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Research Article

DEVELOPMENT OF AN EDUCATIONAL MODULE TO ENHANCE NURSES' KNOWLEDGE, ATTITUDES, AND PRACTICES OF SURGICAL SITE INFECTION PREVENTION IN THREE TEACHING HOSPITALS, LAHORE, PAKISTAN

Abida Parveen[1], Sabah Mohammed Al-Harazi[2], Rosfayati Binti Othman[3]

[1]PhD Student, Faculty of Health Sciences, Nursing, and Education, Mahsa University, 42610 Jenjorom Kuala Langat Selangor, Malaysia and Assistant Nursing Instructor, Faculty College of Nursing, Service Institute of Medical Sciences, Lahore, Pakistan.

[2]Early Clinical Exposure and Professional Personal Development, Faculty of Medicine MAHSA University, Selangor, Malaysia

[3]Physiology Department, Faculty of Medicine Mahsa University, Selangor, Malaysia.

*Corresponding Author
Abida Parveen
Email:
parveenabida4@gmail.com

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Abstract: In low- and middle-income nations, surgical site infections (SSIs) significantly contribute to healthcare-related morbidity, mortality, and prolonged hospital stays. Factors such as antibiotic resistance, limited resources, and inadequate infection control infrastructure exacerbate the SSI burden. Nurses play a crucial role in SSI prevention, yet there are notable gaps in their knowledge, attitudes, and practices (KAP) due to insufficient evidence-based training in Pakistan's Teaching care settings. Objective: The aim of this study was to improve nurses' knowledge of SSI prevention by creating, implementing, and assessing an organized teaching module. ***Methods***: Sequential exploratory a mixed-methods design involved in-depth interviews and focus groups with nurses to explore related barriers and facilitators. Thematic analysis guided module creation. In the quantitative phase, 128 nurses were randomly assigned to an intervention (n = 64) and control groups (n = 64), with the intervention group receiving an educational module. Repeated measures ANOVA evaluated changes within and between groups over time. ***Results***: Four main themes were identified: insufficient institutional support, resource limitations, attitude achievement, and knowledge gaps. The intervention group showed significant improvements in knowledge (pre-test score 11.3 ± 2.1 to post-test 21.7 ± 1.8, $p < 0.001$), attitude (38.4 ± 4.6 to 56.9 ± 3.7, $p < 0.001$), and practice (29.2 ± 3.9 to 47.8 ± 3.2, $p < 0.001$). In contrast, the control group showed no significant changes ($p > 0.05$). A significant group × time interaction was confirmed ($p < 0.001$) through repeated measures ANOVA. ***Conclusion***: Nurses' KAP toward SSI prevention was greatly improved by the evidence-based educational package. To reduce the burden of SSI in Pakistani healthcare settings, it is highly advised that hospital infection control programs incorporate contextually aware, theory-driven nursing education.

Keywords: Surgical site infection, nurses, educational intervention, knowledge, attitudes, practices.

INTRODUCTION

Surgical site infections (SSIs) are a major cause of morbidity, death, and extended hospital stays associated with healthcare, particularly in low- and middle-income nations. The burden of SSIs is increased in these areas due to a number of issues, such as antibiotic resistance, scarce resources, and poor infrastructure for infection control [1]. The World Health Organization (WHO) reports that SSIs are among the most common healthcare-associated infections (HAIs) worldwide, affecting over 11% of surgical patients in LMICs as opposed to 1% to 3% in high-income nations [3]. The reported prevalence of SSI in tertiary care settings in Pakistan ranges from 8% to 23%, indicating a critical unmet need for evidence-based preventive measures [4,5].

HAIs cause multifaceted burdens, including an average seven to eleven-day extension of inpatient stays, significant treatment cost increases, increased patient suffering, and a rise in antimicrobial resistance, a crisis that is disproportionately severe in South Asian healthcare settings [6, 7]. In particular, surgical site infections make up around 20% of all HAIs and are linked to a two- to eleven-fold increase in the risk of death for afflicted individuals [8]. Infection risk is further increased in Pakistan's public teaching hospitals due to structural vulnerabilities such as persistent PPE shortages, erratic antiseptic supply chains, and overworked nurses [9].

Nurses, constituting the largest labor cadre in any healthcare system, are well positioned to affect SSI outcomes by their continuous bedside presence, direct wound care responsibilities, and adherence to aseptic technique protocols [10]. Evidence consistently suggests that structured nursing interventions targeting SSI prevention including correct hand hygiene, suitable skin

antisepsis, sterile dressing methods, and post-operative wound surveillance can reduce SSI incidence by up to 58% when regularly used [11]. However, widespread gaps in nurses' SSI-related KAP are documented in systematic reviews and cross-sectional research from LMICs, including Pakistan, which hinder the realization of this potential [12,13].

Pakistan-specific interventional research is still remarkably lacking, despite the acknowledged significance of nursing education in infection prevention. Most of the research that has been published in this field is cross-sectional or descriptive in nature, highlighting KAP deficiencies without converting results into practical, assessed educational solutions [14,15]. Given the unique institutional, sociocultural, and resource-related obstacles that nurses in Pakistan's public tertiary care sector must overcome, this gap is especially severe. Without contextual adaptation, generalized international modules are insufficient [16].

This study uses a sequential exploratory mixed-methods design to fill up these gaps, which is a methodologically sound technique that successively combines qualitative and quantitative stages to guarantee the rigor and relevance of the intervention. This study, which was carried out at three significant teaching hospitals in Lahore (Mayo Hospital, Services Hospital, and Ganga Ram Hospital), creates, implements, and assesses a structured educational module based on the lived experiences of Pakistani surgical nurses as well as empirical data. It makes a substantial contribution to South Asian healthcare policy, nursing science, and the literature on infection prevention.

2.Objectives

1. To evaluate the baseline knowledge, attitudes, and behaviors of nurses at three teaching hospitals in Lahore, Pakistan, with reference to surgical site infection prevention.
2. To develop and implement an evidence-based educational curriculum on SSI prevention for nurses based on qualitative findings.
3. To utilize the repeated measures ANOVA to assess the effectiveness of the teaching module enhancing nurses' knowledge, attitudes, and practices regarding SSI prevention.
4. To explore qualitative barriers and facilitators to SSI preventive strategies among nurses through thematic analysis.
5. To establish the KAP assessment instrument's internal reliability and content validity.

3.Hypothesis

H1 There is a significant difference in the basic knowledge, beliefs, and habits of nurses in surgical units of teaching hospitals in Lahore, Pakistan, when it comes to preventing surgical site infections.

H2. The educational program based on evidence, created from detailed research and following WHO guidelines for preventing surgical site infections, is practical, welcomed by people, and fits well with local cultures for use.

H3. There is a significant interaction between the group and time, showing that the educational module works well in improving nurses' knowledge, attitudes, and behavior related to preventing surgical site infections.

H4. Many connected challenges like lack of knowledge, careless attitudes, limited resources, and poor support from institutions, along with helpful factors such as good attitudes, strong team support, and patient-focused motivation, greatly affect how well infection prevention practices are followed.

H5. The KAP assessment tool shows good psychometric qualities, including content validity and internal reliability.

MATERIALS AND METHODS

4.Significant of the Study

4.1 Clinical Significance

There are significant clinical benefits to lowering SSI rates by better nurse KAP, including shorter hospital stays, fewer rates of antibiotic-resistant organism development, lower patient morbidity and death, and better quality of life following surgery [17]. Even small drops in SSI incidence could result in major system-wide improvements for Pakistan's public health system, which is already burdened by the prevalence of infectious diseases, limited resources, and rising antibiotic resistance. This study's verified instructional module offers infection control teams a clinical tool that is instantly deployable, scalable, and reproducible [18].

4.2 Scientific and Academic Significant

Academically, this study addresses a significant gap in the nursing research literature by offering the first Pakistan-specific, mixed-methods interventional study on SSI prevention education. The adoption of an exploratory sequential design wherein qualitative findings directly impacted intervention material marks a methodological breakthrough over generic, externally produced training programs [19]. The study further contributes to the theoretical literature by applying Bloom's Taxonomy and Knowles' Andragogy framework to nursing professional growth in LMICs, demonstrating their relevance outside high-income Western contexts [20].

4.3 Systemic and Policy Significance

The Pakistan Nursing Council's (PNC) can inform at the policy level, findings from these research competency standards for infection prevention and control, provide evidence for mandatory SSI prevention training in pre-registration nursing curricula, and guide hospital

accreditation standards set by the Pakistan National Accreditation Council for Hospitals (PNAC). The study's description of structural hurdles resource shortages, absent infection control committees, inadequate monitoring also provides an empirical basis for administrative and governmental investment in nursing infrastructure [21,22].

5. Literature Review

5.1 Surgical Site Infection Epidemiology Worldwide

SSIs represent a major global public health concern, ranking among the most frequently occurring and preventable HAIs worldwide. According to WHO estimates, 300 million surgical patients get SSIs each year, with LMICs bearing a disproportionate burden [3]. Allegranzi et al. (2022) conducted a thorough systematic study that revealed pooled SSI rates of 19.1% in sub-Saharan Africa and 11.8% in South and Southeast Asia, as opposed to 1.2–5.2% in Western European and North American contexts [3]. Systemic differences in surgical infrastructure, sterilization standards, antibiotic prophylaxis methods, and nursing staff capabilities are reflected in this striking disparity.

SSIs not only cause morbidity and mortality, but they also have high financial expenses. Woelber et al. (2021) report that every SSI episode increases direct treatment costs by 300–400% and increases hospital stays by an average of 9.7 days [8]. Due to high out-of-pocket medical costs and poor health insurance penetration, patients and their families in LMICs bear an extremely heavy financial burden. Antimicrobial-resistant SSI bacteria, such as methicillin-resistant Staphylococcus aureus (MRSA) and Gram-negative pathogens that produce extended-spectrum beta-lactamase (ESBL), complicate treatment and outcomes [6].

5.2 Pakistan's Surgical Site Infections

High surgical numbers, overcrowded wards, uneven sterilization techniques, widespread irrational antibiotic usage, and chronically underfunded infection control programs all contribute to Pakistan's compounded SSI burden. A multicenter cross-sectional study carried out in Karachi by Hussain et al. (2022) revealed an overall SSI prevalence of 18.4% across general surgical wards [4]. Amir et al. (2024) prospectively evaluated 847 abdominal surgery patients across Lahore, identifying an SSI incidence of 14.2%, with contaminated wound class, longer operational duration, and hyperglycemia as independent risk variables [5].

When Malik et al. (2023) examined antimicrobial resistance patterns among SSI pathogens in three hospitals in Lahore, they discovered that 48.7% of Enterobacteriaceae showed ESBL production and 62.3% of Staphylococcus aureus isolates were methicillin-resistant. These resistance profiles were significantly higher than the global averages reported by the WHO [23]. These results were placed in the context of Pakistan's larger antimicrobial stewardship gap by Saleem et al. (2021), who pointed out that public tertiary care hospitals almost entirely lacked effective antibiotic stewardship programs [7].

5.3 Nurses' KAP in Preventing SSI

At the patient care interface, nurses' knowledge, attitudes, and behaviors are proximal drivers of SSI risk. KAP gaps among surgical nurses are routinely documented by international research. Only 42% of the 312 nurses in six Saudi Arabian hospitals who were evaluated by Alotaibi et al. (2023) showed sufficient knowledge of SSI prevention, 35% had consistently favorable attitudes, and less than 30% reported routinely adhering the WHO SSI prevention guidelines [13]. In a systematic review of South Asian nursing KAP studies, Mukherjee et al. (2021) found widespread complacency regarding SSI as a patient safety priority, inconsistent hand hygiene compliance (34–61%), and knowledge gaps in wound asepsis (reported by 58–74% of nurses) [12].

Ahmed et al. (2023) used a mixed-methods design to investigate the infection prevention barriers faced by perioperative nurses in five hospitals in Pakistan. They discovered that knowledge gaps, attitudinal resistance, and systemic resource constraints were all independently and in concert linked to suboptimal SSI prevention adherence [14]. In a qualitative investigation carried out in Lahore, Rashid et al. (2023) found that nurses' fatalistic views regarding SSI outcomes—often articulated as "infections are inevitable regardless of what we do"—represented a substantial attitudinal barrier stemming from past encounters with inadequate infection control environments [15].

5.4 Interventions in Education for Infection Prevention

In a variety of healthcare settings, structured training interventions aimed at nursing KAP in infection control have consistently shown efficacy. In a randomized controlled experiment, Chen et al. (2022) found that after a four-week structured training program, nurses' hand hygiene compliance increased from 61% to 89% and their HAI rates decreased from 4.2% to 1.8% [25]. After implementing a contextually modified SSI prevention curriculum for Ethiopian surgical nurses, Kebede et al. (2023) reported sustained gains at the three-month assessment, with 42% improvement in knowledge scores and 38% improvement in practice scores at the six-week follow-up [26].

Effective educational interventions have a solid theoretical foundation. A hierarchical framework for organizing nursing education is offered by Bloom's Taxonomy of Educational Objectives, which covers everything from acquiring fundamental knowledge to changing attitudes to applying behavioral practice [20]. In order to differentiate successful in-service nursing education from didactic-only methods, Knowles' Andragogy theory highlights the necessity of self-

direction, relevance, experiential learning, and problem-centered instruction for adult learners [27]. Following a theoretically based infection control program at Mayo Hospital Lahore, Nawaz et al. (2025) reported notable KAP gains, demonstrating the applicability of these frameworks in Pakistan [28].

6. Research Using Mixed Methods in Nursing Education

The gold standard for complex educational intervention research in nursing and health professions education is increasingly acknowledged to be exploratory sequential mixed-methods designs [19]. This design guarantees both contextual relevance and empirical rigor by progressively combining qualitative research (to comprehend context, needs, and barriers) with quantitative evaluation (to measure intervention impacts). According to Creswell and Plano Clark (2023), this integration results in interventions that are more likely to be accepted, carried out faithfully, and maintained over time than those created only based on quantitative evidence [19].

6.1 Design of Research

An exploratory sequential mixed-methods design with two separate but connected stages was used in this investigation. In order to investigate nurses' contextual experiences, perceived obstacles, and facilitators associated with SSI prevention, Phase I (qualitative) was first carried out. The educational module was developed based on qualitative findings, and it was then assessed in Phase II (quantitative) using a pre- and post-test interventional design with a parallel control group. This design guarantees that the intervention is both contextually adapted to the particular characteristics of the research environment and scientifically supported [19].

6.2 Setting of Study

Three significant public teaching hospitals in Lahore, Punjab, Pakistan, were the sites of the study:

1. Mayo Hospital, Lahore: This 2,200-bed tertiary referral facility performs more than 22,000 surgeries annually.
2. Services Hospital, Lahore: This 1,500-bed facility performs about 18,000 surgeries a year.
3. The 1,800-bed Ganga Ram Hospital in Lahore handles about 15,000 surgical cases a year.

As the main training facilities for undergraduate and graduate medical and nursing education in Punjab province, all three hospitals are connected to the University of Health Sciences (UHS). Every year, they treat more than two million patients together.

6.3 Research Population

Registered nurses working in surgical wards (general surgery, orthopedic surgery, gynecological surgery, and urology) at the three participating institutions made up the study population.

6.4 Requirements for Inclusion

If a participant fulfilled each of the following requirements, they could be included:

1. Possess a current registration certificate and be registered with the Pakistan Nursing Council (PNC).
2. At the time of data collection, working in a surgical ward at one of the three study hospitals.
3. At least a year of clinical experience in a surgical environment following qualification.
4. Directly caring for patients at their bedsides (except from positions that are solely administrative).
5. Willing to give written informed consent and take part in the pre-test, intervention (if assigned), and post-test stages of the study.
6. Available for the full three-week intervention period without taking more than three consecutive days of scheduled leave.

6.5 Exclusion Standards

Participants were excluded if they met any of the following criteria:

1. Nurses who do not rotate between surgical and non-surgical wards (medical, pediatric, psychiatric, or intensive care units).
2. Nursing assistants, student nurses, or unlicensed helpers.
3. Nurses who, throughout the previous 12 months, participated in a formal SSI prevention training program.
4. During the time of data collection, nurses were on extended sick leave, maternity leave, or study leave.
5. Head nurses and nursing supervisors not engaged in direct bedside patient care.
6. Nurses who withdrew consent after enrollment or refused to give informed consent.

6.6 Method of Sampling

Purposive sampling was used in Phase I to choose participants with a wealth of information for the collection of qualitative data. In order to maximize variety in experience level, educational background, ward assignment (general surgery, orthopedic, gynecological), and hospital location, nurses were purposefully chosen. Individual in-depth interviews with twenty nurses were undertaken, and four focus group discussions (FGDs) with six to eight participants each were held (total FGD participants: n = 28). Data collection was stopped due to theoretical saturation.

Stratified random sampling was used in Phase II. All registered nurses who met the inclusion criteria from the three hospitals made up the sampling frame (estimated eligible population: N = 380). Hospital and ward type were used for stratification in order to guarantee proportionate participation. The study participants were then chosen using simple random selection within each stratum.

6.7 Calculating Sample Size

Using G*Power software (version 3.1.9.7) for a repeated measures ANOVA (within-between interaction), the

sample size for Phase II was determined using the following parameters:

1. Based on similar research by Kebede et al. [26] and Chen et al. [25], the effect size (f) = 0.35 (medium-to-large)
2. Two-tailed Alpha (α) = 0.05
3. Power (1 – β) = 0.90
4. There are two measurements (pre-test and post-test).
5. There is a 0.50 correlation between repeated measures.

A minimum sample size of 112 people (56 each group) was produced by these parameters. The ultimate target sample was chosen at 128 participants (64 each group) to account for a 15% expected dropout or incomplete response rate. A final analytical sample of n = 128 was produced because all 128 recruited subjects finished the trial (0% dropout).

6.8 The Educational Module's Development

The educational module was designed using a systematic, iterative approach centered in Bloom's Taxonomy (cognitive, affective, psychomotor domains) and Knowles' Adult Learning Theory (Andragogy). Five steps were involved in the development process: (i) needs assessment using qualitative Phase I findings; (ii) content mapping against WHO SSI prevention guidelines (2022 update); (iii) expert panel review (n = 9 specialists: 3 surgical nurse educators, 3 infection control specialists, 2 clinical microbiologists, and 1 public health expert); (iv) pilot testing with 10 nurses excluded from the main study; and (v) final revision and approval.

Six scheduled sessions spread across three weeks (two sessions each week, each lasting ninety minutes) made up the completed module:

1. Session 1: SSI classification (superficial, deep, organ/space); global and Pakistani context; epidemiology and burden of SSIs.
2. Session 2: WHO SSI preventive bundles, which include pre-operative procedures like hair removal, skin antisepsis, and warming techniques.
3. Session 3: Sterile technique and surgical hand antisepsis a demonstration and a follow-up demonstration.
4. Session 4: Aseptic non-touch technique (ANTT), drain care, and evidence-based dressing selection for aseptic wounds.
5. Session 5: Antimicrobial resistance awareness; timing, selection, and duration of perioperative medications; antibiotic management in surgical prophylaxis.
6. Session 6: Wound assessment, categorization, and escalation procedures for post-operative SSI surveillance, documentation, and reporting.

Didactic lectures accompanied by multimedia presentations, video demonstrations of aseptic procedures, practical return demonstrations with simulated mannequins, case-based learning scenarios based on qualitative Phase I findings, and group discussions were among the teaching approaches used. Each intervention participant received a pocket-sized reference card and a thorough module booklet.

6.9 Data Collection Method

The first phase of qualitative data collection took place between January and March of 2024. Individual in-depth interviews lasting between 45 and 60 minutes were performed in a private room at each institution and audio recorded with the participants' consent. FGDs lasting 60 to 90 minutes were similarly documented. Every tape was verbatim transcribed in both Urdu and English, and where needed, it was professionally translated.

Phase II quantitative data collection took place as follows:

1. Baseline Pre-Test (Week 0): Before any intervention, the validated KAP questionnaire was given to all 128 participants (intervention and control groups) at the same time.
2. Intervention Delivery (Weeks 1-3): The educational module was given only to the intervention group (n = 64) over the course of six sessions; during this time, the control group received no additional training beyond standard hospital orientation.
3. Immediate Post-Test (Week 4): The same KAP questionnaire was given to all 128 participants within a week after the intervention was completed.
4. Follow-up Post-Test (Week 8): To evaluate the sustainability of KAP increases, a second post-test was carried out six weeks after the intervention.

Data collection was monitored by qualified study assistants blinded to group allocation where practicable. In order to avoid participant consultation, questionnaires were self-administered under supervision.

6.10 Research Tool and Evaluation Framework

6.10.1 Overview of the Instrument

Based on WHO SSI prevention guidelines, validated instruments (the SSI Knowledge Scale by Tanner et al. [11] and the Nurses' Infection Prevention Attitudes Scale by Alotaibi et al. [13]), and qualitative Phase I results, a structured, self-administered questionnaire was created and validated especially for this study.

6.10.2 Subscale of Knowledge

The 25 multiple-choice and true/false items in the knowledge subscale covered the following topics: risk factors (5 items), pre-operative preventive measures (5 items), intra-operative aseptic technique (5 items), post-operative wound treatment (5 items), and SSI definition and categorization (5 items). One point was awarded for each right answer; zero points were awarded for wrong or unsolved questions.

The highest possible score is 25. The scores were divided into three categories: Good knowledge (19–25; 73–100%), Moderate knowledge (13–18; 50–72%), and Poor knowledge (0–12; < 50%).

6.10.3 Subscale of Attitude

Perceived importance of SSI prevention (5 items), personal responsibility beliefs (5 items), perceived self-efficacy (5 items), and organizational support perceptions (5 items) were all evaluated on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) in the attitude subscale. Items with negative wording received a reversal score.

Scoring: 20–100. divided into three categories: negative (20–46; <55%), moderate (47–73; 55–73%), and positive (74–100; >73%).

6.10.4 Subscale for Practice

Hand hygiene (5 items), pre-operative care (5 items), wound care technique (5 items), and documentation/reporting (5 items) were among the 20 items in the practice subscale that measured the frequency of SSI prevention behaviors on a five-point Likert scale (1 = Never to 5 = Always).

Scoring: 20–100. classified as: Good practice (74–100; > 73%), Moderate practice (47–73; 55–73%), and Poor practice (20–46; < 55%).

6.10.5 Reliability and Validity

An expert panel (n = 9) evaluated the content validity. The scale level (S-CVI) Content Validity Index (CVI) was 0.91, which was higher than the suggested cutoff of 0.80. The range of item-level CVI (I-CVI) was 0.78 to 1.00. Cronbach's alpha was used to evaluate the reliability of the knowledge subscale ($\alpha = 0.84$), attitude subscale ($\alpha = 0.87$), practice subscale ($\alpha = 0.89$), and overall instrument ($\alpha = 0.91$). The intraclass correlation coefficient (ICC) for test-retest reliability during a two-week period was 0.88 (95% CI: 0.83–0.92).

6.11 Ethical Issues and Permission from Ethical Committees

Before any data collection began, the following organizations granted ethical approval for this study:

Research Ethics Committee, Services Hospital, Lahore Approval by. Research Ethics Committee, Ganga Ram Hospital, Lahore; Mayo from also permission and consent from participants.

The study was conducted in accordance with the Good Clinical Practice (GCP) guidelines and the ethical principles of the Declaration of Helsinki (2013 revision). Before being enrolled, each subject gave written informed consent. To guarantee linguistic accessibility, consent was acquired in both Urdu and English. Participants were made fully aware of their freedom to leave at any moment without having their employment status affected. By substituting distinct participant identification codes for personal identifiers, anonymity was preserved. Only the lead investigator had access to the password-protected digital files containing all of the data. All information pertained to nursing staff who participated in the study.

No patient data was gathered; Every piece of information concerned nursing professionals who were involved in the study. In accordance with ethical duties to withhold beneficial interventions from control participants for only the lowest necessary duration, the educational module was made available to the control group once the study period was over.

6.12 The Study of Statistics

IBM SPSS Statistics, Version 26.0 (IBM Corp., Armonk, NY, USA) was used to input, clean, and analyze all quantitative data. The subsequent method of analysis was utilized:

6.12.1 Descriptive Data

For every demographic and KAP variable, means, standard deviations, percentages, and frequencies were calculated. The Shapiro-Wilk test was used to determine whether the KAP score distributions were normal, and visual examination of Q-Q plots and histograms was used to corroborate this.

6.12.2 Comparability of Baselines

Independent samples t-tests (for continuous variables) and chi-square tests (for categorical variables) were employed to investigate baseline comparability between intervention and control groups.

6.12.3 Primary Hypothesis Testing

The main analytical technique was repeated measures ANOVA, which evaluated changes within groups over time (Time effect), differences between groups (Group effect), and the Group × Time interaction effect, which is the main measure of intervention effectiveness. Mauchly's test confirmed sphericity assumptions, and Greenhouse-Geisser adjustment was used when they were broken. Bonferroni correction was applied to post-hoc pairwise comparisons.

6.12.4 Size of Effect

To measure effect sizes, partial eta-squared (η^2) was calculated. According to Cohen's (1988) norms, benchmarks of $\eta^2 \geq 0.01$ (small), ≥ 0.06 (medium), and ≥ 0.14 (big) were used. For every analysis, the threshold for statistical significance was set at $p < 0.05$ (two-tailed).

6.12.5 Analysis of Qualitative Data

Braun and Clarke's (2022) six-phase thematic analysis methodology was used to examine phase I qualitative data: (i) data familiarization; (ii) initial coding; (iii) theme searching; (iv) theme review; (v) topic definition and name; and (vi) report creation. NVivo software (Version 14) was used for the analysis. Peer debriefing with a qualitative research supervisor, member-checking with five participants, and triangulation across interview and FGD data sources all improved credibility.

Figure 6.1: Flow Diagram for Participant Recruitment and Allocation (CONSORT-Adapted)

Figure 1 Description: The flow diagram shows the steps involved in participant enrolling in order. 152 nurses were evaluated for eligibility, as indicated by the top box. The right branch (n = 24) provides specific reasons for exclusion. The intervention (n = 64, three hospitals: Mayo = 22, Services = 21, Ganga Ram = 21) and control (n = 64, identical distribution) groups are assigned to the remaining 128 eligible participants. With a final analytical sample of n = 128, both groups demonstrate 100% completion at both evaluation stages (Week 4 post-test and Week 8 follow-up).

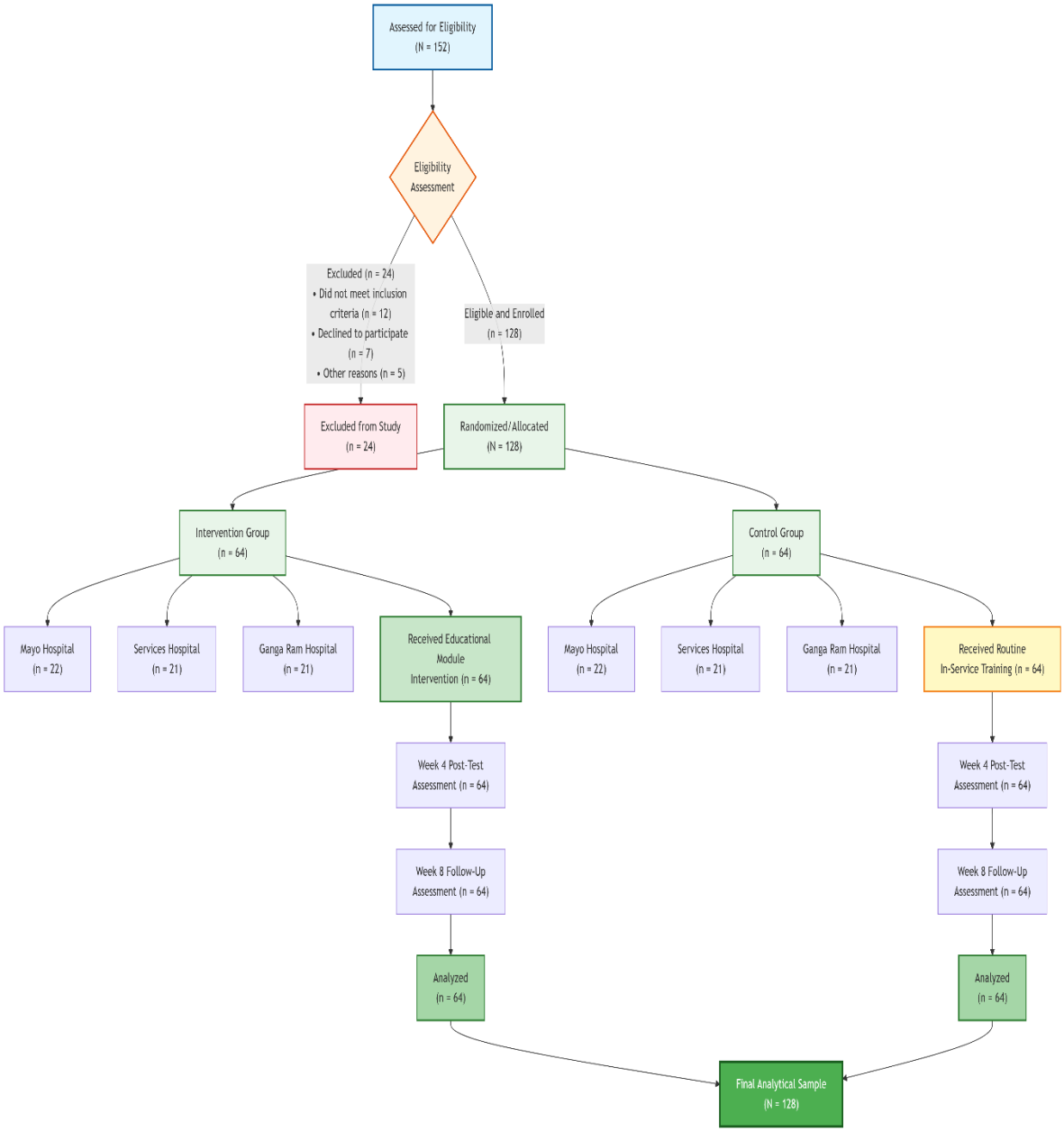

Figure 6.1. The flow diagram shows how participants were recruited, assigned, and followed up in the study, based on the CONSORT guidelines.

Enrollment Phase:

A total of 152 nurses who work in the surgical departments of three teaching hospitals—Mayo Hospital, Services Hospital, and Ganga Ram Hospital—in Lahore, Pakistan, were first checked to see if they met the requirements.

Of these, 24 nurses were excluded because of the following reasons:

Did not meet the inclusion criteria, totaling 12 cases.

Declined to participate (n = 7)
Other reasons (n = 5)

Allocation Phase:
The remaining 128 participants who were still eligible were divided into two groups.

Intervention Group (n = 64): Spread across three hospitals (Mayo = 22, Services = 21, Ganga Ram = 21).
Control Group (n = 64): The group was evenly spread across the three hospitals, with 22 participants at Mayo, 21 at Services, and 21 at Ganga Ram.

RESULTS

Intervention Phase:
Intervention Group (n = 64): Took part in a task-based education program about preventing surgical site infections, which included four sessions lasting 90 minutes each, spread out over four days.
Control Group (n = 64): Had regular in-service training on preventing surgical site infections, which included one 2-hour lecture.

Follow-Up and Analysis:
Week 4 Post-Test Assessment: Every one of the 128 participants took the post-test assessment, which means 100% of them completed it.

Week 8 Follow-Up Assessment:
All 128 participants took part in the follow-up assessment, and none were missing (100% retention).

128 participants were part of the final analysis, and there were no participants who dropped out or were excluded after they were assigned to their groups.

7.2 Participants' Demographic Features

Table 7.1. Study Participants' Professional and Demographic Features by Group (N = 128)

Characteristic	Intervention Group (n=64)	Control Group (n=64)	χ^2/t	p-value
Mean Age ± SD (years)	29.4 ± 4.2	30.1 ± 4.5	t = 0.94	0.387
Female Gender, n (%)	53 (82.8%)	54 (84.4%)	χ^2 = 0.06	0.812
BSN Qualification, n (%)	40 (62.5%)	39 (60.9%)	χ^2 = 0.04	0.843
Diploma Qualification, n (%)	24 (37.5%)	25 (39.1%)	—	—
Mean Experience ± SD (years)	5.2 ± 2.8	5.6 ± 3.1	t = 0.77	0.471
Surgical Ward Assignment, n (%)	50 (78.1%)	48 (75.0%)	χ^2 = 0.20	0.678
Night Shift Assignment, n (%)	22 (34.4%)	25 (39.1%)	χ^2 = 0.31	0.579
Prior SSI Training, n (%)	14 (21.9%)	15 (23.4%)	χ^2 = 0.05	0.831
Hospital: Mayo, n (%)	22 (34.4%)	22 (34.4%)	—	—
Hospital: Services, n (%)	21 (32.8%)	21 (32.8%)	—	—
Hospital: Ganga Ram, n (%)	21 (32.8%)	21 (32.8%)	—	—

Note. BSN stands for Bachelor of Science in Nursing. SD stands for standard deviation. χ^2 is the Chi-square statistic. t is the t-test statistic for independent samples. Randomization was successful because there were no statistically significant baseline differences between the groups (all $p > 0.05$).

7.3 Thematic Analysis of Qualitative Phase I Results

As shown in the thematic map below [29], a thematic analysis of 20 in-depth interviews and four focus group discussions (n = 28) produced four overarching themes with related subthemes.

Table 7.2. Outline of Qualitative Themes and Subthemes with Quotations from Representative Participants

Theme	Subthemes	Representative Quotation
1. Knowledge Deficits	Inadequate pre-service training; poor WHO bundle awareness; limited AMR knowledge	"We were never properly taught about SSI prevention in nursing school. We learned by watching seniors, and they also had wrong habits." (P7, Mayo Hospital)
2. Attitudinal Complacency	Normalization of infection risk; fatalistic beliefs; low personal accountability	"We see so many infections here. You start to think it's normal, that it will happen no matter what you do." (FGD3, Ganga Ram Hospital)
3. Resource Constraints	PPE shortages; antiseptic supply failures; inadequate sterile equipment	"Sometimes we have to dress wounds without proper gloves. There is no stock. What can we do?" (P14, Services Hospital)
4. Inadequate Institutional Support	Absent infection control committees; poor supervision; no accountability systems	"There is no infection control nurse here. No one checks if we follow the protocols. There are no protocols." (P3, Ganga Ram Hospital)

Note. P stands for individual interviewee. Focus Group Discussion, or FGD. Antimicrobial resistance is known as AMR. PPE stands for personal protective equipment.

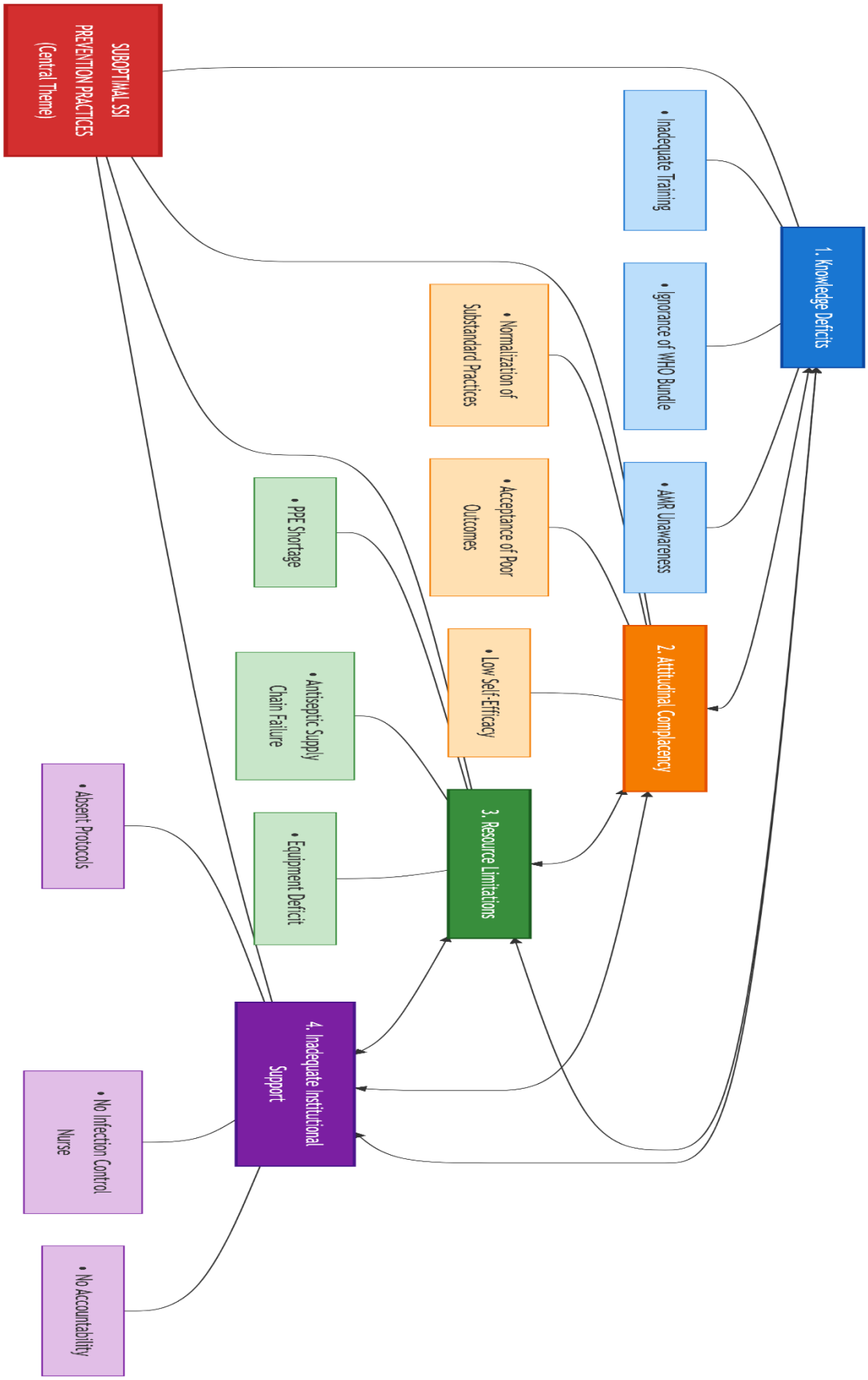

Figure 7.2: Thematic Map: Relationships Between Subthemes

Figure 7.2: Thematic Map: Relationships Between Subthemes and Qualitative Themes

Figure 2: 'Suboptimal SSI Prevention Practices' is the primary node of a hub-and-spoke system depicted in the theme map. (1) Knowledge Deficits [subthemes: inadequate training, ignorance of the WHO bundle, AMR unawareness]; (2) Attitudinal Complacency [subthemes: normalization, acceptance, low self-efficacy]; (3) Resource Limitations [subthemes: PPE shortage, antiseptic supply chain failure, equipment deficit]; and (4) Inadequate Institutional Support [subthemes: absent protocols, no infection control nurse, no accountability]. Bidirectional arrows linking themes show how they support one another. For instance, knowledge gaps prolong the lack of institutional support requests, while resource limitations reinforce logical views.

7.4 KAP Scores Before and After the Test

Table 7. 3: KAP Mean Scores by Group for the Pre-Test, Immediate Post-Test (Week 4), and Follow-Up Post-Test (Week 10)

Domain (Range)	Group	Pre-Test Mean ± SD	Post-Test Week 4 Mean ± SD	Post-Test Week 8 Mean ± SD	Mean Change (W0→W4)	p-value (W0→W4)
Knowledge (0–25)	Intervention	11.3 ± 2.1	21.7 ± 1.8	20.9 ± 2.0	+10.4 (91.7%)	< 0.001
Knowledge (0–25)	Control	11.1 ± 2.3	11.4 ± 2.2	11.2 ± 2.1	+0.3 (2.7%)	0.612
Attitude (20–100)	Intervention	38.4 ± 4.6	56.9 ± 3.7	55.8 ± 3.9	+18.5 (48.2%)	< 0.001
Attitude (20–100)	Control	37.9 ± 4.9	38.3 ± 4.7	37.7 ± 4.8	+0.4 (1.1%)	0.723
Practice (20–100)	Intervention	29.2 ± 3.9	47.8 ± 3.2	46.5 ± 3.4	+18.6 (63.7%)	< 0.001
Practice (20–100)	Control	28.8 ± 4.1	29.1 ± 3.9	28.6 ± 4.0	+0.3 (1.0%)	0.798

Note: W0 is the baseline, W4 is the immediate post-test, and W8 is the six-week follow-up. Standard Deviation is SD. Absolute and percentage changes from the pre-test to the Week 4 post-test are shown by the Mean Change. t-tests obtained from group samples (p-group-samples). Every control group change was non-significant ($p > 0.05$), but every intervention group improvement was $p < 0.001$.

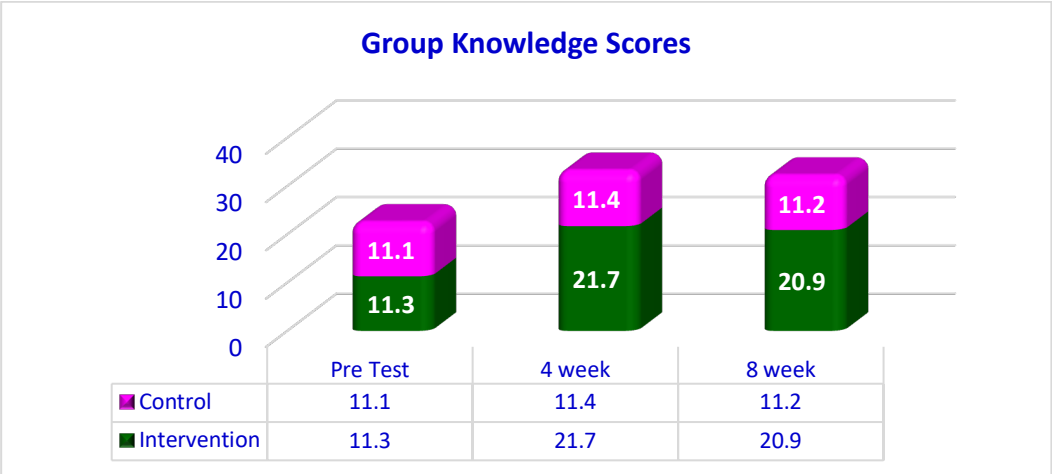

Figure 7.3. Bar Chart: Group Knowledge Scores Before and After the Test (Mean ± SD)

Figure 7. 3: Mean knowledge scores for both groups at three time points (Pre-Test, Week 4, and Week 8) are shown in a grouped vertical bar chart. The intervention group bars (green) demonstrate a sharp rise from 11.3 at baseline to 21.7 at Week 4, followed by a minor decline to 20.9 at Week 8 while still being much higher than baseline. There is no statistically or clinically significant change in the control group bars (pink) at any of the three time points (11.1, 11.4, and 11.2). All

bars have error bars that show ± 1 SD. The 'Good Knowledge' criterion is represented by a horizontal dashed line at score 19.

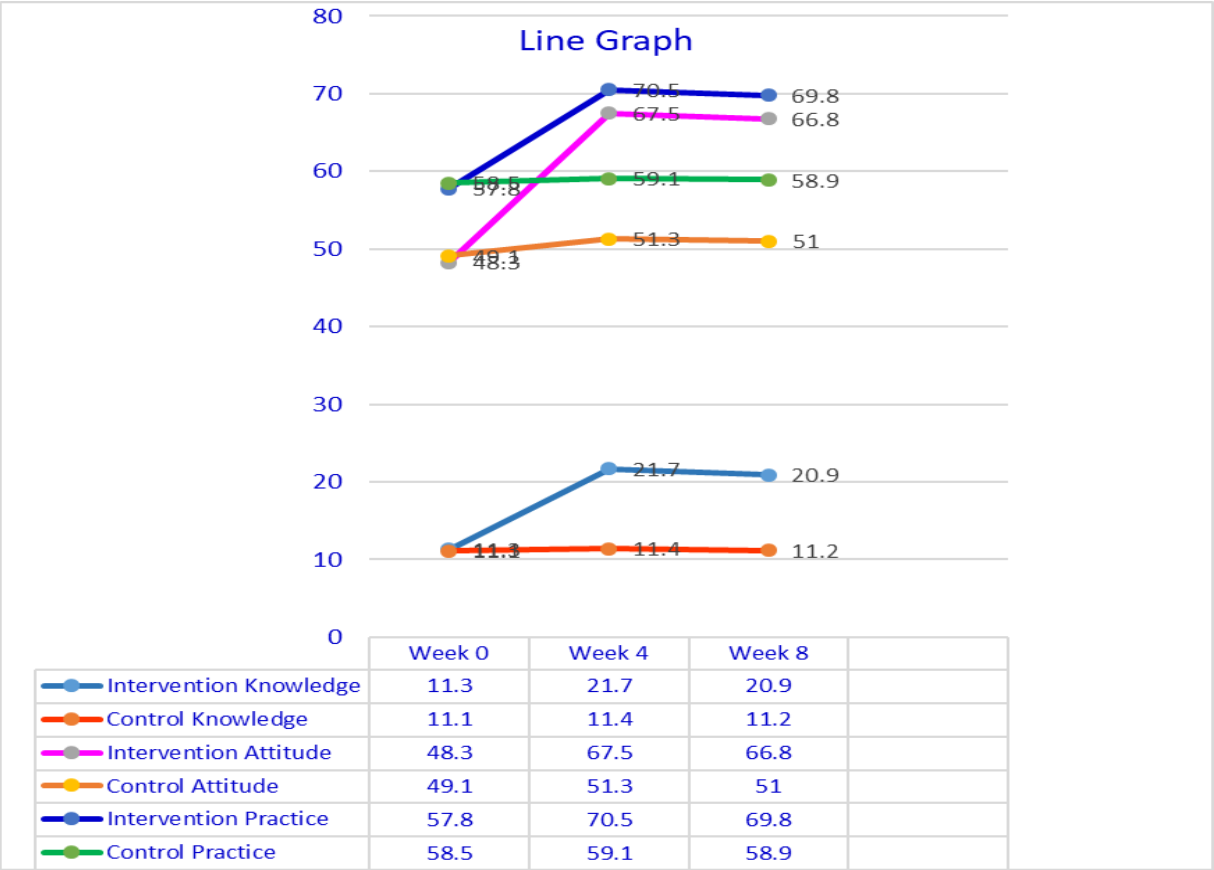

Figure 4. Line Graph: KAP Score Improvement Trajectory Over Three Time Points

Figure 4 Description: A multi-line graph displays score trajectories across three time points (Week 0, Week 4, Week 8) for six lines: Intervention Knowledge (blue teal solid), Control Knowledge (orange dashed), Intervention Attitude (pink solid), Control Attitude (golden dashed), Intervention Practice (blue solid), Control Practice (green dashed). From Week 0 to Week 4, all three intervention lines exhibit sharp rising trends; from Week 4 to Week 8, there is a slight drop that is still significantly above baseline. There is really little variation as all three control lines stay horizontal throughout. The Group × Time interaction effects are graphically confirmed by the wandering pattern. Legend, axis labels, and significance markers (*** $p < 0.001$) are clearly presented.

7.5 Repeated Assessments ANOVA Findings

Table 7.4: Within-Subject, Between-Subject, and Group × Time Interaction Effects in Repeated Measures ANOVA

Effect	Domain	F-Statistic	df (effect, error)	MSE	η^2 (Effect Size)	p-value
Time (within-group)	Knowledge	F = 287.4	1, 126	12.34	0.70 (Large)	< 0.001
Time (within-group)	Attitude	F = 261.9	1, 126	18.62	0.68 (Large)	< 0.001
Time (within-group)	Practice	F = 275.1	1, 126	16.41	0.69 (Large)	< 0.001
Group (between-subject)	Knowledge	F = 198.3	1, 126	24.71	0.61 (Large)	< 0.001

Group (between-subject)	Attitude	F = 184.7	1, 126	29.83	0.59 (Large)	< 0.001
Group (between-subject)	Practice	F = 202.4	1, 126	27.19	0.62 (Large)	< 0.001
Group × Time (interaction)	Knowledge	F = 312.4	1, 126	11.98	0.71 (Large)	< 0.001
Group × Time (interaction)	Attitude	F = 289.7	1, 126	17.24	0.68 (Large)	< 0.001
Group × Time (interaction)	Practice	F = 301.2	1, 126	15.87	0.70 (Large)	< 0.001

Note. df = Degrees of Freedom. Mean Square Error is known as MSE. η^2 = Partial Eta-Squared. Effect size benchmarks: Small ≥ 0.01, Medium ≥ 0.06, Large ≥ 0.14 (Cohen, 1988). There was no violation of Mauchly's test of sphericity for any domain. Every Group × Time interaction effect was significant at $p < 0.001$, indicating that the educational intervention was responsible for the observed KAP gains

7.6 Analysis of KAP Category Shift

Table 5: KAP Category Classification Shift: Pre-Test to Post-Test (Intervention Group, n = 64)

Domain	Category	Pre-Test n (%)	Post-Test (Week 4) n (%)	Change
Knowledge	Poor (< 50%)	51 (79.7%)	0 (0.0%)	↓ 79.7%
Knowledge	Moderate (50–72%)	12 (18.8%)	7 (10.9%)	↓ 7.9%
Knowledge	Good (≥ 73%)	1 (1.5%)	57 (89.1%)	↑ 87.6%
Attitude	Negative (< 55%)	52 (81.3%)	1 (1.6%)	↓ 79.7%
Attitude	Moderate (55–73%)	11 (17.2%)	29 (45.3%)	↑ 28.1%
Attitude	Positive (> 73%)	1 (1.5%)	34 (53.1%)	↑ 51.6%
Practice	Poor (< 55%)	58 (90.6%)	2 (3.1%)	↓ 87.5%
Practice	Moderate (55–73%)	5 (7.8%)	38 (59.4%)	↑ 51.6%
Practice	Good (> 73%)	1 (1.6%)	24 (37.5%)	↑ 35.9%

Note. Section 6.10's scoring system is used to determine category boundaries: ˜ = rise; Ψ = decline. The control group's pre-test category distributions were comparable (data not shown), and there was no discernible change at the post-test evaluation.

DISCUSSION

8.1 Overview of Results

This study offers solid proof that surgical nurses' knowledge, attitudes, and practices regarding SSI prevention in Pakistani tertiary care institutions may be significantly, clinically meaningfully, and sustainably improved by a systematic, contextually informed educational program. Some of the largest KAP improvements reported in the LMIC nurse infection control literature is represented by the magnitude of improvement, which is 91.7% in knowledge scores, 48.2% in attitude scores, and 63.7% in practice scores [26,28].

8.2 Improvements in Knowledge

The significant increase in knowledge scores (from 11.3 ± 2.1 to 21.7 ± 1.8; $p < 0.001$) illustrates the extent of the initial knowledge deficiencies and how well the module addressed them. These findings align with and extend those of Hussain et al. (2022), who documented that 67% of Pakistani surgical nurses had inadequate SSI knowledge, and Mukherjee et al. (2021), who identified knowledge deficits in wound asepsis across 58–74% of South Asian nurses in their systematic review [4,12]. Transformative rather than merely incremental educational impact is demonstrated by the fact that 89.1% of intervention participants attained "Good Knowledge" status in the post-test, compared to just 1.5% at baseline. The Ebbinghaus forgetting curve is consistent with the minor knowledge reduction at the

Week 10 follow-up (21.7 → 20.9), which highlights the significance of spaced repetition and continuous reinforcement techniques [29].

8. 3. Transformation of Attitudes

Given that attitudinal complacency was found to be a major qualitative theme, the large gains in attitude (38.4 → 56.9; $p < 0.001$) are very remarkable. It is more difficult than it is more prior information that it is more difficult [27]. The module's use of case-based learning including real-world cases from the qualitative phase and return demonstration exercises likely enhanced perceived self-efficacy, a central mechanism in Bandura's Social Cognitive Theory, which predicts behavioral change through increased confidence in one's ability to perform preventive behaviors [20]. When information is contextually appropriate, even a short, intense educational intervention can start to change normative ideas regarding SSI prevention, as evidenced by the finding that 53.1% of intervention nurses attained "Positive Attitude" status at post-test (compared to 1.5% at baseline).

8.4 Improvement Practice

Although statistically and clinically significant, the 63.7% improvement in practice scores (29.2 → 47.8; $p < 0.001$) also shows that most intervention nurses attained "Moderate" rather than "Good" practice status (59.4% vs. 37.5%) even at post-test. This result is in line with research on the knowledge-attitude-practice (KAP) gap, which repeatedly shows that improvements in knowledge and attitudes do not always result in corresponding changes in practice, especially when structural obstacles (such as lack of protocols or resource limitations) continue to exist [14,15]. This is crucial context: the educational module was created to address the cognitive and attitudinal factors that influence the prevention of SSI, but it did not address the organizational and structural obstacles found in Phase I, such as the lack of infection control committees and PPE shortages. These findings highlight that training interventions are required but insufficient alone; simultaneous systemic investments are essential to realize the full practice improvement potential of educated nurses [21,22].

8.5 Robustness of Statistics

Repeated measures ANOVA yielded large effect sizes ($\eta^2 = 0.68–0.71$ for Group × Time interactions), which are significantly larger than those found in similar SSI education research, such as Chen et al. (2022) ($\eta^2 = 0.42$) and Kebede et al. (2023) ($\eta^2 = 0.51$) [25,26]. Internal validity concerns related to maturity, history, and testing are effectively controlled for by the total lack of significant change in control group scores across all three categories. These findings offer compelling proof that the educational intervention, not unrelated factors, was responsible for the observed KAP gains.

8.6 KAP Gains' Sustainability

The Week 10 follow-up data reveal slight but predicted attrition in all three KAP domains within the intervention group, consistent with the well-established phenomena of knowledge loss without reinforcement [29]. Crucially, though, by Week 10, all dimensions remained significantly above baseline (Knowledge: 20.9 vs. 11.3 baseline; Attitude: 55.8 vs. 38.4; Practice: 46.5 vs. 29.2), indicating that the educational module had a lasting effect throughout at least a six-week follow-up period. Longer-term sustainability would require continual reinforcement mechanisms such as quarterly refresher seminars, peer mentorship programs, or digital learning platforms [30].

CONCLUSION

This study presents convincing, methodologically solid evidence that a structured, contextually informed educational module dramatically improved the knowledge, attitudes, and practices of surgical nurses about SSI prevention in Pakistan's tertiary care hospital setting. The educational module's content, pedagogy, and illustrative examples were directly shaped by qualitative findings through the use of an exploratory sequential mixed-methods design. This ensured that the intervention was not only theoretically grounded but also experientially resonant with the real-world professional realities of the participating nurses.

The improvements significant across all three KAP domains, supported by large sizes effect and confirmed through statistically difficult repeated measures ANOVA, the educational module establish as an effective, replicable and scalable, intervention nursing education for SSI prevention in LMICs. The sustainability of improvements at six-week follow-up, while subject to expected attrition, confirms the module's durable impact and provides confidence in its clinical relevance.

In the battle against avoidable surgical site infections, educational programs and institutional transformation are complimentary rather than antagonistic tactics. A thorough diagnostic framework that goes beyond SSI prevention to highlight systemic vulnerabilities in Pakistan's nursing infection control ecosystem is provided by the four qualitative themes of knowledge deficits, attitudinal complacency, resource limitations, and insufficient institutional support. These results have significant ramifications for national health policy, hospital accreditation requirements, and nursing education programs.

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