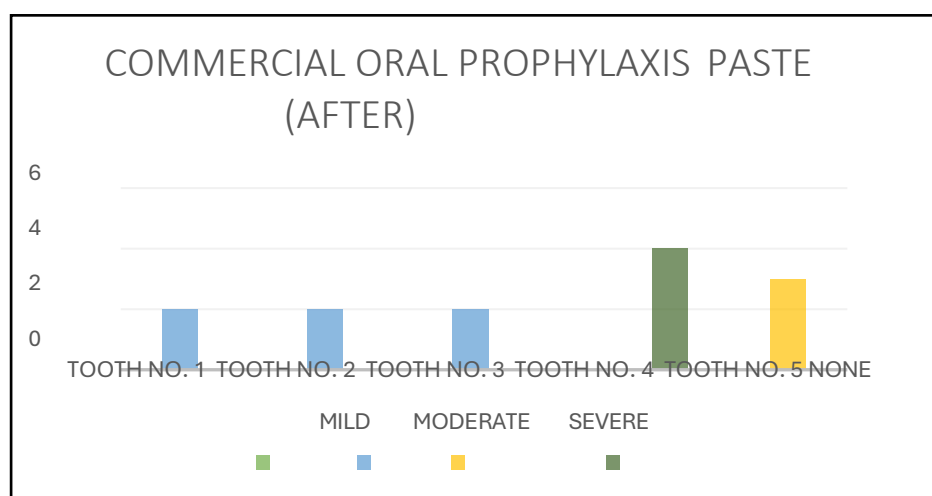


Figure 4 Commercial paste post-treatment average result

Figure 4 presents the stain scores following treatment with the commercial oral prophylaxis paste. The average stain score decreased from 2.65 to 1.35, demonstrating a reduction in stain severity toward the none-to-mild range after polishing. These findings confirm that the commercial paste effectively removed extrinsic stains from tooth surfaces. The figure also serves as a control reference against which the stain-removal performance of the duck eggshell prophylaxis paste can be compared in addressing the primary research objective.

Table 2 Reduction in Tooth Surface Stains Before and After Treatment with Eggshell Oral Prophylaxis Paste (abrasiveness)

Tooth No.	Stain Level (Before)	Stain Score (Before)	Stain Level (After)	Stain Score (After)	Stain Reduction
Tooth No. 1	Moderate	3.0	Mild	2.0	↓ 1.0
Tooth No. 2	Moderate	3.0	None	1.0	↓ 2.0
Tooth No. 3	Mild	2.0	None	1.0	↓ 1.0
Tooth No. 4	Moderate	3.0	Mild	2.0	↓ 1.0
Tooth No. 5	Mild	2.0	None	1.0	↓ 1.0
Average		2.48		1.32	↓ 1.16

Table 2 demonstrates the change in stain scores for each tooth specimen following treatment with the duck eggshell prophylaxis paste. All five specimens showed reductions in stain severity, with stain reductions ranging from 1 to 2 points and an average reduction of 1.16 points. These consistent improvements indicate that the calcium carbonate-based abrasive properties of the eggshell paste effectively removed extrinsic stains from tooth surfaces. The table therefore provides direct evidence that duck eggshell prophylaxis paste achieved measurable stain reduction, addressing the study objective of evaluating its effectiveness as a stain-removing agent. Mayta-Tovalino et al., (2022) noted that eggshell, rich in calcium carbonate, is an effective abrasive for polishing and improving tooth appearance.

C. Comparison of the Stain Removal Effectiveness

Table 3 Stain Removal Effectiveness of Eggshell vs. Commercial Pastes

Product / Effect Size	N	Mean Stain Difference	Standard Deviation	Standard Error Mean	Standardized Value	Point Estimate	95% CI Lower	95% CI Upper
Egg Shell Paste	5	1.0640	0.26595	0.11894	—	—	—	—
Commercial Paste	5	1.2920	0.44785	0.20028	—	—	—	—
Hedges' correction	—	—	—	—	0.40800	-0.559	-1.694	0.608

Hedge's correction uses the pooled standard deviation, plus a correction factor.

Table 3 presents the comparison between duck eggshell prophylaxis paste and commercial oral prophylaxis paste in terms of stain-removal effectiveness. Both prophylactic agents effectively reduced extrinsic tooth stains, with the commercial oral prophylaxis paste exhibiting a slightly greater mean stain reduction (1.2920) than the duck eggshell prophylaxis paste (1.0640). Despite this numerical difference, the observed difference in mean stain reduction between the two groups was small. Furthermore, the duck eggshell prophylaxis paste demonstrated less variability in stain reduction, indicating more consistent treatment outcomes among the specimens. Statistical analysis revealed that the difference between the two prophylaxis pastes was not statistically significant ($p = 0.356$), indicating that neither treatment demonstrated superior stain-removal effectiveness under the conditions of the present study.

The magnitude of the observed difference was further assessed using Hedges' correction, which yielded a small effect size ($g = 0.408$). However, the corresponding confidence interval included zero,

suggesting that the observed difference may be attributable to sampling error rather than a true difference in treatment effectiveness. Taken together, these findings indicate that duck eggshell prophylaxis paste demonstrated stain-removal effectiveness comparable to that of the commercial oral prophylaxis paste, supporting its potential as an effective alternative for the removal of extrinsic tooth stains.

The present findings are consistent with previous studies describing the desirable characteristics of prophylactic polishing agents. Haktan Yurdagüven et al. (2012) stated that an ideal prophylaxis paste should effectively remove stains and polish tooth surfaces while minimizing abrasion and surface roughness. Likewise, Maya-Tovalino et al. (2022) reported that eggshell, owing to its high calcium carbonate content and favorable abrasive properties, effectively removes extrinsic stains while improving tooth surface quality, making it a promising material for oral prophylaxis. Similarly, Onwubu et al. (2020) demonstrated that powdered eggshell possesses low abrasiveness, supporting its safety and effectiveness as a polishing agent in oral care products.

Although the present study did not demonstrate a statistically significant advantage of duck eggshell prophylaxis paste over the commercial oral prophylaxis paste, its comparable stain-removal effectiveness, combined with its eco-friendly nature, cost-effectiveness, and reported remineralization potential, highlights its promise as a sustainable alternative for clinical oral prophylaxis. Nevertheless, further investigations involving larger sample sizes, extended evaluation periods, and well-designed clinical trials are recommended to confirm its long-term effectiveness, safety, and clinical applicability.

6. Discussion

This study investigated the physical properties and effectiveness of eggshell prophylaxis paste in comparison with a commercial oral prophylaxis paste, focusing on its abrasiveness and ability to remove dental stains. Eggshell paste contains calcium carbonate, a naturally occurring mild abrasive that provides gentle yet effective mechanical action for removing extrinsic stains. Compared with many commercially available polishing agents, its abrasiveness is less aggressive, making it a promising alternative for individuals with tooth sensitivity and for consumers seeking environmentally sustainable oral care products. In addition to its functional properties, the use of eggshells transforms an abundant agricultural by-product into a value-added biomaterial, supporting sustainable resource utilization.

Both the eggshell paste and the commercial oral prophylaxis paste significantly reduced stain scores, as demonstrated by the paired t-test results. Although the commercial paste exhibited a slightly higher mean stain reduction (1.2920) than the eggshell paste (1.0640), the difference was not statistically significant ($p = 0.356$). These findings indicate that the stain-removing performance of eggshell paste is comparable to that of the commercial product. Correlation analysis further demonstrated improvements in both groups, with the commercial paste showing a slightly stronger and statistically significant correlation ($r = 0.886$, $p = 0.045$) than the eggshell paste ($r = 0.749$, $p = 0.145$), suggesting greater consistency in treatment outcomes. Nevertheless, the comparable performance of the eggshell paste supports its potential as an alternative polishing material.

The observed effect size using Hedges' correction ($g = 0.408$) indicates a modest but meaningful improvement in stain removal using eggshell paste. Although this effect was not statistically significant, it suggests that eggshell-derived formulations have practical potential as low-cost, eco-friendly alternatives to conventional prophylaxis pastes. This is particularly relevant in settings where access to commercial dental materials is limited due to economic constraints or supply challenges. By utilizing locally available eggshell waste, communities and small-scale manufacturers may have the opportunity to develop affordable oral care products while reducing dependence on imported raw materials.

The findings also highlight the potential for scaling up eggshell-based prophylaxis paste through local manufacturing initiatives. Since eggshells are widely generated as food industry and household waste, establishing standardized collection, processing, sterilization, and quality control systems could enable their sustainable use in the production of oral healthcare materials. Collaboration among academic institutions, local government units, dental organizations, and small and medium-sized enterprises (SMEs) could facilitate technology transfer, product development, and

commercialization. Such initiatives may stimulate local industries, create livelihood opportunities, and promote a circular economy by converting biological waste into high-value healthcare products.

From a public health perspective, eggshell-based prophylaxis paste could complement community oral health promotion programs, particularly in underserved and resource-limited areas where access to affordable preventive dental products remains a challenge. If future studies establish its safety, effectiveness, and long-term clinical performance, the product may be considered for inclusion in community-based oral health initiatives, school dental health programs, and preventive care strategies. Increasing the availability of affordable and sustainable oral hygiene materials could contribute to reducing oral health inequalities and improving access to preventive dental care.

The results of this study also have broader policy implications. They support the development of policies that encourage research and innovation in sustainable biomaterials, promote the recycling of agricultural waste, and strengthen partnerships between the health, environmental, and manufacturing sectors. Policymakers may consider supporting funding mechanisms, regulatory pathways, and incentives for the development of locally produced, environmentally sustainable oral healthcare products. Such efforts align with the principles of a circular economy and may reduce environmental waste while improving access to preventive oral healthcare.

Furthermore, this study contributes to the achievement of several United Nations Sustainable Development Goals (SDGs). By promoting affordable preventive oral healthcare, the study supports SDG 3 (Good Health and Well-being). Through the productive reuse of eggshell waste and the development of sustainable oral care materials, it advances SDG 12 (Responsible Consumption and Production). Finally, the promotion of locally developed biomaterials and innovation in dental products contributes to SDG 9 (Industry, Innovation, and Infrastructure) by encouraging research, technological development, and sustainable manufacturing practices.

Although no significant advantage was observed for eggshell paste over the commercial product, the findings demonstrate its potential as an effective, sustainable, and economically viable alternative for dental stain removal. Future studies involving larger sample sizes, longer evaluation periods, comprehensive safety assessments, and randomized clinical trials are recommended to validate these findings. Further optimization of formulation techniques and manufacturing processes will also be essential to support large-scale production, regulatory approval, and eventual integration into clinical practice and public oral health programs.

7. Conclusion

The findings of this study demonstrate that eggshell-based oral prophylaxis paste, characterized by its medium-sized particle consistency, is effective in removing dental stains, primarily due to its calcium carbonate content. Both the eggshell paste and the commercial prophylaxis paste exhibited statistically significant reductions in stain scores. However, the eggshell paste showed greater consistency in lowering stain levels across specimens, indicating its potential as a viable and effective alternative for dental stain removal. These results highlight the promise of eggshell-derived materials as sustainable and functional components in oral care formulations.

Beyond its clinical potential, the development of an eggshell-based prophylaxis paste may contribute to broader societal and environmental goals by promoting the utilization of agricultural waste as a value-added resource, supporting sustainable waste management practices, and expanding access to affordable oral care products, particularly in resource-limited communities. The findings may also encourage researchers, industry stakeholders, and policymakers to support the development of eco-friendly, locally sourced oral healthcare products and promote innovations that align with public health and sustainability initiatives.

Further studies are recommended to optimize the formulation of eggshell prophylaxis paste, particularly in terms of granulation techniques and thermal treatment processes to ensure microbial safety while preserving its functional properties. Future research may also explore improvements in product acceptability, including the incorporation of mild, natural flavors such as mint or citrus and subtle herbal scents such as eucalyptus to enhance user experience. Emphasis should be placed on maintaining natural ingredients and avoiding artificial additives to align with consumer preferences for safe, sustainable, and effective oral care products. In addition, clinical trials and cost-effectiveness studies are recommended to establish its long-term safety, efficacy, and feasibility for wider adoption in dental practice and community-based oral health programs.

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WASH Insecurity: The Lived Experiences of The Homeless Adults In Lipa City

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Abstract

This study aims to explore the lived experiences and health challenges linked to water, sanitation, and hygiene (WASH) insecurity of homeless adults residing within Lipa City. Using phenomenology, this study was participated by ten (10) homeless adults living in Lipa City, Batangas, who are currently homeless under a broad definition, including those who sleep on the streets or in impermanent accommodations. Purposive and snowball sampling was used to reach individuals with relevant experiences. The findings reveal that the absence of accessible safe WASH facilities significantly compromises the ability of homeless individuals to perform basic self-care practices, leading to increased vulnerability to communicable diseases, chronic health conditions and psychosocial distress. Moreover, this study underscores that despite existing government programs and policies aimed at improving sanitation and social welfare, the homeless population remains largely undeserved due to the household-focused structure of these interventions. The lived experiences of homeless adults in Lipa City demonstrate that barriers such as restricted access to public facilities, stigma, and unsafe environment limit their ability to maintain hygiene and dignity. Participants often rely on unsafe or inconsistent coping strategies which, reflective of resilience, are insufficient for long term health and well-being. Particularly, Self-Care Deficit Theory and Maslow's Hierarchy of Needs emphasizes that the challenges faced by homeless individuals are not due to personal neglect but rather the absence of supportive environments that enable self-care and adaptation. Therefore, addressing WASH insecurity requires a shift toward inclusive, non-household-based interventions that prioritize accessibility, safety, and dignity.

Keywords: WASH insecurity; lived experiences; homeless; Lipa City; challenges

1. Introduction

Homelessness is more than just a housing crisis; it is a significant global public health concern. Around the world, there are an estimated 318 million people who are experiencing homelessness, and 2.8 billion lack access to adequate housing (UN Searches for Solutions to Global Housing Crisis, 2025). In the Philippines, two-thirds of the estimated 45 million homeless individuals are located within Metro Manila. As a result, the country's capital accounts for the highest homeless population in any urban setting in the world (Reyes & Trinidad, 2023). In this study, the researchers identify homelessness as defined by Anthonj et al. (2024), citing DeVuono-Powell (2013) and Kidd et al. (2021), as a wide range of circumstances of inadequate living conditions, such as sleeping rough, living in encampments, or staying in shelters. This includes those who literally lie on the street or in a public place and use different materials to make a temporary shelter to sleep at night. Homelessness is often talked about as if it were just about a lack of shelter, but when we look closer, it tells a much heavier story, one that involves health, survival, and daily struggle. Many homeless individuals face persistent structural and socioeconomic barriers, including poverty and limited access to basic resources, which makes it difficult for them to secure employment and improve their living conditions (Marshall et al., 2022). The daily lives of this population are characterized by constant survival and insecurity of basic needs. They spend much of their days meeting survival needs, such as finding a place to sleep, obtaining food and water, and protecting themselves from the weather and violence across the street (Speak, 2019). Thus, making their living conditions highly unstable, requiring continuous adaptation.

Among all the many difficulties the homeless population experiences, inadequate access to water, sanitation, and hygiene (WASH) is one of the most significant yet overlooked determinants of health. The UN Sustainable Development Goal 6 asserts that access to water, sanitation, and hygiene is a human right. However, 2.2 billion people lack safe drinking water, 3.4 billion people lack proper sanitation, and 1.7 billion lack basic hygiene services at home (Martin, 2026). The current study defines WASH insecurity as the inadequate and unsafe access to basic WASH services. Even though WASH is physically present, access is not always guaranteed if the source is too expensive, unreliable, or unhygienic. Growing evidence suggests that the homeless population experiences a higher burden of WASH insecurity compared with the general population.

Access to sanitation and hygiene facilities is more than just a basic need; it quietly shapes everyday life, health, and a person's sense of dignity. As the world faced the COVID-19 pandemic, these challenges became more visible among people who experience homelessness. During those times, sanitation facilities that were already limited became harder to access; some were closed, and others became dirtier and more expensive (Liera et al., 2023). For homeless individuals, sanitary infrastructure is not freely available to them. Some public restrooms are often tied to opening hours, leaving no options during nighttime. Even when facilities exist, social stigma hinders them from using the facilities. Their physical appearance restrains them from entering a public place, as they are immediately blocked at the entrance (Anthonj, et al., 2024). Similar experiences are reflected in the findings of Nava & Wilson (2024), where homeless adults reported that access to water, soap, and private facilities remains a problem for them. Some were asked to leave the public restrooms the moment they were identified as homeless. In the Philippines, particularly in the highlands of Pampanga, the Aeta community experiences insecurity in accessing basic hygiene services. They had limited sources of clean water and heavily relied on natural water sources to meet their hygiene needs; thus, everyday hygiene practices were constrained, making even simple tasks challenging (Yang et al., 2020).

People living on the streets tend to face heavier health burdens compared to the general population. The study by Richards and Kuhn (2022) reveals that many of them develop chronic illnesses, struggle with mental health conditions, or experience issues related to alcohol and drug use, all while having little to no access to proper healthcare. As time passes, staying longer in the streets increases their risk exposure, turning preventable diseases into serious conditions. In this situation, access to water, sanitation, and hygiene (WASH) becomes essential for survival, yet the absence of it continues to worsen their fragile health. In some cases, the lack of safe water forces homeless individuals to rely on unsafe sources. Crank et al. (2025), found that people living near flood-control tunnels in Las Vegas, Nevada, often rely on contaminated water sources. Using Quantitative Microbial Risk Assessment (QMRA), they found that a single exposure to contaminated water, such as bathing or toothbrushing, carries a 5% probability of illness, exceeding the accepted safety risk threshold of 3.2%. Additionally, People experiencing homelessness face an increased risk of dehydration in response to limited water access and prolonged outdoor exposure (DeMyers et al., 2017). More recent studies highlight persistent barriers in accessing safe water among homeless individuals, indicating that water insecurity is an ongoing public health concern (Liera et al., 2023; Nava & Wilson, 2024). Limited access to sanitation facilities leads to untreated urinary health problems among homeless individuals. In a survey conducted by Egemba et al. (2024), 70.5% of 17 participants reported experiencing severe urinary symptoms, and among those, 75% had not received any prior medical diagnosis. Without proper professional consultation, these individuals rely on self-medication to ease their symptoms, and this was largely driven by financial constraints (Zelege et al., 2024). On the other hand, while some still find ways to obtain medicines, some also reported non-adherence to medication due to its cost and lack of benefit from the government (Hird et al., 2024). These people are forced to prioritize more basic needs such as food, shelter, and safety.

Homelessness is strongly linked to unemployment, sickness, disability, and lack of adequate housing, in which, all of these reduce a person's ability to meet basic daily needs (Meena & Singh, 2025). With prioritization in mind, homeless individuals choose food, work, and survival over WASH practices. Maslow's Hierarchy of Needs provides a useful framework on the current study. This theory consists of a five-tier model of human needs, often depicted as hierarchical levels. The needs on the lower part must be satisfied first before individuals attain the needs on the higher part of the pyramid (McLeod, 2026). The constant need to secure water and meet basic needs limit their

opportunity for personal growth, goal-setting, and improved quality of life. What seemed basic practices to achieve the ultimate functioning level becomes a survival for homeless adults every day. Consequently, stigma significantly affects homeless individuals' mental and physical health outcomes as many experiences discrimination when accessing public facilities that reinforces exclusion and lowers self-esteem (Reilly et al., 2022). In relation again to Maslow's Hierarchy of Needs, love and belongingness, esteem, and respect are essential human needs that come after physiological survival. When homeless adults are denied dignity and social acceptance, they are prevented from achieving confidence, belonging, and personal growth.

Understanding resiliency in the context of homelessness is a crucial aspect of the current research study. Ketel and Abdoli (2024) emphasize that definitions of resiliency among homeless individuals found in the available literature are inconsistent and often fail to capture the dynamic and contextual nature of coping. Their findings indicate that adaptability is a key coping strategy, allowing individuals to adjust their behaviors and routines based on their unstable living conditions. Many studies highlight the importance of resourcefulness and problem-solving, as this population creatively improvises solutions using limited resources to meet their needs (Gebeyaw et al., 2022; Portillo et al., 2023; Anthonj et al., 2024). Their coping mechanisms are not static traits but rather context-dependent processes, heavily influenced by external conditions.

Although public facilities exist in urban areas like Lipa City, these individuals often face barriers in access and safety. In conjunction with the rapid urbanization of Lipa City, it includes the attraction of migrants from remote areas to find opportunities, challenging the WASH provisioning for marginalized groups like the homeless to be overlooked. This situation further heightens the vulnerability of the homeless to preventable health problems such as diarrhea, skin diseases, and respiratory infections.

Ryus et al. (2023) examined the association between homelessness and emergency department (ED) use. While the study highlights health issues among homeless individuals, it did not explore how WASH insecurity contributes to health challenges or the lived experiences of homeless adults. Access levels to basic hygiene facilities vary significantly within countries. Those living in rural and remote areas generally have lower access to such facilities, making daily hygiene practices more difficult for many families (Yu et al., 2021). Anthonj et al. (2024) have made significant contributions as their study explored WASH insecurity among homeless individuals in a high-income country. They found limited and unsafe access to public facilities. However, their findings remain limited to the contexts of the homeless struggles and do not specifically address health challenges linked to WASH insecurity.

Recognizing the vulnerability of the homeless population, Executive Order No. 52 was issued by President Ferdinand Marcos, Jr., institutionalizing and expanding the Pag-Abot Program of the Department of Social Welfare and Development (DSWD). This aims to reduce the risk and vulnerability of street-dwellers by providing immediate relief and long-term support to help them become productive members of society. However, while Pag-abot addresses social protection and welfare needs, it does not integrate long-term WASH access as a core component, leaving the gap unaddressed.

Hence, taking into account the magnitude of homelessness in urban areas in the Philippines, particularly in the City of Lipa, this study is necessary to generate context-specific evidence on the health implications of WASH insecurity among homeless individuals. With this, their lived experiences and coping mechanisms will shed light on the local government in making informed public health policies and interventions that not only reach those in roofed areas but also those living in the streets. This study aims to bridge the existing gap by exploring the lived experiences and health challenges linked to WASH insecurity of homeless adults residing in Lipa City. By understanding their situation, the research provides valuable insights that can address Sustainable Development Goals (SDGs), including SDG 1 (No Poverty), SDG 3 (Good Health and Well-Being), SDG 6 (Clean Water and Sanitation), SDG 10 (Reduced Inequalities), and SDG 17 (Partnership for the Goals).

2. Objectives

This study aims to explore the lived experiences and health challenges linked to water, sanitation, and hygiene (WASH) insecurity of homeless adults residing within Lipa City. Specifically, this study seeks to answer the following questions:

1. How do adults describe their experiences being homeless?
2. What health challenges do homeless adults face that are associated with WASH insecurity?
3. What are the lived experiences of homeless adults in Lipa City regarding access to:

- 3.1 Water;
- 3.2 Sanitation; and
- 3.3 Hygiene?
4. How does WASH insecurity affect the daily lives of homeless adults?
5. What coping mechanisms do homeless adults develop in response to WASH insecurity?

3. Materials and methods

A phenomenological approach was utilized to capture the essence and meaning of participants' experiences, allowing the researchers to explore how individuals interpret and cope with their circumstances beyond surface-level descriptions. The participants consisted of ten homeless adults in Lipa City, Batangas, aged 18 and above, who were selected through purposive and snowball sampling to ensure that they possessed relevant experiences, such as being homeless for at least one year and currently residing in the area. Data were gathered through face-to-face interviews using a semi-structured interview guide developed from related literature on WASH insecurity and was validated by experts. Taking into consideration the population, the questionnaire was translated into Filipino by a professional. This covered themes such as water access, sanitation, hygiene practices, health challenges, daily experiences, and coping mechanisms.

To analyze data from the participants' interview, the researchers followed the six-phase framework thematic analysis of Virginia Braun and Victoria Clarke. This process involves identifying, analyzing, organizing, and interpreting recurring patterns or themes within a data, allowing the researchers to gain a deeper understanding of the participants' experiences (Braun & Clarke, 2006). Following the criteria of Lincoln and Guba (1985), trustworthiness was established through credibility, transferability, dependability, and confirmability. Credibility was enhanced through audio-recording of the interview, verbatim transcription, and incorporation of participants' quotations. Dependability and confirmability were ensured by using thematic analysis and repeated review of the transcripts. Finally, transferability was observed through the clear description of the study's objectives, participants, and methodology.

Ethical considerations were strictly observed throughout the study, including ensuring voluntary participation, maintaining confidentiality and anonymity, minimizing potential harm, and creating a respectful environment for participants to freely share their experiences. Finally, all collected data were securely stored and properly disposed of after the completion of the study to protect participants' privacy.

4. Results

Table 1 Participants

Participants	Characterization (Age/Gender/Comorbidities/Duration of homelessness)	Origin and Reason of Being Homeless
Jun	23 / Male / None / 2 years	Manila Housefire
Dodong	51 / Male / None / 10 years	Cavite Financial Problem
Boyet	33 / Male / Heart Disease / 3 years	Lobo, Batangas Natural Disaster
Nena	52 / Female / UTI / 5 years	Wawa, Batangas Migration for subsistence
Rosa	51 / Female / Hypertension and cardiomegaly / 2 years	Sta. Maria, Bulacan Demolished house
Liwayway	21 / Female / Asthma / 3 years	Tambo, Lipa City Housefire
Pedro	47 / Male / UTI, Kidney Stones / 3 years	Bacolod Family Problem
Maria	44 / Female / UTI, Heart disease, ulcer, hypotension / 6 years	Magallanes, Cavite Family problem

Bong	19 / Male / None / 1 year	Taytay, Rizal Family violence
Marites	49 / Female / Acid Peptic Disease, GERD, Hypertension / 1 year	Lipa City, Batangas Job loss

Table 1 presents the demographic characteristics of the ten participants included in the study. Six participants were male and four participants were female ranging from 19-52 years of age. Several participants reported having comorbidities including heart disease, urinary tract infection, hypertension/hypotension, asthma, kidney stones, ulcer, gastroesophageal reflux disease, and acid peptic disease, while three participants reported having no known comorbidities. Participants came from various locations, and described their reasons for being homeless including housefires, financial difficulties, family conflicts, migration for subsistence, job loss, natural disaster, and family violence.

Table 2 The emergence of the Theme “Economic Survival and Instability” on the Experiences of Homeless Adults

Participants	Data Fragments	Emerging Concepts	Categories	Themes
Nena	“pag may nahihingi ako, ibibili ko ng pagkain.”			
Pedro	“lagi kaming nanghihingi at kung minsan nagbabahay-bahay kami.”	Asking for alms from different community members	Subsistence strategies for survival	
Bong	“panghihingi lang po.”			
Dodong	“minsan kikita, minsan hindi.”	Unsure income for everyday living	Income instability	
Boyet	“nanghihingi lang po ako sir, nangangalakal din po ako sir, minsan po may nagbibigay.”			Economic survival and instability
Jun	“parking lang po o kaya minsan nangangalakal kami para makakain.”	Exploring different ways to earn money	Informal livelihood system	
Maria	“pagparking, nagbobote, minsan pag wala, nanghihingi.”			
Rosa	“pag wala kami kalakal, namamalimos”			

Homeless individuals often face barriers to employment due to limited job opportunities and systemic inequalities. As a result, homeless individuals depend on informal and irregular livelihoods to meet their daily needs, hence the emergence of the theme “Economic survival and instability” as exhibited on Table 2. Participants highlight that they engage in small-scale trading, irregular work, or begging to meet their daily needs. Nena, Pedro, and Bong described that begging serves as their primary means of survival. Their experiences show that they depend on the generosity of other people. Meanwhile, Dodong highlighted the uncertainty of informal work, wherein there were times when there would be no income despite working. Boyet, Jun, Maria, and Rosa combined their multiple livelihood strategies, such as scavenging and collecting recyclable materials, to supplement their income. Overall, the findings indicate that participants' economic survival is characterized by

persistent instability, dependence on informal livelihood strategies, and the continuous need to adapt to unpredictable opportunities.

Table 3 The emergence of the Theme “WASH-related Illnesses” on the Health Challenges Homeless Adults Face Associated with WASH Insecurity

Adults Face Associated with WASH Insecurity				
Participants	Data Fragments	Emerging Concepts	Categories	Themes
Nena	“may UTI ako.”	Compromised urinary health	Inadequate hygiene and sanitation access	WASH-related Illnesses
Pedro	“UTI at sakit sa bato.”			
Maria	“UTI ... ulcer”			
Rosa	“nagtae kami”	Recurrent diarrheal episodes	Structural water access constraints	
Marites	“kung minsan po eh nagkakaroon kami ng diarrhea.”			
Bong	“Ang alam ko po ay sa init, dahil babad po ako dito sa init kaya siguro ako naliliyo, kulang kasi ako sa tubig.”			

In addition to collecting WASH insecurity experiences among homeless adults, this study also collected significant health variables to capture health challenges experienced by this population in relation to WASH insecurity. Table 3 exhibits the theme “WASH-related Illnesses,” which underscores various health challenges brought by structural water access constraints and inadequate sanitation and hygiene access. Nena, Pedro, and Maria linked their urinary health problems to the lack of accessible restrooms, which often forced them to delay urination. Social stigma and the requirement to pay for restroom use further restricted their access to sanitation facilities. Meanwhile, Marites and Rosa relied on unsafe water sources for drinking, resulting in recurrent diarrheal episodes and increased exposure to waterborne illnesses. Bong, on the other hand, described experiencing dizziness because of limited access to drinking water and prolonged exposure to the sun while living outdoors. Moreover, despite experiencing thirst, Bong expressed reluctance to drink from unreliable public faucets and hence endured his discomfort. These findings highlight that although WASH resources are physically present, they are either inaccessible or unreliable.

Table 4 The emergence of the theme “Compromised Health Practices Due to Financial and Healthcare Access Barriers” on the Health Challenges Homeless Adults Face Associated with WASH Insecurity

Participants	Data Fragments	Emerging Concepts	Categories	Themes
Nena	“kapag karamdaman bumibili ako gamot.”	Routine medicine buying when ill	Self-initiated medication practice	Compromised health practices due to financial
Jun	“bumibili din po ako ng gamot.”			
Pedro	“hindi na din makabili ng gamot kasi may kamahalan.”	Medication unavailability due to cost	Financial barrier to healthcare access	

Participants	Data Fragments	Emerging Concepts	Categories	Themes
Maria	“tinitiiis na lang po namin ang sakit na nararamdaman.”	Symptom endurance due to situational condition	Treatment avoidance	and healthcare access barriers
Rosa	“pag sinusumpong lang, saka umiinom.”	Symptom- triggered medication use	Conditional medication intake	

Homeless adults often make healthcare decisions based on affordability and the urgency of their needs. Many are forced to choose low-cost alternatives because professional healthcare services are difficult to access. This situation is emphasized on the theme “Compromised Health Practices Due to Financial and Healthcare Access Barriers,” shown in Table 3. A key pattern displayed by participants suggests substitution of professional care with self-medication. Nena and Jun both reported buying medicine independently whenever they feel ill, reflecting self-initiated medication practice. This behavior suggests that affordable healthcare services are lacking or perceived as unattainable for these individuals, highlighting a compromised form of care.

In contrast, Pedro shared that he no longer buys medication whenever he is experiencing illnesses, as he cannot afford such medications. His behavior reflects the unavailability of medications due to cost, showing a significant financial barrier to healthcare access. Moreover, Maria, when experiencing pain, shared that she endures her illness and pain and therefore, escapes the desired intervention of seeking professional assistance and taking medications. Lastly, Rosa reported taking her maintenance and medicines only when symptoms of her illness flare up and disrupt her everyday activities.

Table 4 The emergence of the theme “Accessing Water Through Community Assistance and Public Facilities” on the Lived Experiences of Homeless Adults in Terms of Water Access

Participants	Data Fragments	Emerging Concepts	Categories	Themes
Dodong	“Pag nabili ho ng pagkain nanghihingi na lang po ako ng tubig.”	Accessing water only when buying meals	Conditional access to water	Accessing Water Through Community Assistance and Public Facilities
Nena	“Pag bumibili ako ng pagkain dun lang ako kukuha ng tubig.”			
Rosa	“Minsan nanghihingi kami sa gasolinahan.”	Drawing water from gasoline stations	Reliance on nearby facilities	
Liwayway	“Madalas po ay dito lang sa may katabi naming gasolinahan.”			
Pedro	“Nahingi po kami ng mineral na tubig sa may lodlod, tindahan mismo ng mineral”	Requesting clean water from water station owners	Dependence on the generosity of others	
Nena	“Sa mga water station po.”			

Access to safe and reliable water is essential for health, hygiene, and daily survival. While people in stable living conditions usually have consistent access to water, homeless individuals often face difficulties obtaining it. Their access to water is largely dependent on external sources rather than private or permanent supplies. Many rely on community assistance and public facilities to meet their daily water needs, thus, the emergence of the theme “Accessing Water Through Community Assistance and Public Facilities,” illustrated on Table 4. Dodong and Nena explained that they are able to access water only when purchasing food, as it comes complementary to meals, indicating a conditional form of access tied to transactions. Rosa and Liwayway highlighted their reliance on

gasoline stations near where they temporarily settle as accessible sources of water, reflecting dependence on nearby public facilities. Pedro described requesting drinking water directly from water station owners, while Nena also mentioned obtaining water from these stations, emphasizing reliance on the generosity and assistance of others. Overall, the findings reveal that homeless individuals experience unstable access to water, reflecting broader structural inequalities and challenges in meeting their basic needs independently.

Table 5 The Emergence of the Theme “Limited and Unequal Access to Water Resources” on the Lived Experiences of Homeless Adults in Terms of Water Access

Participants	Data Fragments	Emerging Concepts	Categories	Themes
Boyet	“may hindi nagbibigay, minsan nagagalit pa.”	Resource gatekeeping within the community	Barriers to access due to social conflict	Limited and Unequal Access to Water Resources
Rosa	“may mararamot, tinataboy nla kami.”	Social exclusion from resources	Discrimination and social exclusion	
Bong	“minsan pag may tira akong pera, bumibili ako.”	Reliance on occasional income to purchase water	Economic constraint	
Nena	“bumibili ako sa 7/11.”			

The theme “Limited and Unequal Access to Water Resources” is based on the challenges that participants experienced when obtaining water while living without a home. While water is an essential aspect for survival, the researchers found a pattern among the participants as they reported challenges they face in accessing water owing to various social and economic challenges. In particular, responses highlight that access to water is not always freely available and is often affected by social interactions and financial constraints. Boyet explained that some individuals refuse to give water and may even respond with anger, indicating barriers created by negative community attitudes. Rosa described experiences of being driven away, reflecting discrimination and social exclusion in accessing basic resources. Bong shared that he purchases water only when he has extra money, emphasizing the role of financial limitation in meeting basic needs. Nena stated that she buys water from convenience stores, showing reliance on commercial establishments when free access is not possible. Overall, the findings indicate that access to water among participants is both limited and unequal, shaped by social rejection, financial constraints, and inconsistent availability. These conditions reflect broader structural inequalities that continue to restrict access to basic resources, further increasing the vulnerability of individuals experiencing homelessness.

Table 6 The Emergence of the Theme “Restricted and Discriminatory Access” on the Lived Experiences of Homeless Adults in Terms of Sanitation Access

Participants	Data Fragments	Emerging Concepts	Categories	Themes
Nena	“minsan hindi kami pinapayagan pumasok.”	Denial of Access	Institutional Exclusion	Restricted and Discriminatory Access
Liwayway	“Kung minsan ay tinataboy kami nila tapos sinasabi nila para hindi kami makapag cr ay sarado daw po yung cr kaya madalas po ay tinitiiis na lang po namin.”	Social Rejection	Stigma	

Participants	Data Fragments	Emerging Concepts	Categories	Themes
Rosa	“sabi nila bawal dito, bawal kayo dito.”	Spatial Exclusion	Social Marginalization	

The theme of “Restricted and Discriminatory Access,” as shown in Table 6 came about based on experiences in which participants faced restricted or outright denial in accessing sanitation facilities because they were homeless. In the analysis, there were experiences of direct and indirect discrimination by participants when trying to access toilets and other forms of sanitation services. Nena represents direct exclusion from institutions when people are deliberately refused access to toilet facilities. It shows that there is access control through institutional power and social perceptions, and not universal accessibility. Liwayway focuses on the stigma and discrimination that take place when individuals are denied entry into establishments on the pretext that their facilities are closed. This is an example of indirect discrimination, which forces individuals to experience discomfort as well as inhibit their physiological functions due to a lack of access. Rosa's quotation, on the other hand, is an example of spatial exclusion, whereby homelessness is used as a criterion for barring homeless people from particular areas. Social marginalization is heightened in that the need for hygiene is conditional on social acceptance and approval.

Table 7 The Emergence of the Theme “Temporal Inaccessibility” on the Lived Experiences of Homeless Adults in Terms of Sanitation Access

Participants	Data Fragments	Emerging Concepts	Categories	Themes
Jun	“Nagtitiis na lang po kami tapos hinihintay na lang namin na magbukas ulit para makagamit kami ng cr.”	Waiting and postponement of basic needs	Delayed use of sanitation	Temporal Inaccessibility
Nena	“sa super 8 alas 7 sarado na.”	Restricted access due to closing times	Structural limitation	
Maria	“pag lumilipat kami sa iba.”	Mobility in search of facilities	Disrupted access	

Sanitation services are expected to be available at all times to accommodate the continuous and immediate nature of human needs. Access to these facilities should not be restricted by time, as hygiene and sanitation are essential at any hour of the day. The theme of “Temporal Inaccessibility,” presented in Table 7 came about based on the experiences of the participants regarding difficulties accessing sanitary facilities within the available operating time. Nena highlights structural limitations in sanitation access due to restricted operating hours. Similarly, Jun asserted that delayed access forces him to endure discomfort while waiting for facilities to open. Meanwhile, Maria shared finding another facility to access sanitation. This shows adaptive behavior in response to limited access, though it also reflects inconvenience and inconsistency. Unlike those who have their own bathrooms and can use them anytime, homeless adults have to adjust their daily activities based on the opening and closing hours of the available sanitary facilities.

Table 8 The Emergence of the Theme “Adaptive Hygiene Practices under Conditions of Limited Access and Financial Constraint” on the Lived Experiences of Homeless Adults in Terms of Hygiene Access

Participants	Data Fragments	Emerging Concepts	Categories	Themes
Dodong	“Yung ginagawa na naming shampoo.”	Resource substitution due to scarcity	Adaptive Hygiene Practices	

Participants	Data Fragments	Emerging Concepts	Categories	Themes
Bong	“Dalawang beses sa isang linggo ako maligo, sa palengke may bayad kinse.”	Paying for access to bathing facilities	Economic Barriers / Limited Facilities	Adaptive hygiene practices under conditions of limited access and financial constraint
Maria	“mahirap maghanap ng banyo, nagbabayad ako.”			
Pedro	“naliligo ako sa ilog ng Pangao.”	Going to nearby rivers to bathe	Use of Natural Water Sources	
Rosa	“dito (gilid ng kalsada) kami naliligo kapag gabi lang pwede.”	Waiting for nighttime to bathe in the open space	Bathing in Public/Informal Spaces	

This theme highlights how homeless individuals access hygiene practices in response to limited resources, lack of access to sanitation facilities, and financial constraints. Dodong’s account is a clear example of resource substitution due to scarcity, whereby people have to find other uses for existing materials in an attempt to satisfy their hygiene needs. The case of Bong and Maria demonstrates how there can be financial limitations when trying to ensure proper hygiene. In such cases, being able to maintain proper hygiene becomes based on one's financial capability. It highlights conditional access, whereby hygiene becomes a luxury. Pedro's claim suggests a reliance on natural water sources, which is what people typically choose when official methods aren't available. Despite being a potentially beneficial option, the water situation puts people's health at risk. Rosa's story serves as an example of how to use both private and public locations and the need to wait until nightfall. Due to the modifications required for hygienic procedures, this highlights the issues of visibility, security, and dignity.

Table 9 The Emergence of the Theme “WASH Insecurity Intensifies Economic Hardship” on the Effects of WASH Insecurity on the Daily Lives of Homeless Adults

Participants	Data Fragments	Emerging Concepts	Categories	Theme
Nena	“yung imbis na ikakain nyo na po e naibabayad pa duon”	Trade-off between food and sanitation	Financial Strain	WASH insecurity intensifies economic hardship
Dodong	“kinse pesos... kasali naman yan sa gastos mo”	Water as recurring expense	Cost Burden	
Boyet	“no choice na eh... nabili na lang ako”			
Rosa	“tubig lang, papabayad pa”			
Jun	“kinukulang din kami pagkain... nagbabayad po kami”	Food vs sanitation conflict	Resource Prioritization	

Participants	Data Fragments	Emerging Concepts	Categories	Theme
Maria	“hindi kasi pwedeng hindi kami magtrabaho kasi wala kaming pang-kain”	Work is needed to afford basic needs	Economic Survival	
Pedro	“hindi ipagpatuloy sa kahirapan”	Inability to sustain medication due to costs	Competing Needs	
Bong	“pag may tsaka nakakaligo”	Hygiene dependent on money	Conditional hygiene access	

Typically, access to water, sanitation, and hygiene (WASH) is considered a basic human necessity that supports health, dignity, and daily functioning. For most individuals, clean water for bathing, washing and sanitation is often readily available and taken for granted as part of everyday life. However, for homeless adults, the absence of shelter and financial resources transforms these ordinary needs into daily struggles. The theme “WASH insecurity intensifies economic hardship” explicitly illustrates how the lack of water, sanitation, and hygiene resources creates financial pressure, difficult choices, and barriers to meeting most basic needs. Nena expressed that money intended for food is sometimes used instead to pay for hygiene-related needs, showing the painful trade-off between nourishment and sanitation. Dodong, Boyet, and Rosa shared the same concern of the unfair reality of having to pay even for basic water. This shows that even a small payment for water becomes an added expense in an already limited budget. They reported that because there were no other options to secure water freely, they were forced to buy water despite financial hardship. Taking into account that they are already struggling with food, yet they still need to spend money on water, reflecting conflicting survival priorities. Maria emphasized the need to keep working because without income, they cannot afford food and other necessities. Pedro revealed that poverty prevented him from continuing to meet important needs such as medication or care. Bong explained that bathing depends entirely on whether he has money available, making hygiene conditional rather than consistent.

Table 10 The Emergence of the Theme “WASH Insecurity Affects Dignity and Social Identity” on the Effects of WASH Insecurity on the Daily Lives of Homeless Adults

Participants	Data Fragments	Emerging Concepts	Categories	Theme
Nena	“wala kaming kakayanan”	Internalized Stigma	Self-perception	
Dodong	“minamaliit... kawawang kawawa”	Perceived Discrimination	Social Stigma	
Boyet	“sinasabihan ako magnanakaw”			
Pedro	“sinasabihan... magnanakaw”	Labeling and Prejudice	Social Exclusion	WASH insecurity affects dignity and social identity
Liwayway	“nasasaktan po ang aming damdamin”	Emotional Burden	Social Rejection	
Rosa	“hindi kami aso ha, tao din kami”	Loss of dignity	Dehumanization	
Bong	“masakit... na din po ako”	sanay Normalization of stigma	Adaptation	

Limited access to water, sanitation, and hygiene (WASH) undermines the dignity and social identity of homeless adults by restricting their ability to maintain personal cleanliness and meet social

expectations. As a result, many experience discrimination, stigma, and negative judgments from society. Table 10 features the theme “WASH insecurity affects dignity and social identity” as participants shared feelings of helplessness, low self-worth, and emotional pain caused by being looked down upon or treated unfairly. Nena expressed feelings of helplessness and low self-worth by saying they lack capability, reflecting internalized stigma. Dodong shared that people look down on them and pity them, showing how society devalues homeless individuals. Boyet and Pedro's responses collectively reflect the emerging concept of labeling and prejudice under the category of social exclusion. Both participants shared similar experiences of being accused of stealing, showing how homeless individuals are often unfairly judged and associated with criminal behavior because of their appearance and living conditions. Liwayway shared that their feelings are deeply hurt, reflecting the emotional burden of being judged by others. Rosa strongly emphasized that they are human beings, not animals, reflecting loss of dignity and the desire for respect. In contrast, Bong shared that the experience is painful, but he has become used to it, showing adaptation to repeated stigma. Overall, the dominant perspective across these statements is that WASH insecurity affects more than physical cleanliness; it also damages the dignity and social identity of homeless adults. Because poor hygiene and homelessness often attract stigma, individuals are judged, disrespected, and emotionally wounded by society.

Table 11 The Emergence of the Theme “Improvisation to meet WASH requirements” on the Coping Mechanisms Developed by Homeless Adults in Response to WASH Insecurity

Participants	Data Fragments	Emerging Concepts	Categories	Theme
Boyet	“iniistock ko na lang po”			
Rosa	“may mga galon kami, iniipunan ng tubig”	Water storage behavior	Water access adaptive strategy	
Maria	“pag may tubig ho kaming tira”	Saving water		
Pedro	“sa ilog... naliligo”	Use of alternative for sanitation facility		Improvisation to meet WASH requirements
Marites	“Ang ginagawa namin syemre hahanap ka ng lugar na walang tao tapos doon ka dudumi”	Open defecation	Sanitation access adaptive strategy	
Dodong	“Yung sabon ginagawa na naming shampoo”	Resource substitution	Hygiene access adaptive strategy	

Table 12 presents the theme “Improvisation to meet WASH requirements” found on the accounts of the participants as they demonstrate that effective water storage management functions as an essential method for survival. Boyet emphasizes the importance of storing water whenever it becomes available, reflecting preparation for scarcity. Similarly, Rosa uses gallons to transport and store water, which shows her ability to manage resources through planning and movement. Maria emphasizes water conservation through her efforts to save water because she needs to use limited resources throughout the day. People use their available water supply at its maximum capacity to fulfill their various needs. Pedro relies on river water for bathing, which demonstrates his need to use unsafe informal water sources to satisfy WASH necessities. Likewise, Marites admitted resorting to open defecation when no sanitation facility nearby is available to relieve herself. Dodong extends a product's use to satisfy other various needs to maintain cleanliness despite limited resources and financial strain.

5. Discussion

The findings of this study provide insight on the lived experiences of the homeless adults in Lipa City on the scope of their access to water, sanitation, and hygiene. Participants revealed that the absence of accessible and safe WASH facilities significantly compromises their ability to perform basic self-care practices affecting their health, daily lives, and overall well-being. This study also collected various coping mechanisms homeless adults developed to meet their basic needs despite limited resources. Further discussion below interprets the results in relation to the study objectives and existing literature to better understand the lived experiences of homeless adults and health challenges in relation to WASH insecurity.

This study found that the homeless population are often excluded from formal work. As a result, they depend on informal and survival livelihood strategies. Participants reported engaging in begging, small-scale trading, scavenging, collecting recyclable materials, and irregular work to obtain income. These sources of livelihood suggest unpredictable income and insufficient to meet basic needs. While some participants relied primarily on the generosity of others, others combined multiple income-generating activities to achieve every day survival. This finding is consistent with the study of Asibey et al. (2025), which found that homeless adults relied on different informal livelihood strategies to afford living expenses. Similar to the present study conducted in Lipa City, an urbanizing city, homeless adults exercise their opportunity and engage themselves in various small-scale income-generating activities. However, this reflects not only their determination to survive but also the absence of stable employment opportunities that could provide them long-term income security. Moreover, participants displayed prolonged economic insecurity which hinders them from improving their daily life (Hyun et al., 2025). Similarly, these individuals are too focused on surviving everyday life by spending their time securing basic necessities such as food, water, shelter, and environmental hazards, keeping them from pursuing long-term economic stability (Marshall et al., 2022, Speak, 2019).

People experiencing homelessness face significant barriers to accessing safe and reliable water, lack of sanitation facilities, and exposure to harsh environmental conditions. These conditions were found to be contributing factors to participants' experiences of urinary tract infections (UTI), kidney-related pain, diarrhea, and symptoms of dizziness associated with dehydration. Participants associated their compromised urinary health with the lack of sanitation facilities in times of need to urinate, describing the situation of having to pay a certain amount in exchange for using the facility (Egemba et al, 2024; Portillo et al., 2023). Oftentimes, they are driven away, not allowing them to access the sanitation facility due to social stigma (Portillo et al., 2023). As a result, they travel to other facilities, forcing them to delay their urination. Homeless adults also reported consuming contaminated water resulting in recurrent diarrheal episodes and increased exposure to waterborne-illnesses (Crank et al., 2025). With repeated exposure, the probability of gastrointestinal infection among homeless individuals increases, which is exacerbated by the inability to maintain hygiene and limited access to soap and other hygiene supplies. People in the “no roof” category, including those who sleep on the streets, access water in various ways to cope with extreme heat. They reported experiencing episodes of dizziness, which is associated with water insecurity and extended exposure to the sun while living outdoors (DeMyers et al., 2017, as cited in Liera et al., 2021). Access to timely and appropriate healthcare is a prevalent challenge among vulnerable populations, particularly those experiencing homelessness tied to financial hardship.

In the context of this vulnerable population, health-seeking behavior is shaped by their financial and clinical check-up capacity, combined with the availability of other health-related resources. A key pattern displayed by participants suggests substitution of professional care with self-medication, which suggests that affordable healthcare services are lacking or perceived as unattainable for these individuals, highlighting a compromised form of care (Zelege et al., 2024). Meanwhile, other homeless adults no longer buy medication when experiencing illnesses, as he cannot afford such medications. This behavior reflects the unavailability of medications due to cost and hence, they are forced to prioritize more basic needs such as food, shelter, and safety, showing a significant financial barrier to healthcare access (Hird et al., 2024). As guided by Orem's Self-Care Deficit Theory (Gonzales, 2024), the health conditions experienced by the homeless adults arise not from personal neglect but from limited self-care agency brought by structural barriers, specifically limited access to water, sanitation, and financial resources. Despite the increase in self-care demands

resulting from environmental exposure and unsheltered conditions, homeless adults are unable to meet the necessities of hydration and hygiene practices, resulting in compromised urinary health, recurrent diarrheal episodes, and dizziness due to lack of hydration.

Homeless adults' access to water is not guaranteed and depends on external factors, presenting a serious challenge to their daily living needs. Responses from this study show that homeless adults allocate their water from gasoline stations near from where they settle. Moreover, others rely on the generosity of others by requesting water from businesses. Explicitly, homeless individuals depend on public facilities, businesses, community, and goodwill of others to obtain water (Ballard et al., 2022). Inadequate infrastructure also contributes as to why homeless populations experience poor access to WASH services, particularly water (Verbyla et al., 2021). Thus, many depended on informal and publicly available resources to meet daily WASH necessities. Some also reported accessing water only when purchasing food, indicating a conditional form of access tied to transactions.

Sanitation facilities are inaccessible for the homeless adults. Participants of this study reported that they experience direct refusal to enter sanitation facilities by establishments. Stigma, restrictions from institutions, and exclusions from public places hinders homeless from having easy access to sanitation, one of the key needs of humanity that help people maintain their health, cleanliness, safety, and human dignity (Anthonj et al., 2024). Homeless individuals were frequently denied access to restroom facilities of businesses and public establishments where entry is within the discretion of staff and owners (Ballard et al., 2022). It is clear from both the stories of the participants and the literature associated with it that access to sanitation for homeless people is constrained not only in a physical sense but also in a socio-political sense. Inequality and exclusion contribute to conditioning access, not just guaranteeing universal access to sanitation facilities. Participants' experiences also reveal that access to sanitation is often limited by operational hours and facility availability (Ballard et al., 2022). Many public and private establishments close at specific times, particularly in the evening, leaving individuals to access during critical periods. This forces homeless adults to either delay their needs, endure discomfort, or seek alternative locations (Portillo et al., 2023). This event disrupts homeless individuals's ability to maintain hygiene and meet basic sanitation (Rodriguez et al., 2021).

Present findings and related literature suggest that homeless individuals adjust their sanitation needs around the operating hours of businesses and establishments to access facilities highlighting unequal access to essential WASH services. Hygiene resources for homeless adults are irregular and incomplete. Participants reported using one product for multiple uses in an attempt to satisfy hygiene needs. Moreover, bathing is observed occasionally and not a daily practice as bathing is heavily tied with how much money homeless individuals have to afford sanitation facilities and hygiene materials. This suggests that hygiene practices of homeless adults are adapted due to limited access to resources (Portillo et al., 2023). In order to satisfy the bathing practice, some resorted to using natural water resources, which is what a typical person will choose when formal methods aren't available (Yang et al., 202).

The dominant perspective across statements of how WASH insecurity deeply affects the daily lives of homeless adults suggests that basic WASH services turn to financial burden further exacerbating their homeless situation. Instead of being routine necessities, water and sanitation become conditional resources that depend on money, work, and availability. Hence, homeless adults prioritize food, work, and survival over WASH needs. Expenses for water, showers, laundry, and hygiene supplies are out of budget; however, these individuals understand the importance of achieving and maintaining cleanliness, creating additional financial strain of homelessness (Portillo et al., 2023). Unmet WASH needs also compete with other survival needs such as medications for participants with health issues. This forces individuals to make difficult prioritization and decisions, affecting their ability to maintain hygiene and health, exacerbating cycles of poverty and social exclusion. (Ballard et al., 2022; Anthonj et al., 2024).

Furthermore, homeless adults experience discrimination when accessing public facilities and social services, which reinforces exclusion and lowers self-esteem (Reilly et al., 2022). Participants reported being hurt by the insults, judgements, and unfair treatment from society because of how they look. Repeated humiliation, rejection, and labeling can create long-term emotional harm. Based on Maslow's Hierarchy of Needs, love and belongingness, esteem, and respect are essential human needs

that come after physiological survival. When homeless adults are denied dignity and social acceptance, they are prevented from achieving confidence, belonging, and personal growth.

Homeless adults have different coping mechanisms in response to WASH insecurity. Participants emphasized the role of storing water in preparation of scarcity so that they can manage their resources anytime. Similarly, Portillo et al. (2023) found that homeless people store water whenever it is available while they use makeshift methods to create their own drinking water supplies. As stated earlier, the use of natural water sources like rivers for bathing is seen as an adaptive strategy to difficult living conditions (Yang et al., 2020). Moreover, people experiencing homelessness commonly store and rationed water as access is inconsistent, while, in the absence of toilets, they choose vacant lots or open areas to defecate (Portillo et al., 2023).

6. Conclusion

In this study, the researchers found a lack of WASH access experienced by the homeless adults in Lipa City. Despite the government's sustained efforts to promote accessible water, sanitation, and hygiene (WASH) across the country, its initiatives fail to reach overlooked populations, particularly persons experiencing homelessness. Existing WASH programs are predominantly structured to attend households, schools, health facilities, and communities with fixed residences. This study also sheds light on the health challenges homeless adults faced in response to WASH insecurity. Beyond chronic illnesses, this study uncovered how homeless adults navigate their health despite having limited resources and financial constraints. Water access is dependent on external factors including establishments, businesses, and community generosity. However, not all the time it is available on hand as these individuals also experience social stigma and discrimination. Similarly, sanitation access is also limited due to restrictions and discriminatory access. Hygiene access is fulfilled via adaptive practices under the conditions of limited access and financial constraint. Furthermore, WASH insecurity intensifies economic hardship and affects the dignity and social identity of homeless adults. Despite these obstacles, they have shown resiliency and adaptation by improvising to meet WASH requirements, surviving their day-to-day living.

Limitations of this study include having a small sample size despite the wide area of Lipa City. Researchers should also evaluate how community interventions for WASH access have worked out for this population. Moreover, this study suggests that policy-makers must include the homeless population in WASH programs and view WASH access independent from having a permanent home. For future researchers, it is recommended to use larger sample sizes and identify community interventions for WASH. A mixed-method research approach would also be suggested to further deepen the knowledge and bridge gap for uncovered information among homeless populations.

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A Holistic and Technology-Assisted Nursing Model for Fracture Recovery: Integrating Physical, Psychological, and Digital Care

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Abstract

Fracture recovery extends beyond bone healing. Patients often face pain, reduced mobility, emotional distress, poor rehabilitation adherence, and limited follow-up after discharge, especially in resource-limited settings. This concept paper proposes the Holistic and Technology-Assisted Nursing Model for Fracture Recovery. The model's novelty is its integration of holistic nursing, psychological support, rehabilitation education, family engagement, self-management, and low-cost digital follow-up into one nurse-led continuity-of-care framework. Unlike interventions that depend on dedicated applications, telemedicine platforms, or wearable devices, the model uses accessible channels such as telephone calls, SMS, and common messaging applications. Grounded in Holistic Nursing Theory, the Person-centred Practice Framework, and Self-management Theory, it links physical, psychological, behavioural, and social dimensions of recovery. Because the framework is conceptual, it should be tested before clinical adoption. Future pilot studies should evaluate feasibility, acceptability, nurse workload, patient engagement, rehabilitation adherence, psychological outcomes, and recovery indicators across orthopedic and community settings.

Keywords: fracture recovery; holistic nursing; digital health; continuity of care; patient-centered care; rehabilitation adherence; low-resource settings

1. Background

Bone fractures are a major global public health concern and a leading source of disability and healthcare use worldwide. Incidence data underscore the scale of the problem: worldwide, up to 37 million fragility fractures occur annually among individuals aged over 55, equivalent to approximately 70 fractures every minute, and more than 10 million hip fractures occur globally in this age group based on 2019 data (GBD 2019 Fracture Collaborators, 2021; International Osteoporosis Foundation, n.d.). Fractures affect individuals of all ages and commonly result from falls, road traffic accidents, sports injuries, osteoporosis, and other traumatic events.

Clinical treatment has traditionally evaluated success through bone union, pain control, restored limb function, and prevention of complications. Orthopedic nursing therefore emphasizes pain assessment, neurovascular monitoring, wound care, medication support, infection prevention, mobilization, and patient safety (Pang et al., 2022). Yet recovery rarely ends at discharge. Many patients continue to experience pain, limited mobility, reduced confidence, fear of reinjury, emotional distress, and difficulty returning to social or occupational roles (McPhail et al., 2012). These experiences show that fracture recovery is multidimensional and requires nursing care that addresses both physical and psychosocial needs.

Recovery often continues for several months after discharge. During this period, patients must follow rehabilitation plans, perform prescribed exercises, manage pain, recognise warning signs, and rebuild functional independence (Yadav et al., 2019). They may also face uncertainty, anxiety about reinjury, low motivation, and difficulties adapting to temporary or permanent lifestyle changes (Sim et al., 2024; Storr et al., 2024). Family members frequently assume caregiving roles with limited guidance. Continuous nursing support is therefore essential to promote adherence, self-management, and reintegration into daily life (Jensen et al., 2019).

Healthcare systems increasingly view continuity of care as central to long-term recovery. For fracture patients, continuity means coordinated support from admission through community-based rehabilitation and follow-up (Haggerty et al., 2003). In nursing practice, this includes discharge planning, patient education, ongoing communication, psychosocial support, symptom monitoring, and timely intervention when problems arise.

Digital health creates practical opportunities to strengthen post-discharge continuity. Telephone consultations, SMS, mobile messaging, and telehealth services can help nurses reinforce

education, monitor symptoms, support rehabilitation, and respond to concerns without requiring frequent hospital visits. These tools extend professional support into patients' homes and make follow-up more flexible and responsive.

At the same time, contemporary nursing increasingly emphasizes holistic and person-centred approaches. Holistic nursing considers the whole person rather than the injury alone, while person-centred care promotes partnership among nurses, patients, and families (McCormack & McCance, 2017). Together, these perspectives support rehabilitation that combines clinical treatment with psychological support, education, family involvement, and active self-management (Lorig & Holman, 2003).

Problem Statement and Knowledge Gap

Although orthopedic surgery and rehabilitation have improved fracture management, recovery remains prolonged and multidimensional. After discharge, many patients continue to experience pain, physical limitations, psychological distress, fear of reinjury, and reduced confidence in daily activities. Rehabilitation adherence may also decline when follow-up support and self-care education are limited (Jensen et al., 2019; McPhail et al., 2012).

Contemporary nursing has increasingly recognised the importance of holistic and person-centred care in improving patient outcomes (Dossey, 2016). Holistic nursing emphasises caring for the individual as a whole by addressing physical, psychological, emotional, social, and spiritual dimensions of health (Dossey, 2016). Similarly, the Person-centred Practice Framework advocates collaborative partnerships between healthcare professionals and patients, encouraging shared decision-making and care that reflects individual preferences and needs (McCormack & McCance, 2017). Self-management interventions have also been shown to enhance patients' knowledge, confidence, and ability to participate actively in their own recovery (Lorig & Holman, 2003). These approaches have each demonstrated positive effects on rehabilitation and chronic disease management.

Digital health has also become an important strategy for continuity of care. Telephone follow-up, mobile messaging, telehealth consultations, and related tools can improve education, adherence, symptom monitoring, and engagement after discharge. However, many interventions evaluate digital communication as a standalone strategy rather than integrating it with holistic nursing, person-centred care, psychological support, and self-management within one nursing framework.

Many digital health programs also rely on dedicated platforms, wearable monitoring devices, or specialized mobile applications. These technologies can be useful, but they often require infrastructure, funding, and digital literacy that may be unavailable in resource-limited settings. Simpler channels such as telephone calls, SMS, and common messaging applications may be more feasible for routine nursing follow-up.

A knowledge gap therefore remains in orthopedic nursing. Holistic nursing, person-centred care, self-management, psychological support, and digital health have each been studied, but limited work explains how they can be systematically combined in a fracture-recovery model that is practical for diverse clinical and community settings.

To address this gap, this paper proposes the Holistic and Technology-Assisted Nursing Model for Fracture Recovery. The novelty of the model lies in combining whole-person nursing, psychological support, rehabilitation education, family engagement, self-management, and accessible digital follow-up into a single conceptual framework. The model is not presented as an empirically validated intervention; it is intended to guide nursing practice development, pilot testing, and future implementation research.

Proposed Concept

This concept paper proposes the Holistic and Technology-Assisted Nursing Model for Fracture Recovery, a conceptual framework designed to strengthen continuity of care across the recovery journey. The model integrates holistic nursing, psychological support, person-centred care, self-management, family engagement, rehabilitation education, and accessible digital communication. Its central premise is that fracture recovery requires coordinated physical, psychological, educational, social, and behavioural support from hospital admission through home-based rehabilitation.

The model consists of six interrelated nursing components: comprehensive physical care, psychological support, rehabilitation education, family engagement, self-management support, and digital health/technology-assisted communication. These components are designed to reinforce one another rather than operate as isolated interventions.

Comprehensive physical care provides the clinical foundation of the model. Nurses assess pain, mobility, neurovascular status, wound healing, and functional recovery while implementing interventions that promote safe rehabilitation and prevent complications. Because physical recovery alone does not ensure successful rehabilitation, psychological support is included to address anxiety, fear of reinjury, uncertainty, and reduced confidence that may affect adherence (McPhail et al., 2012). Rehabilitation education and family engagement further strengthen the recovery process.

Individualized education enables patients to understand fracture healing, rehabilitation exercises, medication management, complication prevention, and lifestyle modifications, thereby improving health literacy and promoting active participation in recovery (McCormack & McCance, 2017). At the same time, family members are recognized as important partners who provide practical assistance, emotional encouragement, and ongoing support during home-based rehabilitation. Their active involvement contributes to greater rehabilitation adherence and facilitates a supportive recovery environment.

Self-management support encourages patients to gradually develop the knowledge, confidence, and skills required to participate actively in their own recovery. Through continuous nursing guidance, patients are encouraged to monitor symptoms, perform prescribed rehabilitation exercises, solve recovery-related problems, and seek professional advice when necessary (Lorig & Holman, 2003). This component promotes patient empowerment while maintaining collaborative partnerships between nurses, patients, and family caregivers.

Digital health and technology-assisted communication function as the connecting element across the model. Accessible channels such as telephone follow-up, SMS, and common messaging applications allow nurses to reinforce education, monitor rehabilitation progress, answer questions, and provide timely support after discharge. Technology is therefore used to extend holistic nursing care, not to replace therapeutic relationships.

Within the model, the six components operate as an integrated nursing system. Comprehensive physical care supports functional recovery; psychological support strengthens motivation and confidence; rehabilitation education and family engagement reinforce self-management; and digital communication enables continuing support across the hospital-to-home transition. Together, these components are expected to improve rehabilitation adherence, patient engagement, psychological well-being, and recovery experiences.

It is important to emphasize that the paper presents a conceptual model, not empirical findings from a tested intervention. The model synthesizes theory and current evidence to specify relationships among holistic nursing, psychological support, digital health, continuity of care, and recovery outcomes. Pilot testing and implementation research are needed to evaluate feasibility, acceptability, workload implications, and clinical effectiveness. The overall relationship among these elements is summarized in Figure 1.

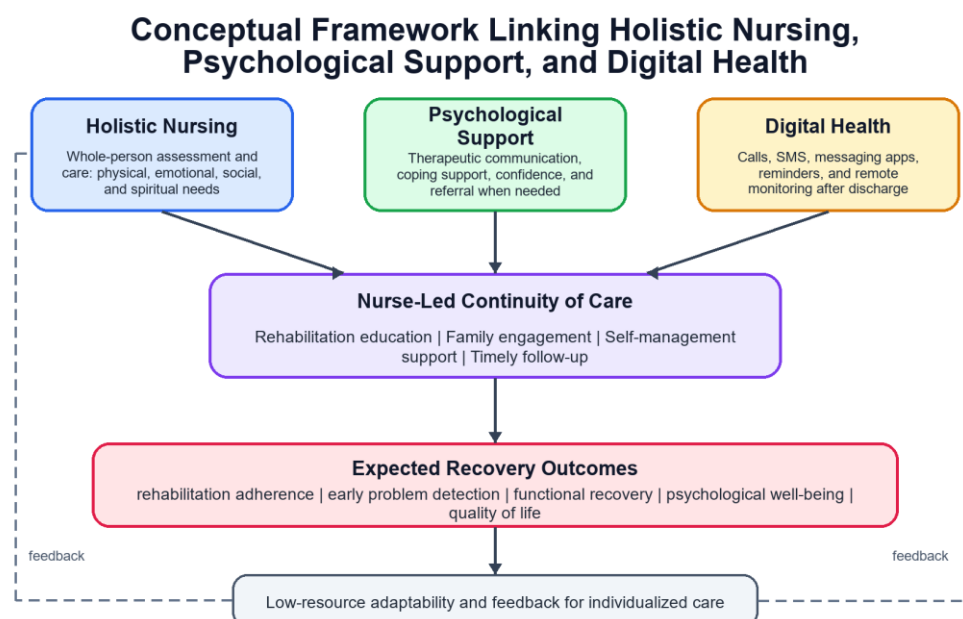


Figure 1. Conceptual framework linking holistic nursing, psychological support, and digital health in fracture recovery

Model Components

As shown in Figure 1, the proposed model links holistic nursing, psychological support, and digital health through nurse-led continuity of care. Its six components collectively address patients' physical, psychological, educational, behavioural, and social needs. Comprehensive physical care, psychological support, rehabilitation education, family engagement, self-management support, and digital communication are intended to function as one coordinated system rather than separate nursing activities.

Comprehensive Physical Care

Comprehensive physical care forms the clinical foundation of the model. Fracture recovery begins with appropriate assessment and management of patients' physiological condition, including pain control, neurovascular assessment, wound management, mobility assessment, prevention of complications, and rehabilitation monitoring. Nurses play a central role in continuously evaluating patients' physical status and tailoring interventions according to individual recovery needs. Rather than focusing solely on bone healing, comprehensive physical care aims to restore functional mobility while supporting patients' overall well-being. This approach reflects the principles of holistic nursing, which recognize that physical health is closely interconnected with psychological, social, and emotional well-being (Dossey, 2016).

Psychological Support

Psychological support is an essential component because emotional well-being substantially influences rehabilitation participation and recovery outcomes. Following a fracture, many patients experience anxiety, fear of reinjury, frustration, uncertainty, or reduced confidence, particularly during the transition from hospital to home (McPhail et al., 2012). These psychological challenges may reduce adherence to rehabilitation programs and delay functional recovery. Within the model, nurses provide therapeutic communication, emotional reassurance, active listening, and psychological assessment throughout the recovery process. Where appropriate, patients may also be referred to additional psychological services. By promoting emotional resilience and self-confidence, psychological support enhances patients' motivation to participate actively in rehabilitation and complements ongoing physical recovery.

Rehabilitation Education

Rehabilitation education enables patients to understand their condition and actively engage in the recovery process. Education extends beyond routine discharge instructions by providing continuous guidance regarding fracture healing, pain management, rehabilitation exercises, medication adherence, recognition of warning signs, fall prevention, and healthy lifestyle behaviors. Consistent with the principles of person-centred care, educational interventions are individualised according to patients' health literacy, learning needs, and recovery goals (McCormack & McCance, 2017). Continuous education improves patients' understanding of their rehabilitation programme, strengthens decision-making capacity, and promotes confidence in performing self-care activities throughout recovery.

Family Engagement

Family engagement recognizes that fracture recovery frequently occurs within the home environment, where family members provide substantial practical and emotional support. Their involvement may influence rehabilitation adherence, mobility, emotional well-being, and patients' ability to perform activities of daily living. Within the model, family members are regarded as active partners in care rather than passive caregivers. Nurses encourage family participation by providing education, involving caregivers in discharge planning, and promoting effective communication regarding rehabilitation goals. A supportive family environment reinforces rehabilitation activities and contributes to the sustainability of recovery after hospital discharge.

Self-management Support

Self-management support empowers patients to become active participants in their own recovery while maintaining continuous collaboration with healthcare professionals. Guided by Self-management Theory, this component focuses on developing patients' knowledge, confidence, and practical skills required to monitor symptoms, perform rehabilitation exercises, adhere to treatment recommendations, and respond appropriately to recovery-related concerns (Lorig & Holman, 2003). Nurses facilitate self-management through goal setting, problem-solving, motivational support, and regular reinforcement of rehabilitation strategies. Rather than encouraging independent self-care alone, this component emphasises shared responsibility between nurses, patients, and family caregivers throughout the recovery journey.

Digital Health and Technology-Assisted Communication

Digital health and technology-assisted communication strengthen continuity of care across the model. Practical methods such as telephone calls, SMS, and common messaging applications allow nurses to monitor progress, reinforce education, answer questions, identify emerging concerns, and provide timely emotional support after discharge. Because these channels are familiar and low cost, they may be more feasible than specialized platforms in resource-limited settings. Figure 2 outlines this technology-assisted continuity-of-care process.

Collectively, the six components operate as an integrated nursing system. Comprehensive physical care supports physiological recovery; psychological support promotes resilience and motivation; rehabilitation education and family engagement strengthen self-management; and digital communication maintains nurse-patient contact after discharge. Through this coordinated approach, the model aims to support adherence, engagement, and holistic recovery after fracture.

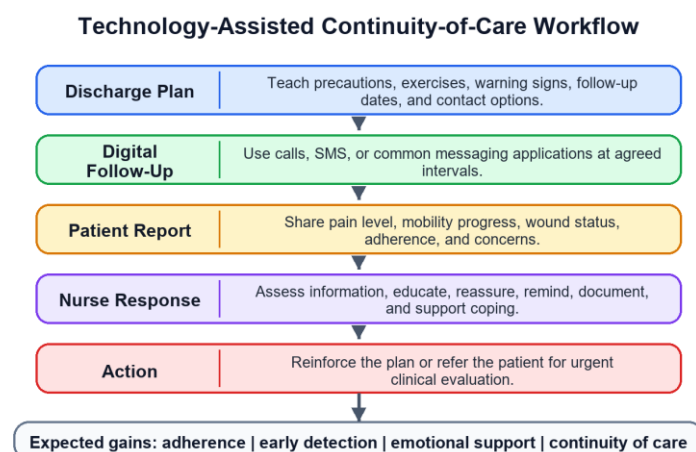


Figure 2. Technology-Assisted Follow-Up Workflow for Fracture Recovery

Continuity of Care and Self-management Support

Technology-assisted follow-up plays a central role in maintaining continuity of care after hospital discharge, as illustrated in Figure 2. Through regular communication using telephone calls, short message services (SMS), or commonly used messaging applications, nurses are able to monitor patients' recovery progress, reinforce rehabilitation education, and respond promptly to emerging concerns. This ongoing interaction helps bridge the transition from hospital to home and reduces potential gaps in post-discharge nursing care.

Regular follow-up also strengthens patient self-management by encouraging individuals to actively monitor symptoms, adhere to rehabilitation programs, perform prescribed exercises, and communicate recovery-related concerns to healthcare professionals. Guided by self-management principles, nurses support patients through continuous education, motivation, and collaborative problem-solving, thereby promoting greater confidence, self-efficacy, and active participation throughout the recovery process. Through sustained communication and timely nursing support, technology-assisted follow-up facilitates both continuity of care and effective self-management during fracture rehabilitation.

Adaptability to Low-resource Settings

An important advantage of the model is its adaptability to low-resource healthcare settings. Unlike many digital health interventions that depend on sophisticated telemedicine platforms or advanced monitoring technologies, this model emphasises practical and accessible communication methods that are already available in many healthcare institutions and communities. Telephone follow-up, SMS, and commonly used messaging applications can be incorporated into routine nursing practice without requiring substantial financial investment or specialised technological infrastructure. The workflow presented in Figure 2 demonstrates how technology-assisted follow-up may be integrated into routine fracture rehabilitation using simple and scalable nursing interventions. This practical approach enhances the feasibility, sustainability, and potential transferability of the model across diverse clinical settings, particularly where healthcare resources and technological capacity are limited.

2. Theoretical Basis

The model is underpinned by three complementary theoretical perspectives: Holistic Nursing Theory, the Person-centred Practice Framework, and Self-management Theory. These theoretical foundations provide the conceptual rationale for integrating comprehensive physical care, psychological support, rehabilitation education, family engagement, self-management support, and technology-assisted communication into a coordinated nursing framework. Rather than functioning independently, the three theories complement one another and collectively support the multidimensional nature of fracture recovery.

Holistic Nursing Theory

Holistic Nursing Theory provides the primary theoretical foundation for the model. Holistic nursing recognizes that health extends beyond physical healing and encompasses psychological, emotional, social, cultural, and spiritual dimensions of well-being (Dossey, 2016). Within fracture rehabilitation, recovery is influenced not only by bone healing but also by patients' emotional responses, functional ability, confidence, family support, and capacity to resume everyday activities. Consequently, nursing care should address the individual as a whole rather than focusing solely on physiological recovery.

Within the model, holistic nursing principles underpin the integration of comprehensive physical care and psychological support. Nurses are expected to assess patients' physical condition while simultaneously identifying emotional concerns, rehabilitation barriers, and individual care needs. This integrated approach promotes holistic recovery by recognising the interdependence of physical and psychological well-being throughout the rehabilitation process.

Person-centred Practice Framework

The Person-centred Practice Framework further supports the model by emphasising collaborative partnerships between healthcare professionals, patients, and their families. The framework advocates respect for individual preferences, shared decision-making, effective communication, and active patient participation in healthcare planning.

These principles are reflected in the rehabilitation education and family engagement components of the model. Individualised education enables patients to understand their rehabilitation goals and participate actively in recovery, while family engagement recognizes the important contribution of caregivers during post-discharge rehabilitation. By promoting collaboration between nurses, patients, and families, person-centred practice strengthens patient engagement and supports continuity of care across the transition from hospital to home.

Self-management Theory

Self-management Theory provides the behavioural foundation for the model by emphasising patients' ability to participate actively in managing their own health (Lorig & Holman, 2003). The theory proposes that patients who possess adequate knowledge, confidence, and problem-solving skills are more likely to adhere to treatment recommendations and maintain positive health behaviours over time.

Within the model, self-management principles underpin both self-management support and technology-assisted communication. Nurses facilitate self-management by providing ongoing education, reinforcing rehabilitation behaviors, monitoring patients' progress, and encouraging timely communication regarding recovery-related concerns. Technology-assisted follow-up further supports these activities by maintaining regular contact between nurses and patients after discharge, thereby reinforcing behavioral change and promoting sustained engagement throughout the recovery process. Collectively, these three theoretical perspectives provide a coherent conceptual foundation for the model. Holistic Nursing Theory supports comprehensive and integrated nursing care, the Person-centred Practice Framework guides collaborative rehabilitation and family involvement, and Self-management Theory promotes patient empowerment and sustained rehabilitation behaviors. Together, these theories justify the integration of the six core components illustrated in Figure 1 and explain the theoretical rationale for strengthening continuity of care throughout fracture recovery.

Rationale

The rationale for the model is grounded in the need for continuous nursing support beyond acute fracture care. Existing interventions often improve single aspects of recovery, but physical care, psychological support, education, family engagement, self-management, and digital communication are frequently delivered separately. This fragmentation can weaken post-discharge rehabilitation and continuity of care (Naylor et al., 2011).

The model adopts a holistic approach because recovery depends on more than physiological healing. Functional progress is shaped by psychological well-being, rehabilitation adherence, health literacy, family support, and confidence in self-management. Integrating these dimensions within one framework helps nurses respond to patients' changing needs across the recovery trajectory.

Digital health and technology-assisted communication further support the rationale by extending nursing contact into the community. Telephone follow-up, SMS, and common messaging

applications can reinforce rehabilitation education, monitor recovery, identify concerns early, and provide emotional reassurance (Yadav et al., 2019). Used in this way, digital communication strengthens rather than replaces person-centred nursing care.

A further strength is the model's emphasis on accessibility. Because it relies on communication channels already used in many communities, it may be more scalable and sustainable than interventions requiring sophisticated digital infrastructure. This focus supports equitable continuity of care in hospitals, community services, and resource-limited settings.

Overall, the model offers a theoretically informed and clinically relevant framework for future intervention development. Its contribution is conceptual: it organizes evidence-informed nursing components into a coherent model that can be refined through pilot studies and later evaluated for effectiveness.

Implications for Nursing Practice

The model has several potential implications for nursing practice by providing a structured framework for delivering holistic and continuous care throughout fracture recovery. Rather than focusing exclusively on acute clinical management, the model encourages nurses to adopt a comprehensive approach that integrates physical rehabilitation, psychological support, patient education, family engagement, self-management support, and technology-assisted communication into routine nursing care.

The model may assist nurses in improving continuity of care during the transition from hospital to home. By incorporating regular technology-assisted follow-up, nurses can reinforce rehabilitation education, monitor patients' recovery progress, identify potential complications at an early stage, and provide timely guidance and emotional support. This ongoing communication may strengthen patients' confidence, promote adherence to rehabilitation programs, and facilitate active participation in the recovery process.

The model may also contribute to more person-centred nursing practice. Through individualised rehabilitation education, collaborative goal setting, and active family involvement, nurses are encouraged to develop care plans that reflect patients' preferences, recovery goals, and social circumstances. Such an approach has the potential to improve patient engagement and strengthen partnerships between healthcare professionals, patients, and family caregivers.

An additional implication of the model is its applicability across diverse healthcare settings. Because the model emphasises practical and accessible communication strategies rather than sophisticated digital technologies, it may be implemented in hospitals, community healthcare services, and resource-limited settings with relatively limited technological infrastructure. This flexibility enhances the potential scalability and sustainability of the model while supporting equitable access to post-discharge nursing care.

Although the model has not yet been empirically tested, it provides a theoretically informed framework that may guide future nursing practice, intervention development, and clinical decision-making. The model also offers a conceptual foundation for future pilot studies and implementation research designed to evaluate its feasibility, acceptability, and effectiveness in improving fracture recovery.

3. Implementation Challenges and Future Research

Implementation of the proposed model will require attention to patient digital literacy and access. Although telephone calls, SMS, and common messaging applications are more accessible than specialized platforms, some patients may have limited phone access, unstable connectivity, visual or hearing difficulties, language barriers, or low confidence using digital tools. Nurses should assess each patient's preferred communication channel, provide simple instructions, involve family caregivers when appropriate, and offer non-digital alternatives so technology-assisted care does not widen inequities (World Health Organization, 2021).

Nurse workload is another practical challenge. Follow-up calls, messaging, triage, documentation, and referral can add responsibilities to already busy orthopedic and community nursing teams. Implementation should therefore include clear follow-up protocols, scheduled contact intervals, documentation templates, escalation criteria, team-based delegation, and workload monitoring. These supports can help embed digital follow-up into routine discharge planning rather than treating it as an unfunded extra task (World Health Organization, 2020).

Future work should begin with pilot testing in selected orthopedic or community settings. Pilot studies can assess feasibility, acceptability, fidelity, time burden, patient engagement,

rehabilitation adherence, psychological distress, satisfaction, and early functional outcomes. Findings from these pilots should be used to refine the model before larger implementation studies or controlled trials evaluate clinical effectiveness.

Limitations

Several limitations should be acknowledged. First, this paper presents a conceptual model rather than empirical findings; its feasibility, acceptability, and effectiveness remain untested. Second, although the individual components are supported by nursing theory and existing evidence, their combined use has not yet been validated as a single intervention. Third, implementation may be affected by digital literacy, communication access, privacy concerns, nurse workload, documentation demands, and organizational resources. Pilot testing is therefore needed before broad clinical implementation can be recommended.

4. Conclusion

Fracture recovery extends beyond physiological healing and requires continuous, coordinated, person-centred nursing care that addresses physical, psychological, educational, behavioural, and social needs. Existing interventions support important aspects of recovery, but they are often implemented separately, leaving gaps in post-discharge care.

This concept paper proposes the Holistic and Technology-Assisted Nursing Model for Fracture Recovery as a conceptual framework for integrating comprehensive physical care, psychological support, rehabilitation education, family engagement, self-management support, and digital communication. Guided by Holistic Nursing Theory, the Person-centred Practice Framework, and Self-management Theory, the model offers a coherent approach to continuity of care from hospital admission through home-based rehabilitation.

A key strength of the model is its use of accessible digital communication to support follow-up, engagement, and self-management without depending on sophisticated infrastructure. This feature may improve applicability across diverse healthcare settings, including resource-limited environments.

As a conceptual model, the framework requires empirical validation. Pilot studies should examine feasibility, acceptability, workload, fidelity, adherence, psychological outcomes, satisfaction, and functional recovery before larger effectiveness studies are undertaken. Even at this stage, the model provides a practical theoretical foundation for designing continuity-of-care strategies aimed at improving fracture recovery.

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Effects of a Trauma Care Training Program on Nurses' Trauma-Informed Care, Confidence, and Interprofessional Collaboration

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Abstract

Trauma-informed care and interprofessional collaboration are essential competencies in trauma nursing, yet many nurses continue to experience gaps in translating trauma care principles into practice, building clinical confidence, and working effectively within collaborative teams. This study examined the association between a trauma care training program and nurses' trauma-informed care, perceived confidence, and interprofessional collaborative competencies. A quasi-experimental one-group pretest–posttest design was used. Forty-five nurses from a tertiary hospital in Pampanga, Philippines participated in a 10-day trauma care training program that combined didactic instruction with clinical immersion. Data were collected before and after the training using validated instruments measuring trauma-informed care, perceived confidence, and interprofessional collaborative competencies. Wilcoxon signed-rank tests and paired-samples t-tests were used to analyze pretest–posttest changes. Findings showed significant improvements across trauma-informed care domains, including knowledge, attitude, and practice, as well as all measured interprofessional collaborative competency domains ($p < .001$). Nurses perceived confidence also increased significantly after the program, $t(44) = 15.23$, $p < .001$, $d = 2.27$, indicating a large effect. These findings suggest that experiential trauma care training may strengthen nurses' trauma-informed practice, confidence, and collaborative competencies. The study highlights the value of structured, practice-based training in preparing nurses for complex trauma care contexts and supports the need for controlled and longitudinal studies to determine causal effects and sustainability of outcomes.

Keywords: trauma-informed care; experiential learning; nursing education; interprofessional collaboration; confidence

1. Introduction

Trauma care is a critical component of acute and emergency nursing, requiring the integration of rapid clinical decision-making, technical proficiency, and patient-centered care. Nurses managing traumatically injured patients must perform timely assessments and interventions while addressing the psychological and emotional dimensions of trauma (Guest, 2021; Goddard et al., 2022; McDowell et al., 2022). The complexity and variability of trauma cases further require adaptability and effective coordination within multidisciplinary teams (Makino et al., 2019). Despite these demands, translating theoretical knowledge into consistent and effective clinical performance remains a persistent challenge in high-acuity settings.

Trauma-informed care (TIC) and interprofessional collaboration have been increasingly emphasized in nursing education and practice. However, gaps remain in nurses' knowledge, confidence, and collaborative competencies, particularly in the translation of learning into clinical practice. Evidence suggests a disconnect between positive attitudes toward TIC and actual practice, as well as limited integration of training outcomes into real-world clinical environments. While prior studies have demonstrated the benefits of TIC and interprofessional education, these domains are often examined independently and within controlled settings, limiting their applicability to complex clinical contexts.

Grounded in Experiential Learning Theory (ELT), which conceptualizes learning as a cyclical process involving experience, reflection, and application (Kolb & Kolb, 2009), this study examines a structured trauma care training program that integrates didactic instruction with clinical immersion. Specifically, the study aims to determine whether participation in the program is associated with

changes in trauma-informed care (knowledge, attitudes, and practices), perceived confidence, and interprofessional collaborative competencies among nurses. By examining these outcomes concurrently within a real-world clinical setting, this study contributes to the development of practice-oriented and theory-informed approaches to trauma nursing education.

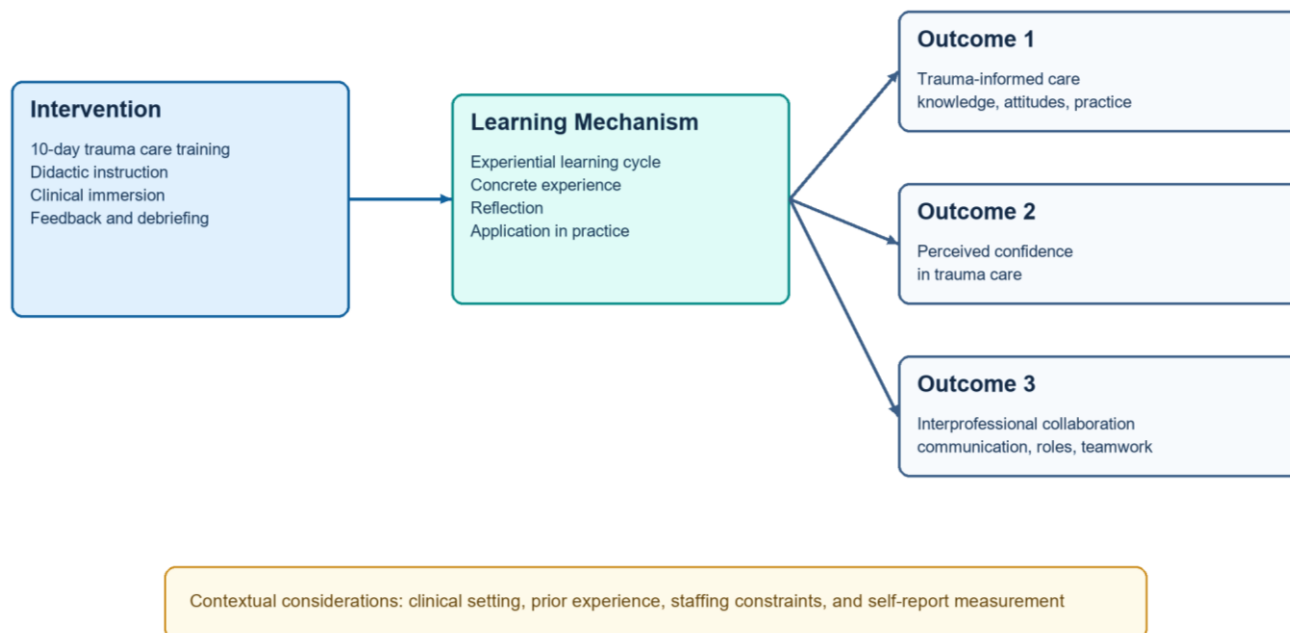


Figure 1. Conceptual framework linking the trauma care training program to trauma-informed care, perceived confidence, and interprofessional collaborative competencies.

1.1. Conceptual Framework

The conceptual framework of the study is presented in Figure 1. The 10-day trauma care training program serves as the intervention, while the experiential learning process provides the mechanism through which didactic instruction, clinical immersion, feedback, and reflective debriefing are expected to influence nurses' trauma-informed care, perceived confidence, and interprofessional collaborative competencies. Contextual factors, including prior experience, staffing constraints, and the clinical setting, may shape how these outcomes are expressed.

2. Objectives

The general objective of this study was to examine the association between participation in a trauma care training program and nurses' trauma-informed care, perceived confidence, and interprofessional collaborative competencies.

Specifically, this study aimed to:

1. Determine the pretest and posttest levels of nurses' trauma-informed care in terms of knowledge, attitudes, and practices;
2. Determine the pretest and posttest levels of nurses' perceived confidence in trauma care;
3. Determine the pretest and posttest levels of nurses' interprofessional collaborative competencies in terms of communication, collaboration, roles and responsibilities, collaborative patient-centered care, conflict management, and team functioning; and
4. Examine whether statistically significant differences exist between pretest and posttest scores after completion of the trauma care training program.

3. Materials and Methods

3.1. Research Design

This study employed a quasi-experimental one-group pretest–posttest design to evaluate the impact of trauma care nursing training on participants' trauma-informed care competencies, perceived confidence, and interprofessional collaborative competencies. Participants were assigned to the intervention using a non-randomized, single-group design due to operational and staffing constraints within the clinical setting. All participants received the same intervention, and no comparison group was included. This design enabled the comparison of outcomes before and after the intervention within the same group of participants, allowing for the assessment of changes associated with the training. The quasi-experimental approach was appropriate given the constraints of the clinical setting, where randomization was not feasible due to staffing and operational demands. By using a within-subject design, the study minimized individual variability and provided a focused evaluation of the training's effectiveness.

3.2. Participants and Setting

The study was conducted in a hospital located in Pampanga, Central Luzon, Philippines, which provides a wide range of healthcare services, including emergency and acute care, serving a diverse patient population. The clinical environment offered a relevant setting for implementing trauma care nursing training and assessing its outcomes in real-world practice.

The sample size was determined based on feasibility and the number of nurses available during the training periods. Given the exploratory nature of the study and the absence of prior local data to inform effect size estimation, all eligible nurses who consented were included. Of the 60 nurses who attended the training batches, 45 consented to participate in the study and completed both pretest and posttest assessments. To minimize potential bias associated with the nonrandomized design, a within-subject pretest-posttest approach was employed, allowing each participant to serve as their own control.

Participants met the following inclusion criteria: (1) registered nurses currently employed in a hospital setting and enrolled in the Basic Trauma Nursing Course; (2) aged 21 to 59 years; (3) directly involved in patient care; and (4) willing to provide informed consent. Nurses were excluded if they (1) did not complete the training, (2) were assigned to purely administrative roles, or (3) declined participation.

3.3. Intervention

Participants underwent a structured 10-day trauma care nursing training program designed to enhance trauma-informed care (TIC) competencies, perceived confidence, and interprofessional collaborative skills. The training was conducted in two batches, held in June and November 2025, with 30 participants in each batch; however, only 45 participants consented to participate in the study. The intervention was grounded in experiential learning principles, emphasizing the integration of knowledge acquisition, reflective practice, and clinical application.

The program was divided into two phases: didactic instruction (4 days) and experiential clinical training (6 days). The didactic phase covered core concepts of trauma-informed care, including principles of safety, trust, empowerment, and patient-centered communication, as well as the roles and responsibilities of trauma nurses within interprofessional teams. Teaching strategies included interactive lectures, case-based discussions, and guided reflection, enabling participants to engage in conceptual understanding and reflective observation.

The experiential phase involved supervised hands-on clinical practice in trauma care settings, where participants applied learned concepts in real-world scenarios. This phase emphasized active experimentation, allowing nurses to practice trauma-informed approaches, interprofessional communication, and collaborative decision-making under the guidance of clinical facilitators. Structured feedback and debriefing sessions were conducted to reinforce learning, promote critical reflection, and enhance skill integration.

To evaluate the effectiveness of the intervention, participants completed standardized assessments at two time points: pretest (prior to training) and posttest (immediately after completion). These assessments measured trauma-informed care (knowledge, attitudes, and practices), perceived

confidence, and interprofessional collaborative competencies. The use of identical instruments at both time points enabled the analysis of changes attributable to the training.

Overall, the intervention was designed to facilitate progressive learning across cognitive, affective, and behavioral domains, ensuring that participants not only acquired knowledge but also developed the confidence and collaborative skills necessary for effective trauma-informed practice. Blinding was not feasible due to the nature of the educational intervention, as participants and facilitators were aware of the training activities. Outcome assessment relied on self-reported measures.

3.4. Measurements

Data were collected using four instruments administered at pretest and posttest. A demographic data questionnaire described participants' characteristics, including age, sex, highest educational attainment, years of experience as a registered nurse, department or unit of assignment, and prior training in trauma care or emergency response. Trauma-informed care was measured using a validated 30-item Trauma-Informed Care (TIC) instrument comprising three domains: knowledge (8 items), attitude (10 items), and practice (12 items). The instrument demonstrated high internal consistency (Cronbach's $\alpha = .939$) and strong content validity (content validity index = .971). Responses were rated on a Likert-type scale, with higher scores reflecting greater competency in trauma-informed care. Perceived confidence in trauma care was assessed using a self-developed 10-item questionnaire aligned with the objectives of the training program. Items were rated on a 5-point Likert scale ranging from 0 (not at all confident) to 5 (extremely confident), with higher scores indicating greater perceived confidence in managing trauma-related clinical situations. Validity was established through expert review by experienced emergency room nurses with clinical and trauma care expertise. The instrument was pilot tested prior to the main study and demonstrated good internal consistency (Cronbach's $\alpha = .89$). Interprofessional collaborative competencies were measured using the Interprofessional Collaborative Competency Attainment Survey (ICCAS), which evaluates communication, collaboration, roles and responsibilities, collaborative patient-centered care, conflict management, and team functioning (Archibald et al., 2014). The ICCAS uses a Likert-type scale, with higher scores indicating stronger collaborative competencies, and has demonstrated high internal consistency, with Cronbach's α values ranging from .94 to .98 across pre- and post-assessments. All instruments were administered before and immediately after the training intervention to assess changes in participants' competencies, confidence, and collaborative skills.

3.5. Ethical Considerations

Ethical approval was obtained from the Ethics Review Committee of Angeles University Foundation (Approval No. 2025-CON-Faculty-003). Additionally, administrative approval was secured from the participating hospital. The informed consent form included in the Google Forms survey outlined the study's purpose, procedures, and potential benefits. Participation was voluntary, and privacy and confidentiality were strictly maintained. No personally identifiable information was collected, and nursing supervisors or administrators had no access to individual responses. Unique identification codes were assigned to each participant for pretest and posttest matching to ensure anonymity. Any contact information provided was used solely for study-related communication.

3.6. Data Analysis

Data were analyzed using IBM SPSS Statistics version 29. Descriptive statistics (frequency, percentage, mean, and standard deviation) summarized demographics and scores on trauma-informed care, perceived confidence, and interprofessional collaborative competencies.

Normality tests were conducted prior to inferential analysis. As most variables were non-normal, the Wilcoxon signed-rank test was used to assess pretest-posttest differences in trauma-informed care (knowledge, attitude, practice) and interprofessional competencies (communication, collaboration, roles and responsibilities, patient-centered care, conflict management, and team functioning). For perceived confidence, which met normality, a paired-samples t-test was applied. Statistical significance was set at $p < .05$. Standardized Z values were reported for nonparametric tests. Effect sizes were calculated using rank-biserial correlation ($r_{rb} = Z/\sqrt{N}$) and Cohen's d for parametric analysis. Ninety-five percent confidence intervals were also estimated. Missing data were

assessed prior to analysis, and cases with complete pretest and posttest data were included in the final analysis.

4. Results

This section presents the findings of the study, including the demographic characteristics of the participants, their prior training experiences, and the pre- and posttest outcomes of trauma-informed care, perceived confidence, and interprofessional collaborative competencies. No adverse events or unintended effects were reported during the implementation of the training program.

Table 1 presents the demographic characteristics of the participants. All 45 participants who were enrolled in the study completed the intervention and both pretest and posttest assessments, with no loss to follow-up. The majority were aged 25–34 years (42.22%) and female (68.89%). Most participants held a Bachelor's degree in Nursing (97.78%). In terms of clinical experience, the largest proportion had 1–5 years of experience as registered nurses (37.78%), while most were assigned to the Emergency Department (84.44%). More than half of the participants reported no prior training in trauma care or emergency response (62.22%).

Table 1: Demographic Characteristics of Nurses (N = 45)

Demographic Variables	Frequency (n)	Percentage (%)
Age		
Under 25	8	17.78%
25-34	19	42.22%
35-44	16	35.56%
45-54	2	4.44%
Sex		
Female	31	68.89%
Male	14	31.11%
Highest Educational Attainment		
Bachelor's Degree in Nursing	44	97.78%
Master's Degree in Nursing	1	2.22%
Years of Experience as Registered Nurse		
Less than 1 year	9	20.00%
1-5 years	17	37.78%
6-10 years	6	13.33%
11-15 years	2	4.44%
More than 15 years	11	24.44%
Department/Unit		
Emergency Department	38	84.44%
Medical/Surgical	5	11.11%
General ward	2	4.44%
Has Previous Training in Trauma Care or Emergency Response		
No	28	62.22%
Yes	17	37.78%

Table 2 summarizes the types of prior trauma or emergency training among participants who reported previous training ($n = 17$). The most commonly reported training was Advanced Trauma Life Support (ATLS) (52.94%), followed by Basic Life Support (BLS) and Advanced Cardiac Life Support (ACLS), each at 23.53%. Other reported training included Standard First Aid (17.65%) and selected specialized trauma-related programs (5.88% each).

Table 2: Types of Prior Trauma/Emergency Training Among Nurses with Previous Training

Training Program	Frequency (n)	Percentage (%)
Advanced Trauma Life Support (ATLS)	9	52.94%
Basic Life Support (BLS)	4	23.53%
Advanced Cardiac Life Support (ACLS)	4	23.53%
Standard First Aid	3	17.65%
Medical Trauma Management	1	5.88%
Basic Toxicology & Biomarine Poisoning	1	5.88%

$n = 17$

Table 3 presents the pretest descriptive statistics for trauma-informed care (TIC) dimensions, perceived confidence, and interprofessional collaborative competencies. Overall, participants demonstrated relatively high baseline levels of trauma-informed care. Among the TIC dimensions, attitude had the highest mean score ($M = 4.40$, $SD = 0.49$), followed by practice ($M = 4.16$, $SD = 0.53$) and knowledge ($M = 4.01$, $SD = 0.76$). Variability was greatest in the knowledge domain, as indicated by its higher standard deviation.

Perceived confidence had a lower mean score ($M = 3.33$, $SD = 0.65$) compared to TIC dimensions. Interprofessional collaborative competencies were reported at moderate levels across domains, with mean scores ranging from 3.42 to 3.56. The highest means were observed in collaborative patient-centered care ($M = 3.56$, $SD = 0.51$) and team functioning ($M = 3.54$, $SD = 0.49$), while communication had the lowest mean score ($M = 3.42$, $SD = 0.49$).

Table 3: Pretest Descriptive Statistics Results for Trauma-Informed Care Dimensions, Perceived Confidence and Interprofessional Collaborative Competencies

Dimensions	Mean	SD
Knowledge	4.01	0.76
Attitude	4.40	0.49
Practices	4.16	0.53
Perceived Confidence	3.33	0.65
Communication	3.42	0.49
Collaboration	3.45	0.52
Roles & Responsibilities	3.53	0.52
Collaborative Patient Care	3.56	0.51
Conflict Management	3.52	0.51
Team Functioning	3.54	0.49

Table 4 presents the posttest descriptive statistics for trauma-informed care (TIC) dimensions, perceived confidence, and interprofessional collaborative competencies. Among the TIC dimensions, attitude had the highest mean score ($M = 4.87$, $SD = 0.24$), followed by practice ($M = 4.83$, $SD = 0.25$) and knowledge ($M = 4.67$, $SD = 0.56$). Variability was relatively low for attitude and practice, as indicated by smaller standard deviations.

Perceived confidence had a mean score of $M = 3.93$ ($SD = 0.51$). Interprofessional collaborative competencies showed higher mean scores across domains, ranging from 3.97 to 4.40. The highest mean was observed in roles and responsibilities ($M = 4.40$, $SD = 1.89$), followed by collaboration ($M = 4.23$, $SD = 0.23$). Other domains, including conflict management ($M = 4.14$, $SD = 0.23$), team functioning ($M = 4.14$, $SD = 0.27$), and collaborative patient-centered care ($M = 4.03$, $SD = 0.20$), also demonstrated relatively high mean scores. Communication had the lowest mean among the interprofessional domains ($M = 3.97$, $SD = 0.13$). Notably, the roles and responsibilities domain showed greater variability compared to other domains.

Table 4: Posttest Descriptive Statistics Results for Trauma-Informed Care Dimensions, Perceived Confidence and Interprofessional Collaborative Competencies

Dimensions	Mean	SD
Knowledge	4.67	0.56
Attitude	4.87	0.24
Practices	4.83	0.25
Perceived Confidence	3.93	0.51
Communication	3.97	0.13
Collaboration	4.23	0.23
Roles & Responsibilities	4.40	1.89
Collaborative Patient Care	4.03	0.20
Conflict Management	4.14	0.23
Team Functioning	4.14	0.27

Table 5 presents the pretest-posttest differences in training outcomes. Wilcoxon signed-rank tests indicated statistically significant increases across all trauma-informed care (TIC) dimensions. Knowledge increased from $M = 4.01$ ($SD = 0.76$) to $M = 4.67$ ($SD = 0.56$), attitude from $M = 4.40$ ($SD = 0.49$) to $M = 4.87$ ($SD = 0.24$), and practice from $M = 4.16$ ($SD = 0.53$) to $M = 4.83$ ($SD = 0.25$) (all $p < .001$). Effect size estimates for these variables were large, with rank-biserial correlations ranging from 0.86 to 0.88 (95% CI [0.75, 0.94]).

Similarly, statistically significant increases were observed across all interprofessional collaborative competency domains (all $p < .001$). Communication increased from $M = 3.42$ ($SD = 0.49$) to $M = 3.97$ ($SD = 0.13$), collaboration from $M = 3.45$ ($SD = 0.52$) to $M = 4.23$ ($SD = 0.23$), and team functioning from $M = 3.54$ ($SD = 0.49$) to $M = 4.14$ ($SD = 0.27$), with similar patterns observed across the remaining domains. Effect sizes for interprofessional competencies were also large, ranging from $r_{rb} = 0.73$ to 0.83 (95% CI [0.57, 0.91]).

A paired-samples t -test revealed a statistically significant increase in perceived confidence from pretest ($M = 3.33$, $SD = 0.65$) to posttest ($M = 3.93$, $SD = 0.51$), $t(44) = 15.23$, $p < .001$, with a very large effect size ($d = 2.27$).

Overall, these findings indicate statistically significant and consistent improvements across measured outcomes. However, the magnitude of the observed effects should be interpreted with

caution, as relatively high baseline scores and reduced variability in posttest responses may suggest potential ceiling effects.

Table 5: Pretest-Posttest Test Differences, Statistical Tests, p values, and Effect Sizes for Training Outcomes

Variable	Pretest M (SD)	Posttest M (SD)	Test statistic	p	Effect size	95% CI
Knowledge	4.01 (0.76)	4.67 (0.56)	$Z = -5.89$	<.001	$r_{rb} = 0.88$	[0.78, 0.94]
Attitude	4.40 (0.49)	4.87 (0.24)	$Z = -5.74$	<.001	$r_{rb} = 0.86$	[0.75, 0.93]
Practice	4.16 (0.53)	4.83 (0.25)	$Z = -5.74$	<.001	$r_{rb} = 0.86$	[0.75, 0.93]
Perceived Confidence *	3.33 (0.65)	3.93 (0.51)	$t(44) = 15.23$	<.001	$d = 2.27$	-
Communication	3.42 (0.49)	3.97 (0.13)	$Z = -5.30$	<.001	$r_{rb} = 0.79$	[0.65, 0.89]
Collaboration	3.45 (0.52)	4.23 (0.23)	$Z = -5.60$	<.001	$r_{rb} = 0.83$	[0.70, 0.91]
Roles & Responsibilities	3.53 (0.52)	4.40 (1.89)	$Z = -5.10$	<.001	$r_{rb} = 0.76$	[0.61, 0.88]
Collaborative Patient Care	3.56 (0.51)	4.03 (0.20)	$Z = -4.90$	<.001	$r_{rb} = 0.73$	[0.57, 0.86]
Conflict Management	3.52 (0.51)	4.14 (0.23)	$Z = -5.00$	<.001	$r_{rb} = 0.75$	[0.60, 0.88]
Team Functioning	3.54 (0.49)	4.14 (0.27)	$Z = -5.20$	<.001	$r_{rb} = 0.77$	[0.62, 0.88]

5. Discussion

The findings indicate that participation in a structured trauma care training program was associated with statistically significant improvements in trauma-informed care (TIC), perceived confidence, and interprofessional collaborative competencies among nurses. Interpreted through the lens of Experiential Learning Theory (ELT), these results suggest that integrating didactic instruction, clinical immersion, and reflective practice can facilitate meaningful learning across cognitive, affective, and behavioral domains (Kolb & Kolb, 2009).

Improvements in TIC knowledge, attitudes, and practices suggest that the intervention supported progression through the experiential learning cycle. Gains in knowledge reflect effective conceptual acquisition, while increases in attitudes and practices indicate deeper internalization and application of trauma-informed principles. This pattern aligns with prior studies demonstrating that experiential and applied TIC training enhances both knowledge and clinical practice outcomes (Badawy et al., 2023; Zordan et al., 2022; Kotake et al., 2025). Moreover, the observed attitudinal shifts are consistent with evidence that experiential approaches foster empathetic, patient-centered care, which are core elements of trauma-informed practice (Wholeben et al., 2023; Loomis et al., 2024).

The significant improvement in perceived confidence supports the role of experiential learning in strengthening self-efficacy. Confidence is often developed through active engagement in clinical experiences, reinforced by feedback and reflection. However, the comparatively lower posttest confidence scores suggest that self-efficacy may require sustained and iterative learning cycles to fully mature. This finding is consistent with previous research indicating that while training can rapidly improve knowledge and attitudes, confidence develops more gradually through continued clinical exposure (Oyesanya et al., 2017; Stewart et al., 2024; Marsac et al., 2025).

Improvements across interprofessional collaborative competencies highlight the value of experiential and team-based learning. Domains such as collaboration, team functioning, and conflict management showed notable gains, suggesting that shared clinical experiences and reflective processes enhanced participants' ability to function effectively within interprofessional teams. These findings are supported by literature demonstrating that interprofessional trauma-informed education

strengthens teamwork, communication, and coordinated care delivery (Cerny et al., 2023; Black et al., 2023; Bills et al., 2023; Snider et al., 2023). Such competencies are essential in trauma care, where coordinated team responses directly influence patient outcomes (Lapierre et al., 2024; Mink et al., 2019).

Despite overall improvements, communication remained the lowest scoring domain. These findings suggest that communication skills in high-acuity settings may require more targeted and sustained interventions. Evidence indicates that communication competencies are best developed through repeated simulation, structured debriefing, and guided reflection (Cohen et al., 2025; Zordan et al., 2022). Additionally, the variability observed in the “roles and responsibilities” domain suggests that role clarity may not be uniformly developed through short-term training alone and may depend on organizational context and prior experience (Cerny et al., 2023; Keesler et al., 2025).

These findings should be interpreted with caution. The one-group pretest-posttest design limits causal inference because the observed improvements may have been influenced by internal-validity threats such as history, maturation, testing effects from repeated exposure to the same instruments, regression to the mean, Hawthorne effects, and participant expectancy. The absence of a comparison group makes it difficult to separate the influence of the training from broader workplace learning or concurrent clinical experiences. The reliance on self-reported measures also introduces the potential for social desirability and response-shift bias, while large effect sizes may partly reflect ceiling effects or reduced variability in posttest scores. The inclusion of confidence intervals strengthens the precision and interpretability of effect size estimates, but future controlled and longitudinal evaluations are needed to determine whether the gains are attributable to the intervention and sustained in practice. Similar methodological limitations have been noted in prior TIC training studies (Goldstein et al., 2024; Qin et al., 2025).

5.1. Limitations of the Study This study has several limitations that should be acknowledged. The use of a single-group pretest-posttest design without a control group limits causal inference and leaves the findings vulnerable to history, maturation, testing, and expectancy effects. The small sample size and single-institution setting further limit generalizability. The absence of objective performance-based measures, such as observed simulation performance, clinical competency ratings, chart audits, or patient-care indicators, limits the ability to validate self-reported outcomes. The reliance on self-reported measures introduces potential response biases, including social desirability and subjective overestimation of competencies. Additionally, the short-term posttest assessment does not capture the sustainability of learning outcomes, particularly for constructs such as confidence and interprofessional collaboration that require longitudinal development. The observed variability in roles and responsibilities also suggests potential inconsistencies in role understanding that were not fully explored.

5.2. Recommendations Training programs should incorporate more intensive and sustained experiential components, including high-fidelity simulation, role-playing, case-based discussions, and structured debriefing. Given that communication remained the lowest scoring domain, targeted interventions focusing on interprofessional communication skills should be prioritized.

To improve role clarity, training should include explicit discussions of professional roles, interprofessional boundaries, and collaborative responsibilities, supported by organizational guidelines and team-based activities. Additionally, integrating trauma-informed care into undergraduate curricula and continuing education programs is recommended to ensure early and continuous exposure.

Future research should employ more rigorous designs, such as randomized controlled trials or quasi-experimental studies with comparison groups, to strengthen causal inference. Larger and more diverse samples across multiple institutions are recommended to enhance generalizability. Longitudinal studies are also needed to assess the sustainability of training effects, particularly for constructs such as confidence and interprofessional collaboration that develop over time.

Future evaluations should complement self-report instruments with objective performance indicators, including observed structured clinical examinations, simulation checklists, facilitator-rated competencies, chart-review indicators, or patient-care quality metrics. Combining subjective and objective measures would provide a more comprehensive assessment of whether improved confidence and collaborative competence translate into observable trauma care practice.

Finally, healthcare institutions should adopt system-level strategies that reinforce trauma-informed and collaborative practices. This includes leadership support, policy development, and the creation of learning environments that promote ongoing reflection, teamwork, and professional growth.

6. Conclusion

This study found that participation in a trauma-informed care (TIC) training program was associated with statistically significant improvements in nurses' knowledge, attitudes, practices, perceived confidence, and interprofessional collaborative competencies. The findings indicate consistent positive changes across cognitive, affective, and collaborative domains following the training. Framed within an experiential learning perspective, the results suggest that integrating didactic instruction, clinical immersion, and reflective activities may support the development of trauma-informed and collaborative competencies in nursing practice. Improvements in interprofessional collaboration further highlight the potential value of structured, practice-based training in enhancing team functioning within complex clinical environments. The study supports the integration of trauma-informed care training into nursing education and clinical practice, particularly through experiential learning approaches. Continued organizational support and sustained training initiatives are essential to reinforce and translate these improvements into routine practice.

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Selective Compassion in Mental Health Advocacy: A Trauma-Informed Framework for Nursing Education

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Abstract

Mental health advocacy is increasingly visible in public discourse, yet compassion is not always applied consistently when distress is expressed by individuals who are socially, politically, ideologically, or relationally opposed to the advocate. This conceptual paper examines this inconsistency as performative mental health advocacy, or selective compassion, in which public support for mental health awareness is contradicted by ridicule, invalidation, and moral judgment. The paper aims to define selective compassion, explain how it operates within mental health advocacy, and propose a trauma-informed framework for nursing education. Methodologically, the conceptual framework was developed through an integrative narrative synthesis of literature on performative allyship, trauma-informed care, mental health stigma, rights-based mental health, the hidden curriculum, and trauma-informed nursing education. The framework was drawn up by identifying the central advocacy contradiction, clustering related concepts from these bodies of literature, arranging them into a process sequence, and refining the sequence according to its implications for nursing education and professional formation. The resulting Selective Compassion Loop explains how advocacy may shift from public identity performance to affiliation-based appraisal, trauma-response invalidation, stigma diffusion, trust erosion, and defensive justification. The paper argues that authentic mental health advocacy requires reflexive awareness, trauma literacy, dignity-based discourse, accountability without psychological harm, and participatory repair. Because this is a conceptual paper, its limitations include the absence of primary empirical data, the use of literature from adjacent rather than directly established constructs, and the need for future validation across nursing education, clinical, institutional, and digital contexts.

Keywords: performative advocacy; selective compassion; nursing education; mental health stigma; dignity-based discourse

1. Introduction

Mental health advocacy has become highly visible in public, institutional, educational, and digital spaces. Schools, universities, health organizations, professional groups, and online communities frequently circulate messages such as "mental health matters," "end the stigma," and "be kind." This visibility has contributed to broader public recognition of psychological distress, stigma, and help-seeking. Yet visibility alone does not ensure ethical consistency. In many public conversations, individuals who identify as mental health advocates may still mock, dismiss, or weaponize the emotional distress of people they dislike or oppose.

This contradiction is captured in the statement: "So-called mental health advocates, yet they mock the trauma responses of those who are not their allies." The statement identifies a central problem in contemporary advocacy: compassion may be extended to the in-group while being withdrawn when distress is expressed by an out-group member. In this paper, such contradiction is conceptualized as performative mental health advocacy, defined as the public expression of support for mental health that is not matched by consistent, trauma-informed, dignity-preserving behavior.

The problem is not limited to hypocrisy. It reflects the selective application of care. A person's panic, silence, anger, emotional withdrawal, fear, defensiveness, or distress may be interpreted with empathy when that person is viewed as deserving, familiar, or aligned with the observer. The same response may be dismissed as weakness, manipulation, attention seeking, instability, or deserved humiliation when the person is socially inconvenient or morally opposed. This selectivity undermines mental health advocacy because it reproduces the stigma and discrimination that advocacy claims to resist.

Mental health stigma remains a global concern. The Lancet Commission on ending stigma and discrimination in mental health emphasized that stigma operates across interpersonal, educational, workplace, media, health care, and community contexts and requires action shaped by people with lived experience (Thornicroft et al., 2022). Rights-based mental health guidance similarly emphasizes dignity, equality, participation, non-discrimination, and the need to address practices that undermine personhood and autonomy (World Health Organization [WHO] & Office of the United Nations High Commissioner for Human Rights [OHCHR], 2023). These perspectives suggest that mental health advocacy should be evaluated not only by its visibility but also by its consistency, inclusiveness, and ethical discipline.

Trauma-informed care strengthens this argument by encouraging caution when interpreting distress. Recent empirical and review evidence in nursing and midwifery education indicates that trauma-informed training can improve knowledge, attitudes, and observable practice behaviors, while also revealing that students and clinicians may feel uncertain, anxious, or underprepared when translating trauma-informed principles into real interactions (Holod et al., 2025; Long et al., 2024; Qin et al., 2025; Tornwall et al., 2024; Zordan et al., 2022). Applied beyond clinical settings, these findings suggest that people should avoid using psychological vulnerability as material for ridicule, even when accountability is warranted.

This paper argues that mental health advocacy becomes performative when compassion is conditional, dignity is selectively granted, and trauma responses are used as tools of ridicule or social punishment. To address this problem, the paper proposes the Selective Compassion Loop, a conceptual framework explaining how performative advocacy emerges and how it may be interrupted through trauma-informed, dignity-based, and participatory advocacy practices.

Contribution to Nursing Scholarship

This paper contributes to nursing scholarship by introducing the Selective Compassion Loop as a conceptual framework for understanding how mental health advocacy can become performative within educational, clinical, institutional, and digital spaces. Nursing literature has extensively addressed stigma, empathy, therapeutic communication, professional values, and trauma-informed care. Less attention has been given to the selective use of mental health advocacy language, particularly when public compassion coexists with ridicule of distress in social conflict.

This contribution is especially relevant to nursing education. Nursing students learn mental health concepts through formal curriculum, but they also learn through faculty behavior, peer culture, clinical modeling, institutional responses to distress, and social media discourse. Hafferty's (1998) discussion of the hidden curriculum remains useful because it clarifies how learners absorb implicit messages through institutional culture as well as formal teaching. When students observe that trauma responses are respected only for acceptable or likable individuals, they may internalize conditional empathy as part of professional practice.

Conditional empathy conflicts with the ethical foundations of psychiatric-mental health nursing. Nurses are expected to communicate therapeutically, reduce stigma, preserve dignity, and provide care to persons whose behavior may be complex, distressing, or difficult to understand. By integrating trauma-informed care, stigma reduction, performative allyship, rights-based mental health, and nursing education, this paper offers a conceptual lens for examining how advocacy can function as authentic professional formation rather than public identity display.

2. Objectives and Research Methodology

This paper has four specific objectives. First, it defines selective compassion as the conditional extension of empathy in mental health advocacy. Second, it explains how selective compassion may reproduce stigma when trauma responses are interpreted through dislike, opposition, institutional loyalty, or group belonging. Third, it constructs the Selective Compassion Loop as a conceptual framework for understanding how performative advocacy develops and persists. Fourth, it identifies educational, leadership, policy, and digital professionalism recommendations that may help nursing programs cultivate trauma-informed and dignity-preserving advocacy.

The study uses a conceptual methodology rather than an empirical design. No survey, interview, experiment, or clinical observation was conducted. Instead, the paper develops a framework through integrative narrative synthesis, a suitable approach when a phenomenon is

theoretically important but not yet established as a directly measurable construct. The synthesis drew from six connected literature streams: performative allyship, trauma-informed care, mental health stigma, rights-based mental health, the hidden curriculum, and trauma-informed nursing education.

The conceptual framework was drawn up through four analytic steps. First, the focal phenomenon was identified from the contradiction between public mental health advocacy and the ridicule of trauma responses among disliked or opposed individuals. Second, concepts from the reviewed literature were examined for their explanatory relevance to this contradiction, especially visibility without accountability, stigma reproduction, trauma-informed interpretation, rights-based dignity, and hidden curricular modeling. Third, these concepts were clustered into process categories and arranged into a loop showing how public advocacy identity can move into affiliation-based appraisal, trauma-response invalidation, stigma diffusion, trust erosion, and defensive justification. Fourth, the loop was refined by identifying corrective practices that are relevant to nursing education: reflexive awareness, trauma literacy, dignity-based discourse, accountability without psychological harm, and participatory repair.

Because the work is conceptual, the framework is presented as a theory-building output rather than as an empirically verified finding. The purpose is to clarify relationships among existing concepts, provide a language for examining selective compassion in nursing education, and guide future empirical inquiry.

3. Theoretical and Conceptual Foundation

Performative Allyship and Advocacy Identity

Performative mental health advocacy is conceptually related to performative allyship. Kutlaca and Radke (2023) described performative allyship as visible, low-cost support that often fails to challenge the status quo and may be motivated by personal or reputational benefits. Applied to mental health discourse, this concept becomes relevant when individuals publicly endorse mental health awareness but fail to preserve dignity when distress belongs to someone they oppose.

Performative mental health advocacy may include posting awareness messages while using stigmatizing language, supporting mental health campaigns while mocking another person's distress, or promoting safe spaces while participating in public humiliation. Public advocacy is not inherently performative; public advocacy can be meaningful, necessary, and transformative. It becomes performative when visibility replaces accountability and when moral identity becomes more important than the protection of human dignity.

Trauma-Informed Care

Trauma-informed care provides a critical foundation for interpreting distress with caution rather than judgment. Empirical nursing education studies show that trauma-informed competence is not automatically acquired through professional socialization; it requires intentional instruction, simulation, guided reflection, and assessment of communication, safety, trust, empowerment, and collaboration in practice (Holod et al., 2025; Tornwall et al., 2024; Zordan et al., 2022). A recent hybrid systematic narrative review also found that trauma-informed care is viewed positively by nurses but remains difficult to implement because of knowledge gaps, time constraints, resource limitations, and concerns about retraumatization (Qin et al., 2025). These principles are relevant not only in clinical settings but also in classrooms, organizations, and digital spaces where people respond to distress and conflict.

A trauma-informed perspective recognizes that distress can appear in different forms. Silence may reflect emotional overwhelm. Defensiveness may reflect threat perception. Anger may reflect fear or previous harm. Avoidance may reflect self-protection. Crying may reflect emotional flooding. These responses do not excuse harmful behavior, but they should not become material for ridicule. Trauma-informed advocacy requires interpretive humility: an advocate does not need to diagnose another person, but must avoid stigmatizing psychological vulnerability.

Trauma-informed nursing education supports this position. Cannon et al. (2020) found that trauma-informed content improved nursing students' knowledge and skills related to trauma-informed care and was acceptable to undergraduate and graduate students. More recent Elsevier-published studies extend this evidence: Zordan et al. (2022) reported improved trauma-informed knowledge and

behaviors after simulation-based training for graduate nurses, Tornwall et al. (2024) identified distinct APRN student viewpoints that shaped confidence and anxiety about trauma-informed care, and Holod et al. (2025) showed that APRN students often remained at novice competency levels when applying trauma-informed principles in simulation. Aktan et al. (2023) also emphasized trauma-informed educational practices in graduate nursing education as a means of supporting student learning and well-being. These findings support the importance of embedding trauma-informed principles in the learning climate, not merely presenting trauma as course content.

Mental Health Stigma and Rights-Based Mental Health

Mental health stigma is reproduced through language, exclusion, stereotyping, discrimination, social distancing, and public ridicule. Thornicroft et al. (2022) emphasized that stigma affects help-seeking, social participation, employment, education, and health care experiences. In nursing education, recent studies show that stigma may be reduced through meaningful contact, role-play, creative drama, and high-quality mental health clinical placements, but it may persist when learners hold fear-based stereotypes or encounter stigmatizing clinical cultures (Gu et al., 2021a, 2021b; Patterson et al., 2021; Roberts et al., 2025; Shen et al., 2023; Shi et al., 2024; Tok & Kesgin, 2024; Zhang et al., 2021). These findings reinforce the importance of leadership by people with lived experience in anti-stigma work.

Rights-based mental health further strengthens this argument by locating advocacy within dignity, equality, participation, and non-discrimination. WHO and OHCHR (2023) emphasized person-centered, rights-based mental health systems and described the need for laws and systems that address stigma, discrimination, coercion, and exclusion. Within this perspective, dignity does not depend on agreement, likability, or group membership. A person does not lose the right to dignity because they are disliked, criticized, or held accountable.

Nursing Education, Hidden Curriculum, and Professional Formation

Nursing education is shaped by both formal and informal messages. The formal curriculum may teach empathy, trauma-informed care, and stigma reduction; the hidden curriculum may communicate different lessons through faculty modeling, peer norms, clinical culture, and institutional responses to conflict. Hafferty (1998) argued that hidden curricular forces can undermine formal educational reform when learners observe values that contradict what is taught.

This concern is important in psychiatric-mental health nursing education. Chukwuere et al. (2025) identified ongoing challenges in integrating mental health competencies into undergraduate nursing education, including stigma, communication difficulties, cultural misconceptions, and the absence of standardized frameworks. Empirical studies further show that students may enter psychiatric placements with fear, stereotypes, insecurity, or limited relational confidence, while high-quality placement experiences can support destigmatization, therapeutic communication, and professional confidence (Marriott et al., 2024; Patterson et al., 2021; Roberts et al., 2025; Shen et al., 2023; Zhang et al., 2021). If students encounter stigmatizing discourse in classrooms, clinical areas, or online professional spaces, they may struggle to develop the communication habits needed for safe and ethical mental health care.

Trauma-informed nursing education offers a corrective orientation. Cannon et al. (2020), Aktan et al. (2023), Zordan et al. (2022), Tornwall et al. (2024), and Holod et al. (2025) demonstrate the relevance of trauma-informed content, simulation, and pedagogy for nursing learners. The Selective Compassion Loop extends this work by naming a specific advocacy problem: the tendency to apply trauma-informed compassion selectively when social conflict, moral judgment, or group loyalty is activated.

Synthesis: A Lens for Understanding Selective Compassion

The reviewed literature converges around one central claim: mental health advocacy should be evaluated by ethical consistency. Performative allyship literature explains how public support can become symbolic when it does not challenge harmful norms. Trauma-informed care explains why distress should be approached with safety, trust, collaboration, and interpretive caution. Stigma literature shows how ridicule and discriminatory language cause harm. Rights-based mental health emphasizes dignity, participation, and non-discrimination. Nursing education literature demonstrates

that professional formation depends on modeled values, communication practices, learning climate, and the hidden curriculum.

Together, these perspectives support the development of the Selective Compassion Loop, a process-oriented conceptual model explaining how mental health advocacy becomes performative and how authentic advocacy may be cultivated in nursing education and practice.

4. Resulting Conceptual Framework

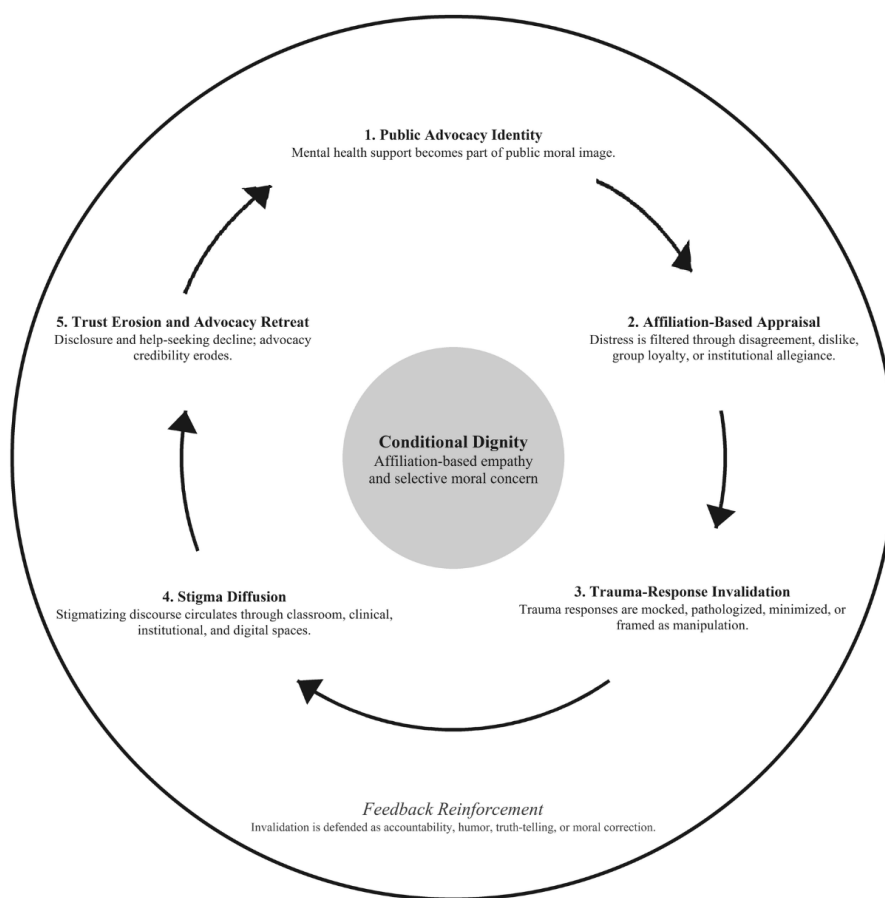
Narrative Overview of the Selective Compassion Loop

Because this paper uses a conceptual methodology, the central output is not an empirical results section but a finished conceptual framework. The Selective Compassion Loop presents a process explanation of how mental health advocacy can become performative when compassion is applied according to affiliation, agreement, or perceived deservingness.

The framework was drawn from the synthesis of performative allyship, trauma-informed care, stigma, rights-based mental health, the hidden curriculum, and nursing education literature. Across these sources, three organizing insights guided the model: public support can become symbolic when it is not matched by behavior; trauma responses require interpretive caution; and nursing students learn professional values through observed discourse as well as formal curriculum.

The completed framework contains three connected layers. The first layer is the public claim of mental health advocacy. The second layer is the five-stage loop through which selective compassion develops: public advocacy identity, affiliation-based appraisal, trauma-response invalidation, stigma diffusion, and trust erosion with advocacy retreat. The third layer is the corrective praxis that interrupts the loop through reflexive awareness, trauma literacy, dignity-based discourse, accountability without psychological harm, and participatory repair.

Fig. 1. The Selective Compassion Loop.



At the center of the framework is conditional dignity. The person in distress is treated with care only when considered deserving, agreeable, familiar, or aligned. This condition is dangerous because it transforms mental health advocacy from an ethical commitment into a tool of social approval. The framework therefore clarifies that the main problem is not accountability itself, but accountability that is pursued through humiliation, pathologizing language, or the public weaponization of psychological vulnerability.

Stages of the Selective Compassion Loop

1. Public Advocacy Identity

The loop begins when mental health advocacy becomes part of public identity. Individuals, groups, educators, or institutions may claim to support mental health awareness, stigma reduction, safe spaces, self-care, and psychological well-being. This stage is not inherently problematic. Public advocacy can increase awareness, normalize help-seeking, and challenge stigma.

Advocacy becomes vulnerable when it functions primarily as identity signaling. When the appearance of compassion becomes more important than the discipline of compassion, advocacy may remain superficial. The advocate may support mental health in principle but fail to apply trauma-informed principles during conflict.

2. Affiliation-Based Appraisal

The second stage occurs when the distressed person is viewed through social distance or opposition. This may involve differences in politics, religion, profession, institution, peer group, clinical role, academic status, or personal history. The advocate does not interpret the trauma response neutrally. The response is filtered through dislike, anger, fear, rivalry, or group loyalty.

For example, silence may be interpreted as guilt. Crying may be interpreted as manipulation. Anxiety may be treated as weakness. Anger may be labeled as instability. Withdrawal may be judged as avoidance or disrespect. This appraisal converts distress into a moral defect. This is especially important in nursing education because students' mental health-related stigma has been associated with perceived stress, depression, adverse life events, and other personal and educational factors (Shi et al., 2024).

3. Trauma-Response Invalidation

The third stage involves invalidation or ridicule of trauma responses. This may occur through direct insults, sarcasm, memes, gossip, public shaming, speculative diagnosis, or pathologizing language. Terms such as "crazy," "unstable," "attention seeking," "playing victim," or "dramatic" may reduce distress to a character flaw.

This stage is especially harmful because it reproduces stigma under the cover of advocacy. The advocate may still claim to support mental health, but the behavior teaches observers that distress is acceptable only when expressed by the right person. This contradiction weakens the credibility of advocacy and normalizes conditional empathy. Anti-stigma education studies suggest that meaningful contact, role-play, and creative drama can improve mental health literacy and reduce stigma, but only when learners are invited into reflective, humanizing engagement rather than fear-based social distancing (Gu et al., 2021a, 2021b; Roberts et al., 2025; Tok & Kesgin, 2024).

4. Stigma Diffusion

The fourth stage occurs when invalidating language spreads through social networks, classrooms, workplaces, clinical areas, or online spaces. Stigma diffusion normalizes the idea that psychological vulnerability can be used as a weapon during conflict.

In nursing education, this may influence how students talk about patients, peers, educators, and colleagues. If students observe faculty, leaders, or peers mocking distress, they may internalize this as acceptable professional behavior. This is especially concerning in psychiatric-mental health nursing, where learners are expected to develop empathy, therapeutic presence, nonjudgmental communication, and respect for patients with complex emotional and behavioral presentations. Psychiatric placement studies show that students' beliefs and confidence can shift through direct engagement with service users, but stigmatizing clinical discourse can also reinforce fear and discomfort (Marriott et al., 2024; Patterson et al., 2021; Shen et al., 2023; Zhang et al., 2021).

5. Trust Erosion and Advocacy Retreat

The final stage is trust erosion. When people observe selective compassion, they may become less willing to disclose distress, seek help, or participate honestly in mental health conversations. Advocacy loses credibility because people learn that compassion is conditional.

In educational settings, students may become cautious about expressing emotional difficulty. In clinical settings, nurses may become reluctant to discuss moral distress, burnout, trauma exposure, or mental health concerns. In digital spaces, people may avoid advocacy conversations because they fear humiliation. This concern is consistent with research showing high levels of psychological distress among nursing students and associations between self-care practices, sleep, and distress (Brouwer et al., 2021; Mulyadi et al., 2021).

Feedback Reinforcement

The loop persists when the advocate defends invalidating behavior as accountability, humor, truth-telling, moral correction, or social justice. This defense obscures the difference between holding someone accountable and weaponizing psychological vulnerability. As a result, the advocate may maintain a public identity as a mental health supporter while continuing behaviors that intensify stigma and reduce trust.

Authentic Mental Health Advocacy Praxis

The Selective Compassion Loop may be disrupted through authentic mental health advocacy praxis, composed of five interrelated practices: reflexive awareness, trauma literacy, dignity-based discourse, accountability without psychological harm, and participatory repair.

Reflexive Awareness

Reflexive awareness requires advocates to examine whether their compassion changes based on affiliation. The central reflective question is: Would I still protect this person's dignity if they were not my ally?

For nursing educators and students, reflexive awareness can be integrated into reflective journaling, debriefing, values clarification, and case-based discussion. It encourages learners to examine bias, countertransference, moral judgment, and group loyalty before responding to distress. Contact-based and placement-based studies suggest that reflection is most useful when it helps students examine stereotypes and build relational confidence rather than merely complete an academic requirement (Gu et al., 2021a; Marriott et al., 2024; Roberts et al., 2025).

Trauma Literacy

Trauma literacy involves understanding that trauma responses can appear as silence, anger, withdrawal, fear, defensiveness, emotional numbing, or overexplaining. It does not require public diagnosis. It requires caution, humility, and restraint.

In nursing education, trauma literacy should be embedded across psychiatric nursing, communication, ethics, leadership, community health, and clinical practicum courses. Students must learn that behavioral presentation is not always equivalent to intention. Simulation and Q-methodology studies indicate that learners need opportunities to practice trauma-informed communication, manage uncertainty, and receive feedback on observable trauma-informed behaviors (Holod et al., 2025; Tornwall et al., 2024; Zordan et al., 2022).

Dignity-Based Discourse

Dignity-based discourse means criticizing harmful behavior without attacking psychological vulnerability. The guiding principle is: critique the action, not the trauma response.

Instead of saying, "They are unstable," one may say, "The behavior caused harm and requires accountability." Instead of saying, "They are just playing victim," one may say, "Their distress does not remove responsibility, but it should not be mocked." This form of communication protects justice and compassion simultaneously.

Accountability Without Psychological Harm

Authentic advocacy does not eliminate accountability. A person can be held accountable without humiliation, public diagnosis, ridicule, or trauma weaponization. Accountability should focus on behavior, impact, repair, and prevention.

For nursing education, this distinction is essential. Students must learn to address unsafe, unethical, or harmful behavior while maintaining respect for human dignity. This is central to professional communication, therapeutic relationships, patient safety, and interprofessional collaboration.

Participatory Repair

Participatory repair involves people with lived experience, students, faculty, nurses, and communities in developing standards for mental health discourse. This aligns with anti-stigma recommendations emphasizing lived-experience leadership and co-production (Thornicroft et al., 2022). Evidence from mental health placement research also supports the value of high-quality, respectful contact with people living with mental illness as a means of reducing stigma and improving willingness to care (Gu et al., 2021b; Roberts et al., 2025).

In nursing programs, participatory repair may include student-informed mental health advocacy guidelines, lived-experience panels, restorative dialogue, faculty development, peer support structures, and mechanisms for addressing stigmatizing language in classrooms and clinical spaces.

6. Discussion and Recommendations

The following discussion interprets the Selective Compassion Loop as a conceptual output for nursing education rather than as empirical findings. Its value lies in showing where mental health advocacy may fail, how those failures may be learned through educational and professional cultures, and what practices may help nursing programs align advocacy with trauma-informed and rights-based principles.

Implications for Nursing Education

The Selective Compassion Loop has significant implications for nursing education because mental health advocacy is not only a public value; it is a professional competency. Nurses are expected to provide care to persons experiencing psychological distress, psychiatric conditions, trauma, crisis, stigma, and social exclusion. Nursing students therefore require formation in ethical communication as well as conceptual knowledge.

First, the framework challenges nursing programs to examine the hidden curriculum of compassion. If students are formally taught empathy but informally observe ridicule, gossip, shaming, or stigmatizing language, they may learn that compassion is situational. This hidden curriculum can weaken psychiatric-mental health nursing formation and compromise the development of therapeutic communication (Hafferty, 1998).

Second, the framework supports trauma-informed pedagogy across the curriculum. Trauma-informed education should shape classroom climate, debriefing practices, clinical supervision, student advising, simulation design, and faculty-student communication. Evidence supports the value of trauma-informed content, simulation-based training, and competency assessment for nursing students and graduate learners (Aktan et al., 2023; Cannon et al., 2020; Holod et al., 2025; Qin et al., 2025; Tornwall et al., 2024; Zordan et al., 2022).

Third, the framework strengthens psychiatric-mental health nursing education by linking advocacy, stigma reduction, and trauma-informed communication. Students should be trained to recognize how stigma appears not only in clinical labels but also in jokes, social media comments, classroom conversations, and peer interactions. This is particularly important because stigma, communication barriers, and misconceptions remain challenges in undergraduate mental health nursing education (Chukwuere et al., 2025), and because studies of nursing students continue to document stigma, fear, social distance, and uncertainty in relation to mental illness and psychiatric care (Gu et al., 2021a, 2021b; Patterson et al., 2021; Roberts et al., 2025; Shi et al., 2024).

Fourth, the framework can inform simulation and reflective learning. Nursing educators can develop scenarios in which students respond to a distressed peer, patient, family member, or public figure while distinguishing accountability from psychological harm. These scenarios can help students practice correcting harmful behavior without using stigmatizing or pathologizing language.

Simulation-based and creative pedagogical approaches have shown value in strengthening trauma-informed behaviors, mental health literacy, and stigma reduction (Holod et al., 2025; Tok & Kesgin, 2024; Zordan et al., 2022).

Finally, the framework supports professional identity formation. Authentic mental health advocacy should be understood as part of becoming a nurse: the disciplined ability to preserve dignity, communicate with restraint, resist stigma, and advocate for people even when their behavior is difficult, uncomfortable, or socially unpopular.

Practical Applications for Nursing Education

The Selective Compassion Loop may be operationalized in nursing education through several strategies. Nurse educators may integrate the framework into psychiatric-mental health nursing courses, especially in lessons on stigma, therapeutic communication, trauma-informed care, and patient advocacy. Students can analyze case vignettes in which trauma responses are misunderstood, mocked, or treated as moral defects. Because students' stigma and willingness to care are shaped by contact, perceived competence, placement culture, and mental health literacy, these vignettes should be paired with structured reflection and respectful exposure to lived experience (Gu et al., 2021b; Marriott et al., 2024; Roberts et al., 2025; Tok & Kesgin, 2024).

Clinical debriefing may include reflection on language. After psychiatric, community, or acute care exposure, students may be asked: Did any part of our discussion unintentionally stigmatize a patient's distress? This question helps students connect clinical reflection with ethical communication. Debriefing is especially relevant after psychiatric placements because studies show that these placements may produce destigmatization and confidence as well as fear, discomfort, disappointment, or sadness (Shen et al., 2023; Zhang et al., 2021).

Reflective journaling may be used to examine selective compassion. Students may write about situations in which they found it difficult to empathize with a patient, peer, family member, or public figure. The reflection can then examine how bias shaped interpretation and how dignity-based discourse might have changed the response. Such reflection should also consider students' own distress and coping practices, since nursing students' mental health and self-care are linked to learning readiness and psychological well-being (Brouwer et al., 2021; Mulyadi et al., 2021).

Simulation-based learning may include conflict scenarios. For example, a patient becomes angry, a family member cries, a student withdraws after feedback, or a colleague becomes defensive. Students can practice responses that maintain safety, acknowledge impact, and avoid pathologizing language.

Nursing programs may develop a Mental Health Advocacy Code of Conduct for students and faculty. Such a code may include commitments to avoid stigmatizing language, refrain from public diagnosis, protect confidentiality, respect lived experience, distinguish accountability from humiliation, and address digital conduct as part of professional formation.

Faculty development should also include trauma-informed communication. Educators model professional discourse. When faculty communicate with dignity during conflict, students learn that advocacy is a disciplined practice rather than a slogan.

Recommendations for Leadership, Policy, and Digital Professionalism

Beyond classroom teaching, the framework has implications for nursing leadership and institutional policy. Nursing schools and health care organizations should evaluate whether their mental health advocacy practices are symbolic or structurally meaningful. Campaigns should be matched with accessible support systems, referral pathways, anti-stigma policies, and mechanisms for addressing harmful discourse.

Leadership is especially important because students and novice nurses watch how authority figures respond to distress. If leaders use mental health language publicly but ridicule emotional vulnerability privately, the hidden curriculum becomes ethically inconsistent. Conversely, leaders who preserve dignity during conflict help create psychologically safer learning environments and more trustworthy advocacy cultures.

Digital professionalism is also essential. Students and nurses increasingly participate in public conversations online. Nursing education should therefore address how professional values apply to social media. Before posting or sharing content about another person's distress, nurses and students should ask: Does this post correct harm, or does it humiliate vulnerability?

This distinction matters because online engagement often rewards outrage, sarcasm, and public shaming. Nurses must be prepared to participate in public discourse without reproducing stigma. Dignity-based digital communication should be treated as part of professional advocacy, not as an optional personal preference.

6. Limitations

Several limitations were encountered in developing this conceptual paper. First, the Selective Compassion Loop has not yet been empirically tested. The model should therefore be treated as a theory-building framework rather than as evidence of causal relationships. Second, because selective compassion is not yet a well-established research construct, the framework draws from adjacent bodies of literature, including performative allyship, trauma-informed care, stigma, rights-based mental health, and the hidden curriculum. This strengthens conceptual breadth but also means that some relationships require direct validation.

Third, the synthesis is interpretive and may be influenced by the authors' theoretical positioning and nursing education context. The framework may not fully capture how selective compassion appears across different cultures, institutions, clinical specialties, or digital communities. Finally, the framework should not be used to excuse harmful behavior or to label individuals as performative advocates. Its intended use is educational and reflective: to help nurses, students, educators, and institutions preserve dignity while still maintaining accountability.

7. Conclusion

Mental health advocacy becomes performative when compassion is conditional. When individuals publicly support mental health but mock the trauma responses of people outside their circle, they reproduce the stigma they claim to oppose. This paper introduced the Selective Compassion Loop as a conceptual framework explaining how public advocacy identity can be distorted by affiliation-based appraisal, trauma-response invalidation, stigma diffusion, trust erosion, and defensive justification.

The proposed framework argues that authentic mental health advocacy requires trauma literacy, dignity-based discourse, accountability without psychological harm, and participatory repair. For nursing education, the implications are significant. Nursing students must be formed to recognize that mental health advocacy is not only awareness work; it is consistent ethical practice. It requires the ability to protect dignity during disagreement, conflict, correction, and accountability.

Ultimately, the credibility of mental health advocacy is tested when compassion is difficult. In nursing education and practice, authentic advocacy begins when dignity is no longer selective.

8. Recommendations for Further Studies

Building on these limitations, future research may examine how performative mental health advocacy appears in nursing education, clinical learning environments, institutional culture, and digital discourse. Empirical work is needed to determine whether the stages of the Selective Compassion Loop are observable, how frequently they occur, and what educational interventions can interrupt them.

Qualitative studies may explore nursing students' experiences of selective compassion, stigma, and trauma-informed communication in classroom and clinical settings. Quantitative studies may develop instruments to measure selective compassion, dignity-based discourse, trauma literacy, and performative advocacy tendencies. Intervention studies may evaluate whether simulation, reflective journaling, lived-experience teaching, faculty development, or advocacy codes reduce stigmatizing language and strengthen authentic advocacy.

Process evaluation may also be useful in examining how nursing programs implement trauma-informed advocacy frameworks. Such work could identify what strategies are feasible, how students and faculty experience them, and how institutional culture shapes implementation.

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The Effects of Cotton Dust Exposure on Self-Reported Respiratory Symptoms and Activities of Daily Living of Fabric Sewing Workers in Biñan, Laguna, Philippines

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Abstract

This descriptive correlational study examined the effects of cotton dust exposure on self-reported respiratory symptoms and activities of daily living among 80 fabric sewing workers in Biñan, Laguna, Philippines. Using the St. George's Respiratory Questionnaire (SGRQ), researchers collected data on sociodemographic profiles, respiratory symptoms, and functional limitations. The study found that a majority (44%) had over two years of work experience, with 56% female participants. Common respiratory symptoms included shortness of breath (46%), wheezing (32%), coughing (30%), and phlegm production (44%). A statistically significant positive correlation was identified between work duration and respiratory symptoms, with longer exposure associated with increased severity and frequency of symptoms. Workers exposed to cotton dust for extended periods demonstrated greater functional limitations in daily activities. The findings indicate that fabric sewing workers face substantial respiratory health risks from occupational dust exposure, with implications for workplace safety and occupational health interventions.

Keywords: Cotton dust exposure, Occupational respiratory health, Fabric sewing workers, Activities of daily living, Textile industry workers

1. Introduction

Numerous studies have established a concerning relationship between cotton dust exposure and respiratory health. Workers in the textile industry face significant occupational health challenges when exposed to cotton dust, which can lead to serious respiratory complications. Long-term textile employees exposed to dust were more likely to experience long-term respiratory health issues, with lung function corresponding to the length of time working in the current department. Cotton dust exposure has been shown to affect respiratory health and activities of daily living (ADLs), with workers diagnosed with byssinosis (acute respiratory illness from cotton dust) experiencing limitations in climbing stairs, carrying heavy objects, and engaging in sports. However, there is a need to investigate the specific effects of cotton dust exposure on self-reported respiratory symptoms and daily living activities in a specific population—fabric sewing workers in Biñan, Laguna, Philippines. This study investigated the to characterize the prevalence and spectrum of self-reported respiratory symptoms among fabric sewing workers in Biñan, Laguna, using the St. George's Respiratory Questionnaire (SGRQ), and to document how symptoms cluster by exposure duration, thereby establishing the epidemiological burden of cotton dust-related respiratory illness in this Philippine population. Moreover, to examine the functional impact of respiratory symptoms on activities of daily living (ADLs) to quantify how occupational respiratory disease translates into disability and reduced quality of life among working adults. Lastly, to establish the dose-response relationship between work duration (as a proxy for cumulative cotton dust exposure) and both respiratory symptom frequency and ADL limitations, using Pearson correlation analysis to test the hypothesis that workers with longer tenure experience proportionally greater respiratory burden and functional impairment.

2. Method

Using the St. George's Respiratory Questionnaire (SGRQ), researchers collected data on sociodemographic profiles, respiratory symptoms, and functional limitations. The study found that a majority (44%) had over two years of work experience, with 56% female participants. Common respiratory symptoms included shortness of breath (46%), wheezing (32%), coughing (30%), and phlegm production (44%).

3. Results

DOSE-RESPONSE RELATIONSHIP—WORK DURATION AND RESPIRATORY SYMPTOM SEVERITY

The relationship between cumulative cotton dust exposure and respiratory symptom severity represents one of the most robust and consistently documented patterns in occupational respiratory epidemiology. There is a well-established link between cotton dust exposure and acute respiratory reactions in some individuals, characterized by symptoms like coughing, wheezing, shortness of breath, and chest tightness that can appear and disappear intermittently (Berlian et al., 2023). Textile workers exposed to dust for more than five years had a higher risk of reduced lung functions compared to those with fewer than five years of service, with long-term textile employees more likely to experience long-term respiratory health issues. (Oo et al., 2021).

OCCUPATIONAL RESPIRATORY DISEASE AS FUNCTIONAL LIMITATION—TRANSLATION OF SYMPTOMS INTO ACTIVITIES OF DAILY LIVING

While pulmonary function impairment is clinically measurable through spirometry, the patient-centered outcome of functional limitation in activities of daily living (ADLs) often provides more clinically meaningful assessment. Activities of daily living or ADLs serve as an indication of a person's functional status, including simple activities that require fundamental skills to perform independently such as eating, bathing, and walking. The inability of performing ADLs results in dependency on other people or machinery, and the inability to accomplish essential ADLs may lead to unsafe conditions and poor quality of life. (Edemekong & F., 2023)

GENDER AND OCCUPATIONAL HEALTH DISPARITIES IN THE PHILIPPINE TEXTILE INDUSTRY

The Philippine textile industry exhibits marked gender composition that carries significant implications for occupational health surveillance, exposure assessment, and intervention design. Data revealed from Philippine Textile Industry (2016) a significant trend highlighting the dominance of female workers within the sector, with roughly 111,100 individuals employed in textiles that year being women, and approximately 75% being women, which statistically suggests that the textile industry in the Philippines leans heavily towards female employment.

4. Conclusion

The present investigation into cotton dust exposure among fabric sewing workers in Biñan, Laguna, reveals three interconnected findings that advance occupational respiratory health research in the Philippine textile context. First, the study demonstrates a strong positive correlation between work duration and respiratory symptom frequency, with workers exposed to cotton dust for longer periods reporting significantly higher rates of shortness of breath, wheezing, chest tightness, and coughing. Specifically, the correlation coefficients ranged from 0.7984 (frequency of general respiratory symptoms) to 0.9042 (wheezing), all at $p < .00001$, indicating that prolonged occupational exposure operates as a cumulative hazard. This dose-response relationship aligns with international evidence establishing that employees with over five years of employment are 1.478 times more likely to experience respiratory disease symptoms than those with shorter tenures, and substantiates the mechanistic understanding that long-term dust accumulation in respiratory tracts progressively compromises pulmonary function. Second, the study establishes that respiratory symptoms translate directly into functional limitations in activities of daily living, with workers reporting breathlessness during strenuous activities (56.25% during heavy physical work), moderate activities (35% during stair climbing or fast walking), and even light self-care tasks (10% during dressing). Sleep disruption due to coughing affected 43.75% of respondents, and fatigue or exhaustion accompanied coughing in 35% of workers, revealing how occupational respiratory disease penetrates fundamental aspects of

workers' recovery and well-being. A significant negative correlation ($r = -0.5702$, $p = .00001$) confirmed that greater respiratory symptom severity predicts worse daily functioning, while absence of symptoms correlates positively ($r = 0.4566$, $p = .000021$) with preserved activity capacity. Third, the demographic profile reveals a predominantly female workforce (56.25%), mirroring the broader Philippine textile industry's gendered labor composition, where approximately 75% of workers are women. This gender-concentrated employment structure raises critical equity concerns regarding differential exposure patterns, intersecting vulnerabilities related to caregiving responsibilities and economic constraints affecting access to personal protective equipment, and potential reproductive health impacts that remain understudied in occupational health research.

Recommendations for Further Studies

Future research studies should examine broader demographics, while focusing on Biñan City is valuable, expanding the study to include sewing workers from other regions could enhance the generalization of the findings. Moreover, Building upon the findings of this study, prioritize a cost-benefit analysis of various dust control strategies implemented in sewing facilities. This analysis would involve a comprehensive evaluation of both the initial and long-term economic implications for LGUs and employers. Furthermore, expand the study to include a group of workers consistently using PPE and another group not using any protection. This would allow for a direct comparison of the effectiveness of PPE in mitigating respiratory symptoms and their impact on activities on daily living. Also, Integrate pulmonary function testing (PFT) alongside self-reported symptoms. PFTs provide objective data on lung function, allowing for a more comprehensive assessment of lung health beyond subjective experiences. Lastly, future studies could test the effectiveness of specific preventive measures such as improved ventilation in the facility of the workplace of sewing workers with varying exposure durations.

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Soil-Transmitted Helminth Infections in the Badjao Community of Dalahican, Lucena City: An Epidemiological Assessment Using the Kato-Katz Technique

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Abstract

Soil-transmitted helminth (STH) infections remain a critical public health challenge among marginalized coastal indigenous populations like the Badjao, who often suffer from poor sanitation, inadequate hygiene, and limited healthcare access. A cross-sectional study evaluated stool samples from 100 Badjao children aged 3 to 12 years in Barangay Dalahican, Lucena City, using the Kato-Katz technique. Structured questionnaires assessed demographic profiles, environmental sanitation conditions, and behavioral hygiene practices. The overall STH prevalence was 89%. Hookworm was the most prevalent species (40%), followed by *Trichuris trichiura* (35%) and *Ascaris lumbricoides* (25%). Infection intensities were predominantly light to moderate, though heavy hookworm burdens were recorded. Poor handwashing practices and barefoot walking were significantly associated with high infection rates and specific helminth species ($p < .05$). The high prevalence underscores intense localized transmission driven by a complete lack of sanitation infrastructure and poor hygiene behaviors. Targeted community-specific public health interventions—combining mass drug administration (MDA), localized Water, Sanitation, and Hygiene (WASH) initiatives, and culturally tailored health education—are urgently needed for the Badjao population.

Keywords: Soil-transmitted helminths, Kato-Katz technique, Badjao community, Sanitation, Hygiene, WASH

1. Introduction

Globally, more than 1.5 billion people suffer from soil-transmitted helminth (STH) infections, making them the most prevalent parasitic diseases worldwide. Caused primarily by *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworms (*Ancylostoma duodenale* and *Necator americanus*), these infections are transmitted via the fecal-oral route or through active skin penetration by larvae in contaminated soil. Children are the most vulnerable demographic due to frequent soil exposure and developing hygiene

In the Philippines, despite sustained mass deworming campaigns and national health initiatives, STH infections remain deeply entrenched within low-income, marginalized, and coastal indigenous populations. High prevalence rates are frequently tied to substandard environmental sanitation, unsafe water supply, and open defecation.

The Badjao community in Barangay Dalahican, Lucena City, represents an exceptionally high-risk, displaced indigenous population. Geographically segregated and economically marginalized, this coastal community faces severe socioeconomic challenges, lack of solid waste management, and virtually zero access to formal sanitation systems. While global and national statistics outline broad STH trends, there is a stark lack of community-specific epidemiological data regarding indigenous coastal populations like the Badjao. Children in this community regularly walk barefoot on contaminated coastal soil and have limited access to clean water, accelerating the transmission cycle.

To bridge this research gap, this study provides a localized epidemiological assessment of STH prevalence, species distribution, and infection intensity among Badjao children, identifying the specific environmental and behavioral risk factors that sustain transmission to inform targeted local health policies.

2. Objectives

General Objective:

To conduct an epidemiological assessment of soil-transmitted helminth (STH) infections among children in the Badjao community of Barangay Dalahican, Lucena City, and identify the key environmental and behavioral factors driving transmission.

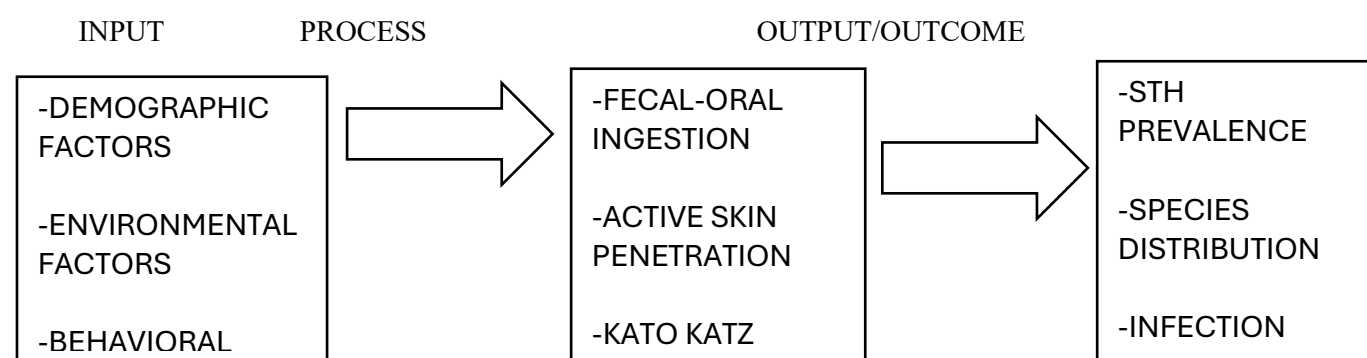
Specific objectives:

1. To determine the overall prevalence of STH infections among children aged 3 to 12 years in the study population.
2. To identify the specific species of soil-transmitted helminths (*Ascaris lumbricoides*, *Trichuris trichiura*, and hookworms) present among the participants.
3. To classify the intensity of infection (light, moderate, heavy) using the World Health Organization (WHO) standard egg-count criteria.
4. To evaluate the environmental and behavioral risk factors specifically access to toilet facilities, defecation practices, handwashing habits, and barefoot walking associated with STH transmission.
5. To determine the statistical association between demographic profiles, environmental/behavioral variables, and STH prevalence and intensity.

3. Materials and methods

Research Design and Conceptual Model

This study utilized a cross-sectional, quantitative research design to assess STH infections and risk factors simultaneously. The conceptual framework of the study is organized into an operational pipeline:



Population, Sampling, and Limitations

The target population comprised Badjao children aged 3 to 12 years residing in Barangay Dalahican, Lucena City. A sample of 100 children was selected using purposive sampling with the assistance of local barangay health workers and community leaders.

Inclusion Criteria: Children aged 3–12 years whose parents or legal guardians provided written informed consent, and who provided verbal assent.

Exclusion Criteria: Children who had taken anthelmintic medication within the past six months or presented with unrelated acute gastrointestinal diseases.

Study Limitations:

The use of a cross-sectional design prevents the determination of seasonal infection patterns or long-term reinfection rates. Additionally, the relatively small sample size (n=100) limits broader statistical power, and reliance on a single Kato-Katz smear may underestimate low-intensity infections due to daily variations in egg excretion.

Laboratory and Data Analysis

Fresh stool samples were collected in sterile, pre-labeled containers. Samples were processed using the standard Kato-Katz technique to detect helminth eggs and determine infection intensity, expressed as eggs per gram (EPG) of feces. Infection intensities were categorized according to WHO diagnostic benchmarks: *Ascaris lumbricoides*: Light (1–4,999 EPG), Moderate (5,000–49,999 EPG), Heavy (50,000 EPG). *Trichuris trichiura*: Light (1–999 EPG), Moderate (1,000–9,999 EPG), Heavy (10,000 EPG). Hookworms: Light (1–1,999 EPG), Moderate (2,000–3,999 EPG), Heavy (4,000 EPG). Descriptive statistics (frequencies and percentages) summarized demographic data and infection characteristics. Chi-square tests evaluated associations between variables at a significance level of $\alpha = 0.05$. Uniform responses with zero variance were excluded from comparative chi-square modeling.

Ethical Considerations

The study adhered strictly to ethical guidelines. Participation was entirely voluntary, and parents or guardians were thoroughly briefed on the scope, methods, and lack of direct financial compensation before signing the informed consent form. Child assent was secured. Individual identities and laboratory results were kept strictly confidential under the Philippine Data Privacy Act of 2012 (Republic Act No. 10173).

4. Results

Table 1. Frequency and Percentage Distribution of Respondents According to Age.

Age	F	%
3	14	14.0
4	9	9.0
5	11	11.0
6	8	8.0
7	7	7.0
8	12	12.0
9	12	12.0
10	14	14.0
11	5	5.0
12	8	8.0
Total	100	100.0

Results show that participants ranged from 3 to 12 years old, representing both preschool and school-aged children. The highest frequencies were observed at ages 3 and 10 (14%), while the lowest was at age 11 (5%). Overall, most participants are in early childhood to pre-adolescence, which are age groups most exposed to environmental factors leading to STH infection. Globally, children aged 1–14 years are particularly vulnerable to soil-transmitted helminths due to frequent contact with contaminated soil and incomplete hand hygiene practices (WHO, 2024).

Table 2. Frequency and Percentage Distribution of Respondents According to Sex.

	f	%
Male	47	47.0
Female	53	53.0
Total	100	100.0

Results indicate a nearly equal sex distribution (47% male, 53% female), minimizing sex-related sampling bias. Both sexes were equally exposed to risk factors for infection. Research

suggests that sex is not a primary determinant of STH infection; environmental and behavioral exposures are more critical (WHO, 2023).

Table 3. Distribution of Respondents by Deworming History Status in the Past Six Months.

	f	%
Yes	0	0
No	100	100.0
Total	100	100.0

Results show that none of the respondents received deworming treatment in the past six months. Lack of preventive chemotherapy contributes to sustained STH prevalence in the community. Mass drug administration in endemic areas is essential to control morbidity (WHO, 2023).

Table 4. Frequency and Percentage Distribution of Soil-Transmitted Helminths (STH) Infections According to Species.

	f	%
Ascaris Lumbricoides	51	25.0
Trichuris Trichuria	70	35.0
Hookworm	82	40.0
Total	203	100.0

Results show that hookworm infections had the highest prevalence (40%), followed by Trichuris trichiura (35%) and Ascaris lumbricoides (25%). This pattern indicates widespread exposure to contaminated soil, typical in communities with poor sanitation. Hookworm infections are associated with anemia, while Ascaris and Trichuris infections are linked to malnutrition and stunted growth (WHO, 2023).

Table 5. Prevalence Rate of Soil-Transmitted Helminth Infection Among Participants.

	f	%
Positive	89	89.0
Negative	11	11.0
Total	100	100.0

Results show a high overall prevalence of STH infection (89%). The widespread infection reflects active transmission within the community, driven by environmental contamination and poor hygiene practices. WHO guidelines classify prevalence above 50% as a major public health concern requiring urgent intervention (WHO, 2022).

Table 6. Frequency and Percentage Distribution of Soil-Transmitted Helminths According to Species and Infection Intensity.

Species	Infection Intensity	EPG Range	Frequency (F)	Percentage (%)
Ascaris Lumbricoides	None	0	49	49.0
	Light	1-4,999	49	49.0
	Moderate	5,000-49,000	2	2.0
	Heavy	>50,000	0	0
Total			100	100.0
Trichuris Trichuria	None	0	30	30.0
	Light	1-4,999	66	66.0
	Moderate	5,000-49,000	4	4.0
	Heavy	>50,000	0	0
Total			100	100.0
Hookworm	None	0	18	18.0
	Light	1-4,999	33	33.0

Species	Infection Intensity	EPG Range	Frequency (F)	Percentage (%)
	Moderate	5,000-49,000	44	44.0
	Heavy	>50,000	5	5.0
Total			100	100.0

Results show that light to moderate infections were the most common for all STH species. Hookworm had the highest proportion of moderate and heavy infections. These infection intensities contribute to malnutrition, anemia, and stunted growth among affected children. WHO recommends preventive chemotherapy and sanitation improvements to reduce infection intensity and transmission (WHO, 2022).

Table 7. Frequency and Percentage Distribution of Respondents According to Access to Toilet Facilities.

	f	%
Yes	0	0
No	100	100.0
Total	100	100.0

The results show that all respondents (100%) reported having no access to toilet facilities, indicating the complete absence of sanitation infrastructure in the study area. This lack of toilets increases the likelihood of open defecation practices and contributes to environmental contamination.

The absence of sanitation facilities is strongly associated with the transmission of Soil-transmitted helminth infections. Open defecation leads to contamination of soil with infective helminth eggs and larvae, increasing exposure risk. Communities without sanitation facilities consistently show higher prevalence of infection. Global sanitation reports emphasize sanitation access as a key determinant of helminth control (WHO & UNICEF, 2023).

Table 8. Frequency and Percentage Distribution of Respondents According to Type of Toilet Facilities.

	f	%
Water-sealed	0	0
Pit latrine	0	0
Open pit	0	0
Shared Toilet	0	0
No Toilet	100	100.0
Total	100	100.0

The results reveal that all respondents (100%) were categorized as having no toilet facilities. This confirms the complete absence of any form of sanitation facility in the community and highlights its vulnerability.

The absence of restroom amenities allows continuous environmental contamination due to improper disposal of human waste. This condition supports the persistence of helminth eggs in the environment and leads to repeated infections. Sanitation development is identified as a fundamental requirement for controlling STH transmission (WHO, 2022).

Table 9. Frequency and Percentage Distribution of Respondents According to Defecation Practices.

	f	%
Home Toilet	0	0
Shared Toilet	0	0
Open field	0	0
Shoreline	100	100.0
Total	100	100.0

The findings show that all respondents (100%) practiced defecation along the shoreline, reflecting

a uniform pattern of open defecation. This behavior increases contamination of both soil and water sources and exposes the community to infection.

Open defecation near water bodies accelerates the spread of STH infections, as helminth eggs can be transported through soil erosion and water movement. Studies indicate higher infection prevalence in communities practicing open defecation, identifying it as a major driver of transmission (WHO, 2023).

Table 10. Frequency and Percentage Distribution of Respondents According to Handwashing Practices.

	f	%
Sometimes	23	23.0
Rarely	77	77.0
Always	0	0
Never	0	0
Total	100	100.0

The results indicate that most respondents rarely practiced handwashing (77%), while only 23% reported doing so occasionally. None reported consistent handwashing behavior, reflecting poor hygiene. Inadequate handwashing increases exposure to fecal contaminants and facilitates fecal-oral transmission of STH infections. Poor hygiene practices are associated with higher rates of infection, particularly among children. Hand hygiene is considered a crucial preventive strategy in controlling STH infections (WHO, 2022).

Table 11. Frequency and Percentage Distribution of Respondents According to Barefoot Walking Practice.

	f	%
Always	86	86.0
Sometimes	4	4.0
Rarely	10	10.0
Never		
Total	100	100.0

The findings show that the majority of respondents (86%) always walk barefoot, while only a few reported occasional or rare barefoot walking. This behavior increases direct contact with contaminated soil. Walking barefoot is a significant risk factor for hookworm infection, as larvae can penetrate intact skin. This mode of transmission makes barefoot exposure particularly dangerous in contaminated environments. Preventive measures, such as wearing footwear, are strongly recommended to reduce infection risk (CDC, 2022).

Table 12. Frequency and Percentage Distribution of Respondents According to Drinking Water Source.

	f	%
Bottled Water	0	0
Rainwater	0	0
Tap water	0	0
Deep well	100	100.0
Total	100	100.0

The results show that all respondents (100%) relied on deep well water for drinking. While deep wells access groundwater, contamination may still occur in areas with poor sanitation.

Fecal contamination from open defecation can infiltrate groundwater sources, potentially exposing individuals to parasitic infections. Studies have shown that water safety is closely linked to

infection risk. Ensuring safe drinking water is an important component of STH control programs (WHO, 2022).

Table 13. Frequency and Percentage Distribution of Respondents According to Waste Disposal Method.

	f	%
Burned	0	0
Open dumping	0	0
Thrown in shoreline/sea	0	0
Collected by LGU	100	100.0
Total	100	100.0

All respondents reported that waste was collected by the local government unit, indicating the presence of structured solid waste management.

However, waste collection alone does not address fecal contamination. While it helps reduce environmental pollution, it is insufficient in preventing STH transmission without proper sanitation and hygiene practices. Comprehensive sanitation programs are necessary for effective disease control (WHO, 2022).

Table 14. Association between environmental and sanitation-related factors and prevalence of soil-transmitted helminths .

	χ^2	Sig. Description	(2-tailed)
Handwashing practice	41.378	.000	Significant
Barefoot walking	92.339	.000	Significant

The results reveal that handwashing practices and barefoot walking are significantly associated with STH prevalence, as indicated by statistically significant chi-square values ($p < .05$). This suggests that poor hygiene and direct contact with contaminated soil increase the risk of infection.

Other variables, such as access to toilet facilities, type of toilet, defecation practices, drinking water source, and waste disposal method, were not statistically analyzed due to uniform responses among participants. According to the Centers for Disease Control and Prevention, STH infections are transmitted through ingestion of contaminated materials and skin penetration, both of which are influenced by hygiene behaviors (CDC, 2022).

Table 15. Association between demographic profile and intensity of infection (Chi-square Test).

Demographic Profile	STH Species	χ^2	Sig. (2- tailed)	Description
Age	Ascaris Lumbricoides	31.181	.027	Significant
	Trichuris Trichuria	16.476	.559	Not Significant
	Hookworm	22.345	.720	Not Significant
Sex	Ascaris Lumbricoides	.663	.718	Not Significant
	Trichuris Trichuria	1.616	.446	Not Significant
	Hookworm	1.553	.670	Not Significant

The findings show that age has a significant association with the intensity of *Ascaris lumbricoides* infection ($p = .027$), while no significant relationship was observed for *Trichuris trichiura* and hookworm. Sex was not significantly associated with infection intensity for any species.

This suggests that age-related behaviors may influence exposure to infection, particularly for *Ascaris lumbricoides*. Younger individuals are more likely to come into contact with contaminated environments. Previous findings indicate that infection intensity varies by age but not significantly by sex (WHO, 2023).

Table 16. Association between environmental and sanitation-related factors and Types of STH species (Chi-square Test).

STH Species	Environmental/Sanitation Factor	χ^2	Sig. (2-tailed)	Description
Ascaris Lumbricoides	Handwashing practices	21.391	.000	Significant
	Barefoot walking	13.244	.001	Significant
Trichuris Trichuria	Handwashing practices	53.456	.000	Significant
	Barefoot walking	37.984	.000	Significant
Hookworm	Handwashing practices	37.554	.000	Significant
	Barefoot walking	55.493	.000	Significant

The results indicate that handwashing practices and barefoot walking are significantly associated with infections caused by *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworm ($p < .05$).

These findings highlight that poor hygiene and frequent exposure to contaminated soil contribute to infection across all STH species. Other environmental variables were excluded from analysis due to a lack of variability. Studies confirm that hygiene behavior and soil exposure are major determinants of STH infections (Jourdan et al., 2022).

Table 17. Association between demographic profile and prevalence of soil-transmitted helminths (Chi-square Test).

	χ^2	Sig. (2-tailed)	Description
Age	5.679	.772	Not Significant
Sex	.828	.595	Significant

The results show no significant relationship between age, sex, and overall STH prevalence ($p > .05$). This indicates that infection is widespread across all demographic groups.

The absence of demographic differences suggests that shared environmental conditions play a more significant role in transmission. In highly endemic areas, infections tend to affect individuals equally due to uniform exposure to contaminated environments (WHO, 2023).

Prevalence, Species Distribution, and Infection Intensity

The overall STH prevalence in the cohort was critically high at 89% ($n=89$). A total of 203 distinct parasitic infections were recorded across the positive individuals, demonstrating widespread polyparasitism (multiple co-occurring helminth species per child).

5. Discussion

The epidemiological assessment reveals a severe STH crisis within the Badjao community of Barangay Dalahican, with an overall prevalence rate of 89%. According to World Health Organization (WHO) benchmarks, any endemic area with an STH prevalence exceeding 50% constitutes a high-risk zone requiring urgent, intensive public health intervention. The 89%

prevalence documented here is exceptionally high and highlights an active, unchecked transmission cycle within this indigenous enclave.

The widespread distribution of species—led by hookworms (40%), followed closely by *T. trichiura* (35%) and *A. lumbricoides* (25%)—is a direct manifestation of the total collapse of environmental barriers. The fact that 100% of the respondents lack toilet facilities and practice open defecation along the shoreline provides a continuous supply of helminth eggs and larvae into the immediate living environment. In coastal environments, high humidity and sandy soils offer optimal ecological matrices for hookworm filariform larvae to survive and remain infectious.

This environmental hazard directly intersects with the community's behavioral patterns. Barefoot walking was found to be nearly universal (86%) and showed a highly significant statistical association with hookworm infection ($\chi^2 = 37.984$, $p = .000$). Because hookworm larvae infect hosts by actively penetrating intact skin, children walking barefoot on the contaminated damp shorelines face constant, repetitive exposure. This explains why hookworms not only led in prevalence but also exhibited the highest severity, including a substantial proportion of moderate (44%) and heavy (5%) intensities. Chronic, high-intensity hookworm infections lead to severe blood loss, iron-deficiency anemia, and protein malnutrition, which can cause permanent cognitive and physical stunting in growing children.

Similarly, *Ascaris* and *Trichuris* species are transmitted via the fecal-oral route, typically through the ingestion of soil-contaminated food, water, or dirty hands. The statistical analysis revealed a significant link between handwashing deficiencies and *Ascaris lumbricoides* intensity ($p = .027$). Since 77% of children rarely wash their hands and 100% rely on untreated deep wells located in an unsewered environment where human waste easily infiltrates shallow groundwater tables, fecal-oral contamination is a daily occurrence. Heavy burdens of *Ascaris* and *Trichuris* are historically linked to nutrient malabsorption, chronic diarrhea, and delayed pre-adolescent growth.

The demographic analysis revealed that neither age nor sex was significantly associated with overall STH prevalence ($p > .05$). This indicates that the environmental contamination is so severe and uniform that it overrides individual demographic protections—males, females, toddlers, and older children are all exposed to the same extreme risk. However, age did show a significant association with the intensity of *Ascaris lumbricoides* ($p = .027$). This variation suggests that younger age brackets engage more frequently in pica or geophagic hand-to-mouth play behaviors in contaminated soil spaces.

These findings align with previous local studies in the Philippines, such as those by Belizario et al. (2021) and Mationg et al. (2021), which observed that remote, marginalized coastal communities consistently experience a disproportionate burden of neglected tropical diseases (NTDs) due to structural exclusion from municipal health lines. The total absence of deworming history within the past six months (100% untreated) demonstrates that regular national school-based mass drug administrations are failing to reach this migratory or marginalized indigenous population.

6. Conclusion

This epidemiological assessment reveals an urgent public health crisis among the Badjao children of Barangay Dalahican, Lucena City, marked by an STH prevalence of 89% and severe polyparasitism. The structural drivers of this epidemic are an absolute lack of sanitation infrastructure (100% open defecation along the shoreline) and a reliance on vulnerable groundwater sources, compounded by behavioral habits like barefoot walking and poor handwashing.

Statistical modeling confirmed that behavioral habits serve as the primary drivers of species-specific transmission, while demographic factors fail to offer any protective effect due to uniform environmental exposure. Without immediate, systemic intervention, these children face ongoing physical and developmental setbacks from chronic parasitic burdens.

Recommendations

From the results, the researchers have made the following recommendations:

1. Targeted Mass Drug Administration (MDA): The City Health Office of Lucena City, in cooperation with the Department of Health (DOH), must initiate immediate, localized bi-

annual deworming campaigns utilizing albendazole (400 mg) or mebendazole (500 mg) specifically mapped to the Badjao community to bypass school-based delivery gaps.

2. Community-Specific WASH Infrastructure: The local government unit (LGU) must prioritize the construction of communal, culturally acceptable, and storm-resilient public latrines near the Badjao settlements to immediately eliminate shoreline open defecation.
3. Behavioral Change Communication (BCC): Barangay health workers should deploy visually accessible, culturally tailored hygiene campaigns focusing on the critical milestones of handwashing with soap and the absolute necessity of footwear.
4. Direct Resource Distribution: Public health programs should distribute basic hygiene packages containing soap, nail cutters, and durable slippers directly to Badjao children to break the skin-penetration pathway of hookworms.
5. Water Quality Audits: Environmental health officers must conduct urgent microbial testing on the local deep wells, establishing low-cost community chlorination or filtration stations to mitigate waterborne parasitic pathways.
6. Advanced Future Research: Future epidemiological tracking should deploy larger sample sizes and utilize more sensitive, modern molecular diagnostic platforms such as quantitative Polymerase Chain Reaction (qPCR) or FLOTAC techniques to overcome the sensitivity limitations of single Kato-Katz smears and accurately track low-intensity or multiplex infections.

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Exercise Interventions for Patellofemoral Pain Syndrome: A Review of Current Evidence

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Abstract

Patellofemoral pain syndrome (PFPS) is one of the most prevalent musculoskeletal disorders affecting the knee, especially in physically active individuals and women. It is characterized by anterior or peripatellar pain that worsens during activities such as stair climbing, squatting, and prolonged sitting. Although the etiology is multifactorial, muscle imbalance, especially between the vastus medialis oblique (VMO) and vastus lateralis (VL), remains a central concern. Exercise therapy is the foundation of conservative management, yet considerable debate remains regarding the optimal exercise type and protocol. This review organizes current evidence by target body region across three areas: knee exercises, hip exercises, and balance and core stability training. For knee exercises, closed kinetic chain exercises, including wall squats, semi-squats, and step-downs, produce exceptional pain reduction compared to open kinetic chain exercises, with knee flexion restricted to 30–50° recommended to minimize patellofemoral joint stress. For hip exercises, abductor and external rotator strengthening is supported as a primary intervention, demonstrating greater pain reduction and functional improvement than knee strengthening alone. For balance and core stability training, dynamic balance tasks and core neuromuscular exercises address proprioceptive and lumbopelvic impairments that peripheral strengthening alone cannot resolve. Clinicians should personalize exercise selection by region of impairment, pain sensitivity, and functional goals.

Keywords: patellofemoral pain syndrome, exercise therapy, vastus medialis oblique, hip strengthening, balance training.

1. Introduction

Patellofemoral pain syndrome (PFPS) is a dominant musculoskeletal condition defined by anterior or peripatellar knee pain in the absence of other identifiable pathology (Ayik et al., 2025; Hansen et al., 2023). Its prevalence ranges from 15–33% in active adults and up to 45% in adolescents, occurring more frequently in women (Ayik et al., 2025). Individuals with PFPS report pain during squatting, stair descent, kneeling, running, and prolonged sitting, leading to reduced physical activity, impaired quality of life, and significant socioeconomic burden (Pereira et al., 2022).

The pathomechanics of PFPS are multifactorial. Structural factors, including increased femoral anteversion, elevated Q angle, and foot pronation, predispose the patella to lateral deviation. Impaired neuromuscular control of the VMO relative to the VL disrupts patellar tracking, generating excessive articular contact stress (Ayik et al., 2025; Pereira et al., 2022). Pain and lower limb malalignment also affect dynamic balance, with evidence suggesting that posterolateral balance is particularly sensitive to pain severity in PFPS patients (Erdoganoglu et al., 2020).

Conservative management, comprising education, taping, orthotic intervention, manual therapy, and exercise, remains the primary treatment strategy. Out of these, exercise therapy is considered most effective (Ayik et al., 2025; Hansen et al., 2023; Winters et al., 2021). However, substantial heterogeneity exists in the literature regarding the type, intensity, and target muscles of the optimal exercise program. This review examines the current evidence for key exercise modalities used in PFPS rehabilitation, with the aim of providing clinically applicable guidance for physiotherapists.

2. Evidence-Based Exercise Recommendations

Through a review of published randomized controlled trials, systematic reviews, and meta-analyses, the authors identified the following exercise interventions as appropriate for the rehabilitation of patients with PFPS. The exercises are presented by target body region: knee, hip, and balance and core stability, and reflect the best available evidence for improving pain, muscle strength, and lower limb biomechanics. To facilitate the interpretation and clinical application of the findings, **Table 1** summarizes the evidence-based exercise recommendations for patients with PFPS. The exercises are categorized according to the primary target region (knee, hip, and balance/core stability) and include their intended therapeutic effects based on the reviewed literature.

Table 1. Summary of evidence-based exercise recommendations for patients with patellofemoral pain syndrome (PFPS).

Study	Design/n	Exercise type	Key exercise	Duration Dose	Key finding
Knee-focused exercises					
Ayik et al. 2025	RCT n=30	OKC	Straight leg raises; isometric quad (pillow under knee & ankle)	6 weeks, 3x/day 10 reps each	↑VM/VMO thickness, ↑fiber angle, ↓pain Less pain reduction vs CKC (p=0.006)
		CKC	Wall squat+hip adduction (45°); semi-squat single leg (20°); step-down ≤10 cm	6 weeks, 3x/day 10 reps each	↑VM/VMO thickness, ↑fiber angle, Superior pain reduction vs OKC (p=0.006)
Hansen et al. 2023	RCT n=200	Knee (QE)	Sitting leg extension; squat; forward lunge	12 weeks, 3 sets×8-12 reps	↑AKPS+7.6 pts; ↑strength ~10% Did not reach MCID (8-10 pts)
Hip-focused exercises					
Hansen et al. 2023	RCT n=200	Hip (HE)	Clam shell; side-lying/standing hip abduction; standing hip extension	12 weeks, 3 sets×8-12 reps	AKPS↑+7.0 pts; equivalent to QE Did not reach MCID; 95% CI within ±8 pts
Raju et al. 2024	RCT n=45	Hip strengthening	Side-lying hip abduction; clam exercise; seated hip external rotation (elastic band) + CPT	4 weeks, 3 sets×10 reps	AKPS↑122.9% (Cohen d=4.3) Greatest vs proprioception & CPT alone (p<0.001)
Balance & proprioception exercises					
Lee et al. 2022	Prospective n=36	Static balance (SBE)	Single-leg stand at 45° knee flexion, 20 sec × 10 sets; stable surface	4 weeks, 2x/week	↑postural stability, ↑quad AT, ↑strength, ↓pain Less dynamic stability gain vs DBE
		Dynamic balance (DBE)	Multi-direction star-excision reaching (6 directions) on 1 leg	4 weeks, 2x/week	Superior: ↑dynamic stability (d=0.72) & ↑quad AT (d=0.86) vs SBE, All outcomes p<0.001
Raju et al. 2024	RCT n=45	Proprioception training	Single-leg stand: stable→unstable, eyes open→closed	4 weeks, 3 sets×10 reps	AKPS↑ 98.7% (Cohen d=4.7) Less than hip strengthening (p=0.002)
Erdoganoglo et al. 2020	Prospective n=62	Dynamic balance (SEBT)	Star excursion balance test (anterior, posteromedial, posterolateral)	Assessment/ cross-sectional	No overall dynamic balance difference between limbs
Motealleh et al. 2019	RCT n=28	Core	Bridging with ball; curl-up straight+lateral; isometric hip abduction standing; shoulder flex/ext on 1 leg; trunk rotation on affected leg	4 weeks, 3 sessions/day	↓Pain more than PT alone (p=0.035) ↑Kujala, ↑step-down, ↑posteromedial balance (p=0.016)

2.1 Knee Exercises

Knee-focused exercise is the traditional foundation of PFPS rehabilitation, targeting the quadriceps muscle group, particularly the vastus medialis oblique (VMO), to restore normal patellar tracking and reduce patellofemoral joint stress. Exercises are broadly classified into open kinetic chain exercises (OKCE), performed with the distal limb free, and closed kinetic chain exercises (CKCE), in which the foot is fixed to a surface. Because CKCE generate less patellofemoral joint reaction force than OKCE (Ayik et al., 2025), they are generally preferred during periods of acute pain, while OKCE remain useful when the range of motion is restricted (Ayik et al., 2025; Pereira et al., 2022).

Open Kinetic Chain Exercises: Straight Leg Raise and Isometric Quadriceps Set

OKCE such as the straight leg raise and isometric quadriceps set produce isolated quadriceps activation without loading the patellofemoral joint through a range of motion. A six-week randomized trial by Ayik et al. (2025) showed that OKCE significantly improved VMO and VM muscle thickness, VMO fiber angle, and VAS pain scores ($p < 0.001$), confirming that these exercises effectively restore VMO architecture even in the absence of weight-bearing. (FITT; F=3x/day, I=Body weight, T=6 weeks T=isometric)



Fig.1 Open Kinetic Chain Exercises (OKCE) (a) Straight Leg Raising (b) Isometric Quadriceps Exercise

Closed Kinetic Chain Exercises: Wall Squat, Semi-Squat, and Step-Down

CKCE such as wall squats with isometric hip adduction, semi-squats, and step-downs mimic weight-bearing daily activities and activate lower limb muscles synergistically. Ayik et al. (2025) found that VAS pain scores improved significantly more in the CKCE group than the OKCE group ($p = 0.006$), suggesting superior pain reduction. The systematic review by Pereira et al. (2022) highlights that patellofemoral joint stress peaks between 60° and 90° of knee flexion; therefore, limiting knee flexion to $30\text{--}50^\circ$ and ensuring proper knee alignment during CKCE is recommended to minimize symptom exacerbation. (FITT; F=3x/day, I=Body weight, T=6 weeks T=isometric) (Ayik et al., 2025)

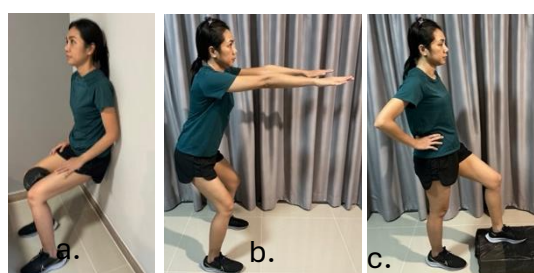


Fig.2 Closed Kinetic Chain Exercise (CKCE) (a) Wall Squat with Hip Adduction (b) Semi-Squat (c) Step-Down

Seated Knee Extension, Squat, and Forward Lunge

A structured 12-week quadriceps program comprising seated knee extension, squats, and forward lunges was evaluated by Hansen et al. (2023) in a high-quality equivalence trial of 200 patients with PFPS. AKPS scores improved by 7.6 points, confirming meaningful clinical benefit. However, because neither the quadriceps nor the hip program alone reached the minimal clinically

important change threshold of 8–10 AKPS points, combining knee-focused exercises with hip-targeted approaches is recommended for optimal outcomes. (FITT; F=3x/day, I=8-12 RM, T=12 weeks, 3 sets per session T=Free weight progression) (Hansen et al., 2023)

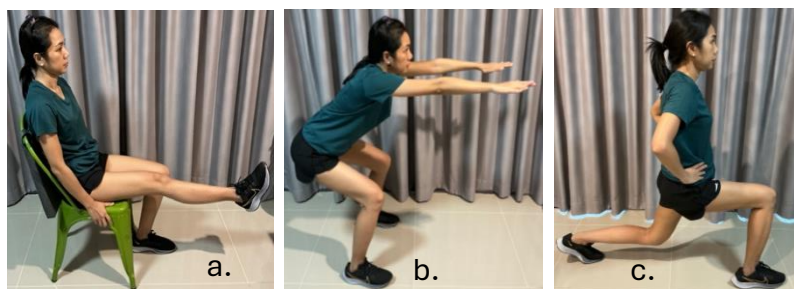


Fig.3 Other Knee Strengthening Exercises (a) Seated Knee Extension (b) Squat (c) Forward Lunge

2.2 Hip Exercises

The role of hip musculature in PFPS management has received significant attention over the past decade. Weakness of the hip abductors and external rotators contributes to dynamic knee valgus, which elevates patellofemoral contact pressure (Lee et al., 2022; Zhang et al., 2025). Hip-targeted exercise programs are therefore recommended as a primary intervention or adjunct to knee-focused rehabilitation (Raju et al., 2024; Yue et al., 2024).

Clam-Shell, Side-Lying Hip Abduction, and Standing Hip Extension

In the equivalence trial by Hansen et al. (2023), participants in the hip exercise group received a 12-week program comprising clam-shell exercise, side-lying hip abduction, and standing hip extension. AKPS scores improved by 7.0 points, comparable to the quadriceps group, confirming that hip-targeted training is equally effective for pain and functional outcomes in PFPS. A meta-analysis by Zhang et al. (2025) further demonstrated that hip strengthening produced greater pain reduction (SMD = -1.74) and functional improvement (SMD = 1.21) than knee strengthening alone, while also significantly increasing hip abductor and external rotator strength. (FITT; F=3x/week, I=3 sets x 10 reps, T=4-12 weeks, 20 min/session T=Free weight) (Hansen et al., 2023)



Fig.4 Hip Strengthening Exercises (a) Clam-Shell (b) Side-Lying Hip Abduction (c) Standing Hip Extension

Hip Abductor and External Rotator Strengthening

Raju et al. (2024) found that isolated hip abductor and external rotator strengthening, which was added to conventional physical therapy, produced the greatest improvement in AKPS scores compared to proprioceptive training or conventional therapy alone, with all between-group differences reaching statistical significance. At the neuromuscular level, Yue et al. (2024) demonstrated that a six-week gluteus maximus activation program, comprising gluteal bridges, clamshells, reverse lunges, and single-leg calf raises, increased gluteal muscle contribution during stair climbing, advanced the activation timing of the gluteus maximus and biceps femoris, and significantly reduced knee pain ($p < 0.01$), providing mechanistic support for gluteal-focused rehabilitation in PFPS. (FITT; F=3x/week, I=3 sets x 10 reps, T=4-12 weeks, 20 min/session T=Free weight) (Raju et al., 2024)



Fig. 5 Hip Strengthening Exercises (a) Hip Abductor Strengthening (b) Hip External Rotation (c) Glute Bridge (d) Reverse Lunge (e) Single Leg Calf Raise

2.3. Balance and Core Stability Training

Impaired proprioception, neuromuscular control, and lumbopelvic-hip stability are interrelated features of PFPS that collectively contribute to dynamic knee valgus, altered lower limb biomechanics, and increased patellofemoral joint loading. Postural stability, encompassing both static and dynamic balance, is closely linked to neuromuscular function, while deficits in core muscle recruitment and lumbopelvic control further exacerbate abnormal patellar mechanics by promoting hip internal rotation and knee valgus posture (Lee JH et al., 2022; Erdoganoglu et al., 2020; Motealleh et al., 2019). These impairments represent important rehabilitation targets that are not fully addressed by peripheral strengthening alone. This is especially relevant for middle-aged and elderly patients with PFPS, who may present with more pronounced balance deficits than younger populations (Zheng et al., 2026).

Dynamic Balance Exercise: Single-Leg Stance and Multidirectional Reach Tasks

Erdoganoglu et al. (2020) demonstrated a significant negative correlation between pain severity and posterolateral balance ($r = -0.286$, $p = 0.019$) in PFPS patients, indicating that pain-targeted interventions may secondarily improve dynamic stability. Zheng et al. (2026) used the Y-Balance Test to confirm that middle-aged and elderly PFPS patients exhibit multiplanar dynamic stability deficits, including greater anterior reach asymmetry and reduced posteromedial and posterolateral reach distances, despite preserved limb symmetry ratios. A prospective comparative study by Lee JH et al. (2022) found that dynamic balance exercise (DBE) produced significantly greater improvements in dynamic postural stability ($p = 0.021$) and quadriceps acceleration time ($p = 0.014$) than static balance exercise over four weeks, attributed to activation of rapidly-adapting mechanoreceptors and enhanced central nervous system adaptation. (FITT; F=2x/week, I=20 sec hold per set, T=4 weeks, 10 sets, 1 hr session, T=Balance) (Raju et al., 2024)

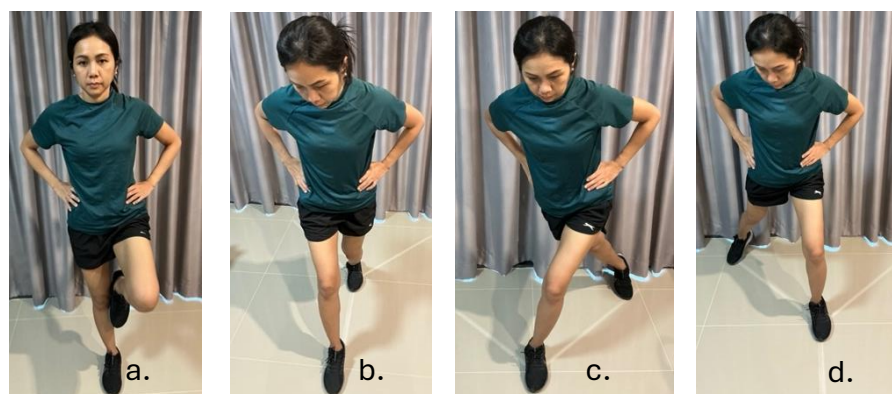


Fig. 6 Dynamic Balance Exercises (a) Single-Leg Stance (b) Y-Balance (Anterior Reach) (c) Y-Balance (Posteromedial Reach) (d) Y-Balance (Posterolateral Reach)

Core Neuromuscular Training: Bridging, Clam Exercise, Lateral Straight Leg Raise, Curl-Up, and Trunk Rotation

Core neuromuscular training addresses the proximal contributors to patellofemoral dysfunction. Motealleh et al. (2019) conducted a four-week randomized trial in 28 women with PFPS comparing routine physical therapy alone with the same program supplemented by core neuromuscular training consisting of bridging with knee squeeze, clam exercise, lateral straight leg rais, curl-ups, and trunk rotation in single-leg stance. The addition of core training produced significantly greater reductions in VAS pain score ($p = 0.035$), improvements in Kujala functional score ($p = 0.039$), step-down performance ($p = 0.027$), and posteromedial Y-Balance reach distance ($p = 0.016$), with mean VAS reductions nearly double those of the control group. These results highlight the correspondence between dynamic balance training and core stabilization in PFPS rehabilitation, supporting their integration into a unified program. (FITT; F=3 session/day, I=3 sets x 5-10 reps; 10 sec old, T=4 weeks, 20 min/session, T=Isometric) (Motealleh et al., 2019)

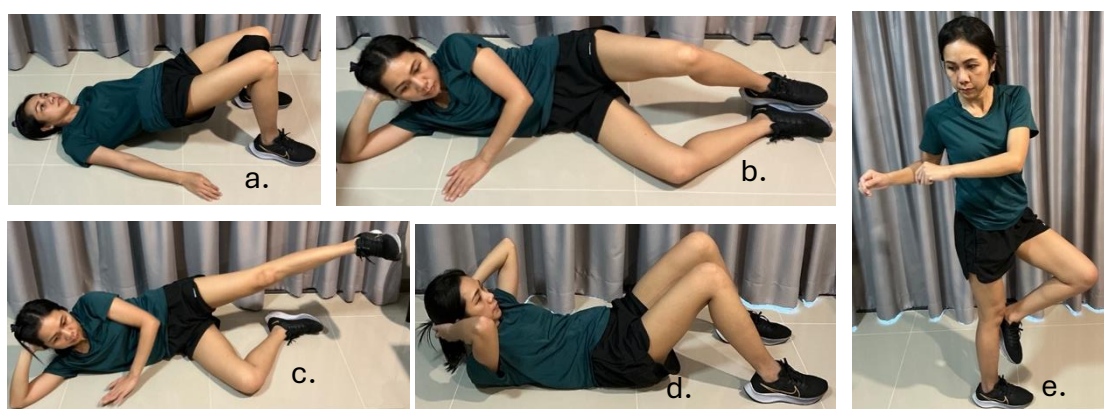


Fig. 7 Core Neuromuscular Training (a) Bridging with Knee Squeeze (b) Clam Exercise (c) Lateral Straight Leg Raise (d) Curl-Up (e) Trunk Rotation in Single-Leg Stance

3. Discussion

The evidence reviewed supports exercise therapy as the primary conservative treatment for PFPS, with the optimal program determined by the region of impairment. For the knee, CKCE are preferred over OKCE for pain reduction, while knee flexion should be kept below 50° during weight-bearing exercises to limit patellofemoral joint stress (Ayik et al., 2025; Pereira et al., 2022). For the hip, strengthening the abductors and external rotators should be considered a primary intervention, as

it produces exceptional pain relief and functional improvement compared to knee strengthening alone and addresses the biomechanical root cause of dynamic knee valgus (Zhang et al., 2025; Raju et al., 2024; Yue et al., 2024). Although hip and quadriceps programs deliver equivalent overall outcomes when assessed independently, combining both approaches is recommended since neither alone reliably achieves the minimal clinically important change threshold (Hansen et al., 2023). For balance and core stability, dynamic balance exercises and core neuromuscular training address proprioceptive and lumbopelvic impairments that peripheral strengthening cannot fully resolve, and should be integrated across all rehabilitation stages (LeeJH et al., 2022; Motealleh et al., 2019; Zheng et al., 2026).

Several limitations should be considered. Most included trials have small sample sizes and follow-up periods under six months, limiting generalizability and the assessment of long-term benefit. Psychological factors, including pain catastrophizing and kinesiophobia, are increasingly recognized as modulators of PFPS outcomes and represent a priority for future research (Hansen et al., 2023).

6. Conclusion

PFPS management benefits from a comprehensive, individualized exercise program organized by target body region. For the knee, closed kinetic chain exercises are preferred for their functional relevance and lower patellofemoral stress, supplemented by open kinetic chain exercises when range of motion is limited. For the hip, abductor and external rotator strengthening should be included as a primary intervention, given its superior biomechanical and clinical outcomes. For balance and core stability, dynamic balance tasks and core neuromuscular exercises address proprioceptive and lumbopelvic impairments that peripheral strengthening alone cannot resolve, and are essential across all stages of rehabilitation. Clinicians should integrate evidence-based, region-specific exercise selection with patient-centered decision-making to optimize outcomes in this predominant and often persistent condition.

Recommendations for Further Studies

Future research should prioritize larger randomized controlled trials with extended follow-up periods to better understand the long-term effects of exercise interventions for PFPS. There is also a need to clarify the most effective combination and progression of knee, hip, and core exercises within rehabilitation programs. In addition, factors such as patient adherence and psychological influences, including fear of movement, warrant further investigation due to their potential impact on outcomes. Exploring responses across different populations, as well as incorporating technologies like tele-rehabilitation, may further support the development of more individualized and effective treatment strategies.

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AI-assisted microbial contamination detection using YOLOv5

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Abstract

Safe drinking water is essential for human health, and rapid assessment of microbial contamination remains an important challenge in water quality monitoring. This study investigates the feasibility of using artificial intelligence (AI) and computer vision techniques to assist in the detection of microbial structures in microscopic images of water samples. Water samples collected from diverse aquatic environments were prepared using Gram staining and imaged using light microscopy. OpenCV was utilized for image processing and enhancement, while YOLOv5 was employed to detect visually distinguishable microbial structures based on staining characteristics and morphology. A dataset of 390 microscopic images was collected, annotated, and used for model training, validation, and testing. The results demonstrate the potential of AI-assisted image analysis as a rapid screening tool for identifying microbial contamination indicators in water samples. In addition, the study highlights challenges associated with environmental water samples, including the presence of non-bacterial microorganisms and complex microscopic structures that may affect detection accuracy. These findings support the feasibility of integrating computer vision and deep learning techniques into future water quality monitoring systems, providing a foundation for the development of more comprehensive microbial detection models.

Keywords : Artificial Intelligence (AI); Microbial Contamination Detection; Water Quality

1. Introduction

Access to safe drinking water remains a major global health challenge despite the abundance of water resources on Earth. Water contamination and pollution caused by human activities can disrupt surrounding ecosystems, reduce biodiversity, destroy habitats, and ultimately contribute to ecosystem degradation. This can lead to an increase in waterborne diseases, posing significant risks to human health.

Access to clean water supplies remains a challenge, particularly in developing countries where waterborne infections are common and may be life-threatening. According to the World Health Organization (WHO), approximately one million deaths occur annually from diarrhea associated with unsafe drinking water, inadequate sanitation, and poor hygiene practices. Microbial water quality monitoring is therefore essential to address this challenge.

Artificial intelligence (AI) refers to computational systems capable of performing tasks that typically require human intelligence, such as learning, reasoning, problem solving, and interaction. AI technologies, particularly machine learning (ML) and deep learning (DL), are capable of analyzing large volumes of data rapidly and efficiently. These technologies can identify patterns, detect anomalies, and assist in image-based analysis, making them valuable tools for water quality assessment and microbial monitoring.

Microscopic examination remains one of the most common approaches for observing microorganisms in water samples; however, manual analysis can be time-consuming and subject to observer variability. Computer vision techniques combined with deep learning models offer a potential approach for automating parts of this process and improving analytical efficiency.

This study investigates the feasibility of applying computer vision and artificial intelligence techniques to detect microbial structures in microscopic images of water samples. Using image processing methods implemented in OpenCV and object detection using YOLOv5, the study evaluates whether AI-assisted image analysis can support microbial contamination screening and contribute to future water quality monitoring applications.

2. Materials and Methods

2.1. Equipment and Setup

An XSP-02 compound microscope equipped with an SVBONY SV189 USB imaging camera was used for microscopic image acquisition. The camera was connected directly to a computer and operated using microscope imaging software for real-time observation and image capture.

Microscopic images were collected at multiple magnifications, including 4×, 25×, and 100× objectives, to capture variations in microbial morphology and structural detail.

2.2. Sample Collection and Dataset Preparation

To improve dataset diversity and model robustness, water samples were collected from multiple aquatic environments, including urban canals, freshwater lakes, ornamental fish ponds, plant-filtered ponds, tap water, and commercially available drinking water. Sampling locations represented different surrounding land-use characteristics, including residential areas, public parks, and mixed residential-commercial environments.

Table 1 Water sample sources and number of microscopic images collected

Sources of water sample	No. of sample images collected
Saen Saep Canal	20
Sammakorn Lake 1	20
Sammakorn Lake 2	20
Sammakorn Lake 3	20
Above-ground concrete fish pond	20
Buried stagnant fish pond	10
Buried flowing fish pond	20
Plant-filtered fish pond	20
Aquarium biofilter system	10
Bottled drinking water	5
Tap water	5
Total	170

These locations were selected to capture a broad range of microbial contamination levels, suspended particles, and naturally occurring freshwater microorganisms that may be encountered in environmental water samples.

Samples exhibiting unusually high microbial density or atypical microscopic structures were documented for further investigation and future dataset expansion.

Image Acquisition and Model Training

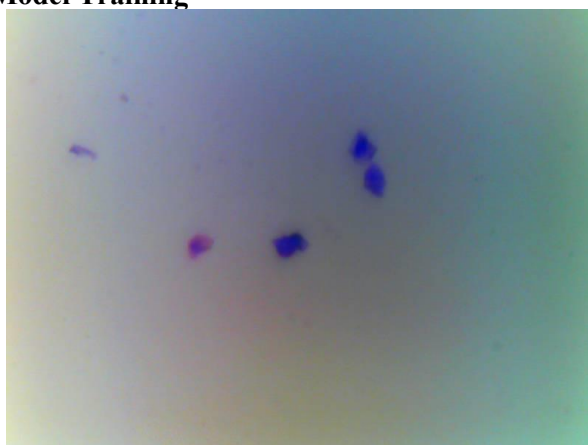


Figure 1 Representative microscopic image of a Gram-stained water sample used for dataset preparation and AI model training.

A total of 390 microscopic images were collected and annotated. The dataset was then split into training, validation and testing subsets for YOLOv5 model development and performance evaluation (Table 2).

Table 2 Dataset distribution used for model training, validation and testing

Dataset split	No. of images
Training set	330
Validation set	35
Test set	25
Total	390

Image annotation was performed using Roboflow. Labels were assigned based on Gram staining characteristics and observable microbial morphology. Data augmentation techniques were applied during training, including random image rotation between -15° and $+15^\circ$ and image cropping with a maximum zoom of 25%.

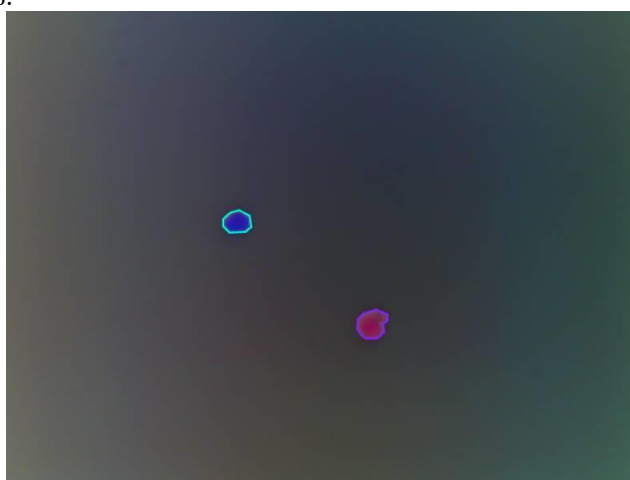


Figure 2 annotated microbial structures

After dataset preparation, the annotated dataset was exported from Roboflow and used for YOLOv5 model training. Initial dataset preparation and annotation were conducted using Roboflow, while model training and evaluation were performed using Google Colab GPU resources and local computing systems.

Additional Microscopic Observations



Figure 3 Unidentified filamentous structure detected in a freshwater sample.

Filamentous and elongated structures were repeatedly observed across multiple freshwater samples. These structures appeared substantially larger than typical bacterial cells and exhibited morphological characteristics inconsistent with common bacterial forms.

The identity of these structures could not be confirmed using the current imaging and staining procedures. Possible explanations include filamentous algae, biofilm fragments, protozoa, nematodes, fungal elements, or other freshwater microorganisms. Additional staining techniques and higher-resolution microscopic analysis would be required for definitive classification.

The presence of these non-bacterial structures highlights a limitation of morphology-based detection approaches and suggests that future datasets should include a wider range of freshwater microorganisms to improve model robustness and reduce false-positive detections.

3. Results

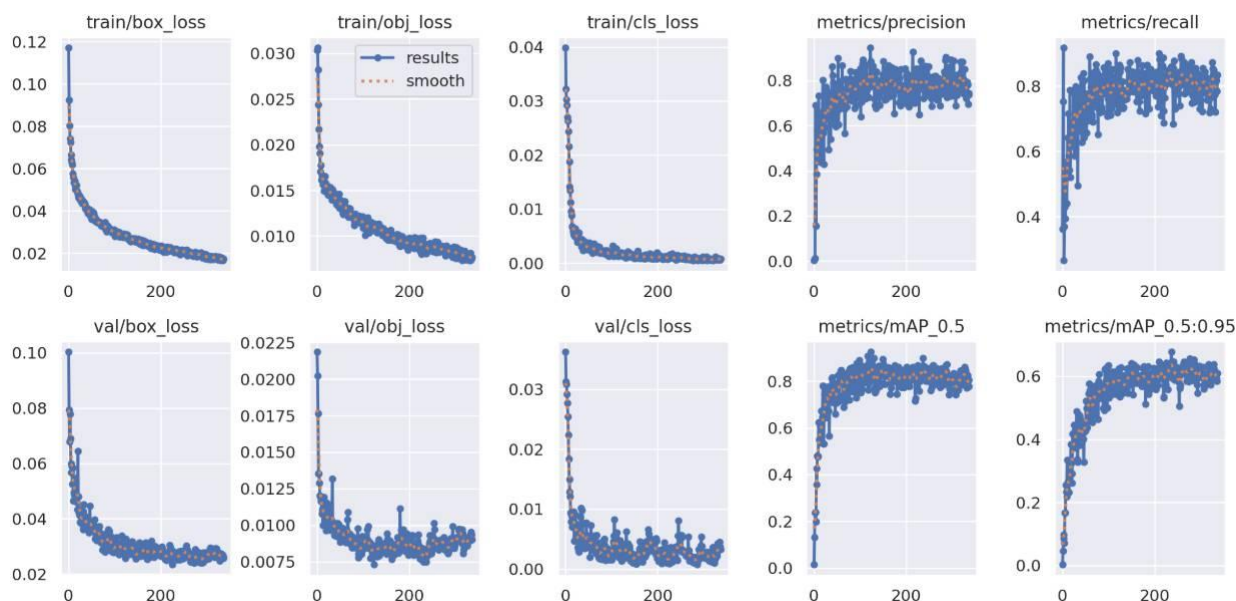


Figure 4 Training and validation performance of the YOLOv5 model for microbial structure detection. The plots show box loss, object loss, classification loss, precision, recall, mAP@0.5, and mAP@0.5:0.95 throughout the 337 epochs training process.

The YOLOv5 model was trained using 330 annotated microscopic images, with 35 images used for validation and 25 images reserved for testing. Training performance was monitored using loss functions and evaluation metrics throughout the training process.

As shown in Figure 4, the training and validation losses decreased steadily during the training process. The box loss, object loss, and classification loss all exhibited progressive reduction, indicating that the model successfully learned relevant image features from the annotated dataset.

The validation losses followed a similar decreasing trend and remained relatively stable throughout training, suggesting that severe overfitting was not observed.

The performance metrics improved rapidly during the early training epochs and gradually converged as training progressed.

Table 3 Model performance metrics during YOLOv5 training

Performance metric	Initial value	Final value
Precision	~0.20	0.84
Recall	~0.50	0.84
mAP@0.5	~0.20	0.90
mAP@0.5:0.95	~0.10	0.68

The final model achieved approximately 0.84 precision, 0.84 recall, 0.90 [mAP@0.5](#) and 0.68 mAP@0.5:0.95.

These results demonstrate that the trained YOLOv5 model was capable of detecting and localizing microbial structures present in microscopic water sample images with satisfactory performance.

4. Discussion

The training curves indicate successful model convergence, as evidenced by the continuous decrease in both training and validation losses. The absence of a substantial divergence between training and validation performance suggests that the model maintained acceptable generalization ability despite the relatively small dataset size. The achieved precision and recall values of approximately 0.84 indicate that the model was able to detect a large proportion of labeled microbial structures while maintaining a moderate false-positive rate. Similarly, the mAP@0.5 value of approximately 0.90 suggests satisfactory object detection performance for this preliminary dataset.

However, several limitations were observed. Environmental water samples frequently contained complex microscopic structures, suspended particles, and unidentified biological materials that differed substantially from typical bacterial morphology. Some elongated and filamentous structures were repeatedly observed across multiple samples and could not be conclusively identified using morphology alone.

These observations highlight an important limitation of image-based microbial detection systems. While the model can detect visually distinguishable microbial structures, microscopic appearance alone is insufficient for definitive taxonomic identification or pathogen classification. Additional microbiological methods, including culture-based analysis, molecular techniques, or higher-resolution imaging, would be required for species-level confirmation.

Future work should focus on expanding the dataset with a wider variety of freshwater microorganisms, improving image quality, incorporating additional staining techniques, and evaluating more advanced deep learning architectures to improve detection accuracy and robustness.

5. Conclusion

This study explored the feasibility of applying artificial intelligence to the analysis of microscopic water sample images. By combining Gram staining, OpenCV image preprocessing, and YOLOv5 object detection, the proposed approach was able to detect and localize microbial structures within environmental water samples. Training results demonstrated stable model convergence and satisfactory detection performance, suggesting that AI-assisted image analysis may support rapid preliminary microbial screening.

However, environmental water samples contained a variety of complex microscopic structures, including unidentified filamentous organisms and non-bacterial materials that could not be conclusively classified using morphology alone. Therefore, the current system should be considered a microbial structure detection and screening tool rather than a definitive pathogen identification method. Future work should focus on expanding the dataset, improving image quality, and incorporating additional microbiological techniques to enhance classification accuracy and reliability.

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Health Risks of Elevated VOC Exposure: A Review of Monitoring Practices and Regulatory Limits in Southeast Asia

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Abstract

This paper reviews the multi-systemic health impacts of volatile organic compounds (VOCs) and the regulatory landscape in Southeast Asia. Classified as hazardous air pollutants (HAPs), VOCs pose significant carcinogenic and non-carcinogenic risks, particularly in indoor environments where limited airflow increases concentrations. A review of regulations in countries such as the Philippines, Vietnam, and Singapore identifies a primary focus on greenhouse gases (NO_x, SO_x) with a notable absence of specific VOC emission standards in several nations. This article integrates regional health data—including exposure risks for Manila's jeepney drivers and Vietnam's nail salon workers—with global regulatory standards to highlight critical gaps. The findings underscore the need for enhanced monitoring, targeted legislation for vulnerable populations, and the adoption of cost-effective detection technologies across the region.

Keywords: VOC, Health Impacts, Southeast Asia, Environmental Regulation, Carcinogens

1. Introduction

Volatile organic compounds (VOCs) are substances mainly composed of carbon and hydrogen and contain different functional groups. They have high vapor pressure and low solubility in water. Generally, they are classified as having a relatively low boiling point of less than or equal to 250°C at the standard atmospheric pressure of 1 atm. Due to the volatility of VOCs, they play an important role in atmospheric chemistry. They provide necessary O.H. radicals as powerful ozone (O₃) precursors for ground-level O₃ production (Liao et al., 2014). Photochemical haze, stratospheric O₃ depletion, and the creation of organic acids, which contribute to environmental acidification by reducing the pH of precipitation, have all been linked to VOCs (Lee et al., 2002; Montzka et al., 2011; Zhang et al., 2019). Because of such properties, VOCs evaporate quickly, making them commonly present in indoor environmental conditions at standard temperature and pressure. They have become commonly available in the outdoor and indoor atmosphere because of the necessity to use such chemicals (Katsikantami and Tzatzarakis, 2022) (Pandey and Yadav, 2018).

There are two kinds of environments for being exposed to VOCs: indoor and outdoor, and their presence depends on the compound's point source. Studies show that indoor VOCs pose greater concern than outdoor VOCs for multiple reasons. Most of the day is spent indoors, causing more frequent exposure. Because of the limitation of flow indoors, concentrations of VOCs increase, significantly affecting exposed individuals. These products are also found in everyday household products because of the variety of their uses.

The source of VOCs is not always the commonly associated harmful products. It can come out of both natural and anthropogenic sources. Plants, animals, microorganisms, and even humans exhale VOCs at a certain level. With the availability of different sources in the environment, studies have been conducted to determine the levels of VOCs in areas where most of the time is spent in the day by different age groups, such as the workplace, schools, and other critical areas. These areas are selected because high-risk individuals spend more time in these areas, like children and adolescents in childcare centers and schools, respectively. Workplaces are also being monitored, wherein adults spend most of the time, and studies are comparing the level of VOCs in industrialized cities compared to urban places.

This is a current research hotspot, and more studies have been conducted yearly since the 1990s. It is being proven to be necessary because of the findings that being constantly exposed to

increased levels of VOCs correlates to contracting different kinds of diseases. There have been studies showing that certain VOCs are carcinogenic. Their poisonous nature and tendency to create tiny aerosols provide both carcinogenic and non-carcinogenic dangers to human health (e.g., asthma, headaches, dizziness, visual impairments, and memory impairment). It is critical to continue to increase our understanding of the existing and future conditions of VOCs, particularly in the tropics (Mohd et al., 2021). Several studies also show that high-level exposure to VOCs will lead to liver, kidney, and respiratory diseases and would even affect the growth of adolescents (Antonelli et al., 2020; Soni et al., 2018; Yang et al., 2020). The United States Environmental Protection Agency has identified VOCs, such as the organs they affect and diseases that would likely appear once a person is exposed to a certain amount of a specific compound for a prolonged period. Negatively affecting the health of an individual may be attributed to the property of such compounds to degrade in a photochemical pathway to produce reactive organic molecules such as radicals that cause rapid oxidation to cells, which leads to humans having diseases (Montero-Montoya et al., 2018).

If substances are causing human diseases, then proper regulatory laws must be imposed to protect such high-risk individuals. With this, several highly developed countries, such as the United States, Japan, and Korea, have strict regulations on the level of VOCs that there should be in the environment. Many countries throughout the world are enacting legislation modeled after U.S. laws. While many of these methods will enhance air quality, just a few are based on a thorough scientific knowledge of individual cities' and nations' air quality issues. Climate, topography, industrial activity, vehicle age, and fuel consumption will all significantly impact the type of air pollution in different cities. While many countries have regulations on limiting air pollutants, they focus mainly on the more commonly known greenhouse gases such as nitrogen oxides (NO_x), carbon oxides (CO_x), sulfur oxides (SO_x), and respiratory-disease-causing particulate matter (PM). These properties are well monitored even in tropical countries, but more studies should be done concerning VOCs, and the public should be protected regarding the negative health impact of such substances commonly found in the indoor and outdoor environment.

This review paper aims to analyze the multi-systemic health impacts of volatile organic compounds (VOCs) and to present the government regulations of Southeast Asian countries relating to such Volatile Organic Compounds (VOCs), which reduce air quality and are regarded as Hazardous Air Pollutants (HAPs).

2. Health Impacts of Exposure to VOCs

2.1 Diseases from exposure to VOCs

2.1.1 Carcinogenic VOCs

Volatile organic compounds (VOCs) have been increasingly recognized for their dual role in cancer as potential carcinogens and diagnostic biomarkers. Chronic exposure to VOCs, particularly in indoor environments, has been linked to an elevated risk of cancer, including lung cancer, due to their ability to cause DNA damage, oxidative stress, and inflammation, which can lead to tumor development and metastasis (Pál et al., 2024) (Hussain et al., 2024). Specific VOCs such as benzene and formaldehyde have been identified as having cancer-causing potential, with studies showing that exposure levels in certain European countries exceed acceptable risk levels, contributing to a significant public health concern (Pál et al., 2024). The analysis of VOCs in exhaled breath and urine has shown high sensitivity and specificity for detecting various cancers, including lung, prostate, and genitourinary cancers (Allard-Coutu et al., 2024) (Dawson et al., 2024) (Ayutaya et al., 2024) (M. Zhou et al., 2023). Techniques such as gas chromatography-mass spectrometry (GC-MS) and secondary electrospray ionization mass spectrometry (SESI-MS) have been employed to identify VOC signatures associated with different cancer types, facilitating early diagnosis and potentially improving patient outcomes (Chu et al., 2024) (Zhu & Choueiry, 2024).

2.1.2 Liver and Kidney Disease

Volatile organic compounds (VOCs) have been increasingly recognized for their role in liver and kidney diseases, with various studies highlighting their potential as both diagnostic biomarkers and contributors to disease pathogenesis. In the context of chronic kidney disease (CKD), VOCs such as ammonia, trimethylamine (TMA), and isoprene have been identified at elevated levels in patients, suggesting their utility in disease monitoring and management through non-invasive methods like selected ion flow tube-mass spectrometry (SIFT-MS) (Romani et al., 2022). Similarly, exposure to VOCs has been linked to liver injury biomarkers such as alanine aminotransferase (ALT) and aspartate aminotransferase (AST) (Liu et al., 2023). The interaction between VOCs and liver disease is complex, as these compounds can exacerbate underlying conditions like steatohepatitis, particularly in individuals with pre-existing risk factors such as poor diet or obesity (Lang & Beier, 2018). Furthermore, VOCs have been proposed as non-invasive diagnostic tools for liver diseases, with studies identifying specific VOC patterns in breath, urine, and stool that correlate with liver damage (Stavropoulos et al., 2021). The impact of VOC exposure is also influenced by biological and socio-cultural factors, including sex and race, which can modulate the severity of liver injury markers in exposed populations (Wahlang et al., 2023). Table 1 shows the VOCs associated with liver and kidney diseases provided by US EPA.

Table 1. Volatile Organic Compounds associated with liver and kidney diseases

Contaminant	MCLG (mg/L)*	MCL (mg/L)**
Chlorobenzene	0.1	0.1
2,4-D	0.07	0.07
Dalapon	0.2	0.2
o-Dichlorobenzene	0.6	0.6
p-Dichlorobenzene	0.075	0.075
1,1-Dichloroethylene	0.007	0.007
cis-1,2-Dichloroethylene	0.07	0.07
Trans-1,2-Dichloroethylene	0.1	0.1
Endrin	0.002	0.002
Ethylbenzene	0.7	0.7
Glyphosphate	0.7	0.7
Hexachlorocyclopentadiene	0.05	0.05
Lindane	0.0002	0.0002
Picloram	0.5	0.5
Styrene	0.1	0.1
Toluene	1	1
2,4,5-TP (Silvex)	0.05	0.05
1,1,1-Trichloroethane	0.2	0.2
1,1,2-Trichloroethane	0.003	0.005

*MCLG – maximum contaminant level goal

**MCL – maximum contaminant level

2.1.3 Respiratory-Disease causing VOCs

Volatile organic compounds (VOCs) have been increasingly recognized as significant contributors to respiratory diseases, including chronic obstructive pulmonary disease (COPD), asthma, and other respiratory ailments. Studies have shown that elevated blood concentrations of VOCs such as benzene, toluene, ortho-, and para-xylene are significantly associated with the prevalence of COPD in the U.S. population, with a non-linear relationship observed particularly for toluene and m-p-xylene (X. Liu et al., 2024). In petrochemical cities like Lanzhou, China, high VOC concentrations, especially in industrial areas, correlate with increased respiratory morbidity, particularly during fall and winter, suggesting seasonal variations in VOC impact (Chang et al., 2024) (Chang et al., 2023).

Occupational exposure to VOCs, particularly in industrial settings, has been shown to impair pulmonary function, with the severity of impact varying by exposure level, age, and duration (Johnson et al., 2023). Additionally, indoor VOCs, often from cleaning products, are linked to asthma and respiratory symptoms, affecting both adults and children (Casas et al., 2022). Table 2 shows the common VOCs that causes respiratory diseases obtained from the U.S. EPA.

Table 2. Volatile Organic Compounds associated with respiratory diseases (US EPA).

Contaminant	MCLG (mg/L)	MCL (mg/L)
Atrazine	0.003	0.003
Carbofuran	0.04	0.04
Di(2-ethylhexyl) adipate	0.4	0.4
Di(2-ethylhexyl) phthalate	0.0	0.006
Dinoseb	0.007	0.007
Methoxychlor	0.04	0.04

The study by Jia et al. (2019) showed the level of exposure of 32 Singapore Child Care Centers (CCCs), and the results showed that there are seven representative VOCs, which benzene, toluene, xylene, DBP, ethylbenzene, naphthalene were dominant contributors. These compounds are detected both in indoor and outdoor environments. This poses a significant concern in tropical regions like Singapore because of the climate conditions and because infants and children spend most of the day in CCCs. Exposing individuals at this critical development stage is of great public concern, which, according to the Office of Environmental Health Hazard Assessment (OEHHA), contributes to an increased risk of contracting cancer and reproductive health diseases.

2.1.4 Bone-Weakening VOCs

VOCs and other air pollutants have been increasingly recognized for their detrimental effects on bone health, contributing to decreased bone mineral density (BMD) and increased risk of osteoporosis and fractures. Studies have shown that exposure to air pollutants such as nitrous oxides (NO_x) and particulate matter (PM₁₀) is associated with lower BMD, particularly affecting the femoral neck and total body BMD, with significant impacts observed in individuals aged 45 to 60 years (Hu et al., 2023).

Zhou et al. (2024) proposed a correlation between exposure to volatile organic compounds and an increased risk of osteoporosis. The concerned volatile organic compounds in the study are different from those carcinogenic compounds. More than 3500 American adults were put under study. The results are that the lumbar spine and hip bone mineral density (BMD) decreases with prolonged exposure to elevated levels of VOCs such as 3- and 4-methyl hippuric acid, N-acetyl-S-(n-propyl)-l-cysteine (BPMA), and N-acetyl-S-(3-hydroxypropyl)-l-cysteine (Zhou et al., 2024). Endocrine-disrupting chemicals (EDCs) such as bisphenol A (BPA) and per- and polyfluoroalkyl substances (PFASs) have been linked to impaired bone metabolism, inhibiting osteoblast differentiation and promoting osteoclast activity, thereby increasing osteoporosis risk (Park et al., 2024).

2.1.5 Growth development

One factor affecting human health is the growth and development of adolescents, which is greatly affected by environmental pollutants and contaminants (Ren et al., 2024). This shows that conducting studies on the effects of VOC exposure on teenage development during adolescent growth is essential to creating successful preventative measures. Specific growth indicators, such as height and weight, are critical during adolescence (Klis & Wronka, 2020). Growth and development are dependent on the buildup of bone mineral density (BMD) (Priya et al., 2023). Around 90% of the maximum bone mass density is reached during late adolescence, and previous research shows a more transparent relationship between BMD and growth markers, including height and weight. Aside from height and weight, other parameters, such as the number of osteoblasts, osteoclasts, and bone marrow cells, are altered with prolonged exposure to VOCs (Zhou et al., 2024).

Prenatal exposure to VOCs, such as those measured in the Mothers and Children's Environmental Health study, has been linked to reduced birth weight and early postnatal growth, indicating that elevated prenatal VOC exposure can adversely influence early development (M. Chang et al., 2017). Children are particularly vulnerable to VOC exposure due to their rapid physiological and biochemical changes and unique activity patterns, which differ from adults (Czernych et al., 2017). The health risks associated with VOC exposure are compounded by the fact that children, especially those in low- and middle-income countries, are disproportionately affected by indoor pollution, which can lead to respiratory complications, immune suppression, and neurodevelopmental issues (Sonne et al., 2022). Furthermore, VOCs have been associated with adverse neurocognitive outcomes, such as attention-deficit/hyperactivity disorder (ADHD) and autism spectrum disorder (ASD), highlighting the need for more advanced research and practical strategies to protect children's health from these pollutants (Ha, 2019).

2.1.6 Mental health

The relationship between VOCs and mental health, particularly depression, has been increasingly scrutinized in recent research. Several studies have identified a significant association between exposure to VOCs and the prevalence of depression. For instance, a cross-sectional study using data from the National Center for Health Statistics (NHANES) found that exposure to multiple VOCs was positively correlated with depression, with gender differences noted in the effects of certain VOCs (Ma et al., 2024). Another study using NHANES data from 2011-2020 confirmed that higher concentrations of urinary VOC metabolites were significantly associated with depressive symptoms, identifying specific VOCs such as acrylonitrile, toluene, and styrene as particularly relevant (Tang et al., 2023). Experimental studies have also explored the cognitive impacts of VOCs, with findings suggesting that even low concentrations of VOCs like toluene can alter cognitive function, although not necessarily leading to discomfort or significant performance decline (Wang et al., 2023).

2.1.7 Cardiovascular diseases

Research utilizing data from NHANES has shown a positive association between urinary VOC metabolites and cardiovascular diseases (CVD), independent of traditional risk factors such as hypertension and smoking (Han et al., 2024) (X. Wang et al., 2023). Furthermore, VOC exposure has been associated with nonfatal cardio-cerebrovascular events, although the statistical significance of these findings varies (Jing et al., 2024). VOCs have also been identified as biomarkers in exhaled breath, including myocardial infarction and cardiac ischemia (Kar et al., 2024). The impact of VOCs extends to subclinical biomarkers of cardiovascular injury, where they may contribute to endothelial damage and vascular inflammation (Taylor, 2022).

2.2 VOCs in Southeast Asian Countries

2.2.1 Brunei Darussalam

Volatile organic compounds (VOCs) are primarily associated with Brunei's geological and environmental context (Curiale et al., 2000). Both natural processes and human activities, including industrial emissions and vehicle exhaust, influence them. In Brunei, VOCs are often linked to thermogenic gases and bitumen in offshore sediments (Warren et al., 2011).

The Environmental Protection and Management Act (Chapter 240) of Brunei provides the framework for environmental protection in Brunei, including air quality. It sets out general principles, defines terms, and outlines the powers of the Department of Environment, Park and Recreation. Brunei may have specific industrial standards or guidelines that regulate emissions from various industries, including those that could contribute to air pollution. While Brunei does not have a dedicated air quality law specifically targeting VOCs, these existing laws provide a framework for addressing air pollution and can indirectly impact VOC emissions.

2.2.2 Kingdom of Cambodia

Cambodia's air pollution issues are exacerbated by VOC emissions from various sectors, including residential, transport, and waste, which contribute significantly to national air pollutant levels. Currently, there are no studies on the environmental monitoring of HAPs in this country, only monitoring of VOC levels in different varieties of Cambodian rice (Thong et al., 2021).

The Royal Government of Cambodia has recognized the need to address these emissions through its first Clean Air Plan, which aims to reduce air pollutant emissions, including VOCs, by implementing 14 mitigation measures. These measures are projected to reduce emissions by 60 to 80% by 2030 (Sokharavuth et al., 2023).

2.2.3 Republic of Indonesia

Current studies on VOC monitoring in Indonesia include those related to agriculture and the level of VOCs in food, particularly rice (Kusbiantoro & Handoko, 2024). There are also studies on the natural source of VOCs from peatland fires, especially during El Niño events, which release large amounts of ozone and phenols in the atmosphere, increasing oxidative activities (Rosanka et al., 2021) (Stockwell et al., 2016). No studies have been conducted on monitoring VOC levels that can affect vulnerable populations and may affect their health.

The regulation relative to this is Law No. 32 of 2009 on Environmental Protection and Management under the Ministry of Environment and Forestry of Indonesia (FAOLEX, n.d.). This is the overarching environmental law in Indonesia, providing a framework for environmental protection and management, including air quality. It sets out general principles, standards, and responsibilities for environmental protection.

2.2.4 Lao People's Democratic Republic

There are no related studies conducted in Cambodia on VOCs.

The government regulation related to this is the Environmental Protection Law of 1999, which outlines the rules, principles, and measures for protecting the environment, including air, water, and soil. In 2013, this law was revised into 13 parts, including environmental protection, environmental emergencies, and environmental rehabilitation (Environmental Protection Law., n.d.).

2.2.5 Malaysia

In Danum Valley, Sabah tropical rainforests, VOCs are primarily emitted by plants as part of their defense mechanisms, including isoprene and monoterpenes, which are crucial for plant adaptation in complex ecosystems (Linatoc et al., 2023). In Peninsular Malaysia, bryophytes in montane and lowland forests emit a variety of VOCs, such as tetradecane and naphthalene, which play roles in plant communications and chemotaxonomy (Koid et al., 2022). In shopping malls in Malacca, VOC levels vary between morning and evening, affecting indoor air quality and potentially causing health issues like headaches and irritation among workers (Ibrahim & Ibrahim, 2020). Additionally, VOCs are present in drinking water across Peninsular Malaysia, with chloroform being the most common, although concentrations remain within national safety guidelines (Abdullah & Chian, 2011). VOCs from both natural and anthropogenic sources highlight the need for comprehensive monitoring and management strategies to mitigate their environmental and health impacts in Malaysia (Hosaini et al., 2016).

The related law to mitigate air pollution is the Environmental Quality (Clean Air) Regulations 1978 – P.U. (A) 28078, which is under the Department of Environment (DoE) and part of the Ministry of Energy, Science, Environment and Climate Change (MESTECC) of Malaysia (Department of Environment – Ministry of Environment and Water, n.d.). The New Ambient Air Quality Standard of Malaysia, which was fully implemented in 2020, adopts six air pollutants which are PM₁₀, PM_{2.5}, sulfur dioxide, carbon monoxide, nitrogen dioxide, and ground-level ozone (“New Malaysia Ambient Air Quality Standard,” n.d.). This replaces the older Malaysian Air Quality Guideline established in

1989. However, none of the common VOCs, such as benzene, toluene, etc., are included even in this new regulation.

2.2.6 Myanmar

There are no related studies conducted in Myanmar on VOCs.

The National Environmental Quality (Emission) Guidelines (2015) provide standards for controlling noise, vibration, air emissions, and liquid discharges from various sources, including industries and vehicles. It sets specific emission limits for different pollutants, including air emission levels (National Environmental Quality (Emission) Guidelines 2015 Dec 29 - O.D. Mekong Datahub, n.d.). This is included in the National Environmental Policy (2018) under the Environmental Conservation Department (ECD), which provides a strategic framework for environmental protection and sustainable development in Myanmar, emphasizing the importance of air quality management (National Environmental Policy of Myanmar, n.d.).

2.2.7 Republic of the Philippines

A study focusing on jeepney drivers in Manila revealed that these individuals are exposed to high levels of VOCs, including benzene, toluene, ethylbenzene, and xylenes (BTEX), with personal exposure levels significantly exceeding urban ambient conditions, highlighting the occupational risk associated with urban transportation (Balanay & Lungu, 2009).

In the Philippines, regulatory measures such as the Clean Air Act of 1999 establish air quality standards, emission standards, and a national air quality improvement program. However, this law does not include the HAPs mentioned by other leading countries such as the U.S., Japan, and Korea. Despite the efforts to curb pollutant emissions, the ongoing urbanization and industrial activities in the Philippines continue to pose significant challenges in managing VOC-related pollution and its associated health risks (Parao, 2012) (Balanay & Lungu, 2009).

2.2.8 Singapore

In Singapore, the urban setting and high vehicular traffic contribute to the ambient levels of VOCs, which are further influenced by regional climatic conditions and vegetation (Yin et al., 2023). The concentration of VOCs in Singapore varies significantly based on location and time of day, with higher levels typically observed near significant roads and during peak hours (Yin et al., 2023). Efforts to mitigate VOC pollution include improving ventilation, reducing the use of VOC-containing products indoors, and implementing stricter regulations on emissions from industrial and vehicular sources (Barr et al., 2024) (Mythili & Gayatri, 2024). Such monitoring studies are crucial for effective pollution control strategies.

The Environmental Protection and Management Act (EPMA) 1999 is the law related to air pollution in Singapore. This is the overarching law governing environmental protection and management in Singapore, which implements air pollution control, including setting air quality standards, regulating emissions, and licensing activities that could cause air pollution. The following provisions are for the control of air pollution, including (1) Setting air quality standards, (2) Regulating emissions from industrial facilities and vehicles, (3) Licensing of activities that could cause air pollution, and (4) Enforcement powers for the National Environment Agency (NEA) (Environmental Protection and Management Act 1999 - Singapore Statutes Online, 2023).

2.2.9 Kingdom of Thailand

There are several studies on VOCs in Thailand. In rubber plantations in Northeastern Thailand, VOCs like isoprene and monoterpenes are emitted, influencing ozone and secondary organic aerosol (SOA) formation, with seasonal variations affecting their concentrations (Khruengsai et al., 2024). In industrial areas like the Maptaphut Petroleum and Petrochemical Industrial Estate, VOCs such as benzene and toluene are prevalent, contributing to elevated cancer risks and ozone formation potential (Malakan et al., 2022) (Pinthong et al., 2022). In Bangkok, VOCs from motor vehicle emissions,

particularly benzene, toluene, ethylbenzene, and xylene (BTEX), are significant, with higher concentrations observed in roadside areas compared to residential zones (Tunsaringkarn et al., 2015). In Kalasin Province, indoor and outdoor VOC levels, including formaldehyde, exceed Thai air quality standards in specific locations, posing health risks (Suwanaruang, 2023).

The Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), is the cornerstone of Thailand's environmental legislation, providing the framework for air quality management (Thailand, EHS Compliance | Envilience ASIA, n.d.). In 2023, the Thai cabinet approved a draft of the Clean Air Act. This proposed legislation aims to strengthen Thailand's air quality regulations and includes measures to control transboundary air pollution (Thailand, Journey to Clean Air Act | Envilience ASIA, n.d.).

2.2.10 Democratic Republic of Timor-Leste

There are no related studies conducted in Timor-Leste on VOCs.

While Timor-Leste may not have a specific, standalone air quality law, several environmental laws and regulations address air pollution as part of broader environmental protection measures. The Environmental Basic Law (Decree-Law No. 26/2012) provides the overarching legal framework for environmental protection in Timor-Leste. It establishes principles for sustainable development, pollution control, and natural resource conservation (RDTL Basic Environmental Law, n.d.).

2.2.11 Socialist Republic of Vietnam

In nail salons in Da Nang, workers are exposed to high levels of VOCs, with benzene posing an exceptionally high cancer risk (Tran et al., 2022). Similarly, in Ho Chi Minh City primary schools, VOCs were found at higher indoor concentrations than outdoors, indicating significant indoor emission sources and potential health risks for students and staff (Lu et al., 2021). Occupational symptoms such as headaches and skin irritation among nail salon workers in Danang further highlight the adverse health effects of VOC exposure (Tran et al., 2020). Urban air studies in Hanoi reveal the presence of a broad spectrum of VOCs, contributing to air pollution and posing cancer risks through inhalation (Hoai, 2017). Additionally, incense burning in religious sites in Ho Chi Minh City and Binh Duong province contributes significantly to indoor VOC levels, with concentrations reaching thresholds directly impacting human health (Thuy et al., 2021).

There are related laws on VOCs in Vietnam, with the Law on Environmental Protection (2020) as the cornerstone of Vietnam's environmental legislation, providing a general framework for environmental protection, including air quality. It outlines the rights and responsibilities of individuals, organizations, and the government about environmental protection (Vu, 2021). The National Technical Regulation on Air Quality (QCVN 05:2023/BTNMT) renews the environmental regulations on water, air, and soil. This includes limits on air pollutants, some of which are VOCs (LawNet, n.d.).

Table 3. Summary of Relevant law/act and Central Authority in respective Southeast Asian country

Country	Central Authority	Relevant law/act:
Brunei	Department of Environment, Parks and Recreation	Environmental Protection and Management Act (Chapter 240) Industry-Specific Standards and Regulations
Cambodia	Ministry of Environment	Cambodia's First Clean Air Plan (2021)
Indonesia	Ministry of Environment and Forestry	Law No. 32 of 2009 on Environmental Protection and Management Government Regulation No. 41 of 1999 on Air Pollution Control:
Laos	Lao Ministry of Natural Resources and Environment (MONRE)	Environmental Protection Law (1999) <i>Revised on 2013</i>

Malaysia	Department of Environment (DOE)	Clean Air Regulations 2007 National Air Quality Action Plan 2018-2025
Myanmar	Department of Environmental Conservation	National Environmental Quality (Emission) Guidelines (2015) National Environmental Policy (2018)
Philippines	Department of Environmental and Natural Resources	Republic Act No. 8749 - Clean Air Act of 1999
Singapore	National Environment Agency (NEA)	Environmental Protection and Management Act (EPMA) 1999
Thailand	Ministry of Natural Resources and Environment (MNRE)	Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) Clean Air Bill (Draft)
Timor-Leste	Ministry of Agriculture, Forestry, and Fisheries	Environmental Basic Law (Decree-Law No. 26/2012)
Vietnam	Ministry of Natural Resources and Environment (MONRE)	Law on Environmental Protection (2020) National Technical Regulation on Air Quality (QCVN 05:2023/BTNMT)

3. Conclusion

In conclusion, VOC exposure poses significant health risks across various biological systems, as evidenced by research linking VOCs to cancer, respiratory diseases, liver and kidney disorders, and even mental health issues. The need for robust monitoring and stricter regulation of VOCs is underscored by studies showing elevated exposure levels in both developed and developing regions. Despite international differences in regulatory approaches, a global strategy to manage VOC exposure, particularly in vulnerable settings like child care centers and high-risk occupations, is essential. Future research should aim to identify and mitigate specific VOCs most harmful to health and adapt policies for regions with unique environmental and socio-economic contexts.

Exposure to volatile organic compounds (VOCs) poses serious health risks, particularly for vulnerable groups like children and adolescents. To mitigate these impacts, research and regulation must focus on targeted areas where VOC exposure may have the most significant consequences.

- Research on VOC impacts on children's neurodevelopment, especially in low—and middle-income countries should be prioritized to develop protective strategies against indoor pollution.
- Investigate the relationship between VOC exposure and bone health, focusing on osteoporosis risk due to links with decreased bone mineral density.
- Conduct studies on VOC effects on adolescent growth and development, considering unique physiological changes in this period.
- Assess the effectiveness of current VOC regulations and identify gaps to inform the need for improved emission standards in Southeast Asia.

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