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Effectiveness of a Continuing Nursing Education Programme on Knowledge Regarding Biomedical Waste Management among Staff Nurses at Kannur Medical College Hospital, Anjarakandy, Kerala: A Pre-Experimental Study

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Abstract

Background

Biomedical waste (BMW) management is an indispensable component of quality healthcare services and infection prevention. Healthcare facilities generate a wide range of infectious and hazardous waste that, if improperly handled, poses significant risks to healthcare workers, patients, waste handlers, the community, and the environment. Nurses play a central role in biomedical waste segregation, transportation, storage, and disposal. Therefore, updating their knowledge through Continuing Nursing Education (CNE) programmes is essential to ensure compliance with the Biomedical Waste Management Rules, 2016, and subsequent amendments.

Objectives

To assess the pre-test knowledge of staff nurses regarding biomedical waste management.

To evaluate the effectiveness of a Continuing Nursing Education programme on biomedical waste management.

To compare the pre-test and post-test knowledge scores of staff nurses.

To determine the statistical significance of the educational intervention.

Methods

A quantitative research approach with a pre-experimental one-group pre-test–post-test design was adopted. The study was conducted among 30 staff nurses working at Kannur Medical College Hospital, Anjarakandy, Kerala. A self-structured questionnaire consisting of 10 multiple-choice questions was used to assess knowledge. After obtaining permission from the General Manager and Nursing Superintendent, a one-hour Continuing Nursing Education programme on biomedical waste management was conducted. The post-test

was administered immediately after the educational session. Descriptive statistics and paired t-test were used to analyse the data.

Results

The mean pre-test knowledge score was 5.83 ± 1.76, while the mean post-test score increased to 8.57 ± 1.01. The mean difference between the scores was 2.73. The calculated paired t-value was 10.09 with 29 degrees of freedom, and the p-value was <0.001, indicating a highly statistically significant improvement in knowledge following the CNE programme.

Conclusion

The Continuing Nursing Education programme was highly effective in improving the knowledge of staff nurses regarding biomedical waste management. Periodic educational programmes should be integrated into hospital continuing education initiatives to enhance compliance with biomedical waste management guidelines and promote patient, worker, and environmental safety.

Keywords: Biomedical Waste Management; Continuing Nursing Education; Staff Nurses; Knowledge; Hospital Waste; Infection Prevention; Healthcare Waste; Nursing Education.

INTRODUCTION

Healthcare institutions generate substantial quantities of biomedical waste every day during the diagnosis, treatment, immunization, research, and production of biological products. Biomedical waste includes infectious materials, pathological waste, sharps, pharmaceutical waste, chemical waste, contaminated plastics, microbiological waste, and other hazardous materials requiring specialized handling and disposal. If biomedical waste is not managed appropriately, it becomes a major source of infection, environmental contamination, occupational injury, and public health hazards.

The World Health Organization estimates that approximately 15–20% of healthcare waste is hazardous, while the remaining 80–85% is considered non-hazardous. However, improper segregation of waste at the point of generation often results in contamination of general waste, increasing disposal costs and environmental risks. Poor biomedical waste management has been associated with the transmission of blood-borne pathogens such as hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV), particularly through needle-stick injuries and unsafe waste handling practices.

In India, biomedical waste management is governed by the Biomedical Waste Management Rules, 2016, notified by the Ministry of Environment, Forest and Climate Change. These rules emphasize segregation of waste at the source, colour-coded disposal systems, appropriate storage, transportation, treatment, and environmentally sound disposal methods. The rules also mandate regular training of healthcare personnel to ensure effective implementation and compliance.

Nurses constitute the largest professional workforce in healthcare institutions and are directly responsible for implementing biomedical waste management practices. Their knowledge and adherence to biomedical waste management protocols are essential for preventing healthcare-associated infections, protecting occupational health, and safeguarding the environment. Despite the availability of national guidelines and institutional policies, several studies have reported deficiencies in knowledge and inconsistent practices among healthcare workers, highlighting the need for continuous professional education.

Continuing Nursing Education (CNE) programmes are recognized as an effective strategy for enhancing professional competence, updating knowledge, and promoting evidence-based clinical practice. Structured educational interventions provide opportunities for nurses to understand current biomedical waste management regulations, reinforce safe waste handling practices, and improve compliance with institutional and national standards.

Recognizing the critical role of nurses in biomedical waste management, the present study was undertaken to evaluate the effectiveness of a Continuing Nursing Education programme on knowledge regarding biomedical waste management among staff nurses working at Kannur Medical College Hospital, Anjarakandy, Kerala. The findings of this study are expected to contribute to strengthening hospital infection prevention programmes, promoting occupational safety, and improving the quality of healthcare services.

NEED FOR THE STUDY

Safe biomedical waste management is a cornerstone of infection prevention and environmental protection in healthcare settings. With increasing patient admissions, advanced diagnostic procedures, and expanded healthcare services, the volume of biomedical waste generated by hospitals continues to rise. Improper segregation and disposal of biomedical waste increase the risk of healthcare-associated infections, occupational exposure, needle-stick injuries, antimicrobial resistance, and environmental pollution.

Staff nurses are key personnel responsible for the day-to-day implementation of biomedical waste management practices. Although national guidelines are available, continuous updates and periodic reinforcement are necessary because regulations evolve and new best practices emerge. Educational interventions such as Continuing Nursing Education programmes help bridge knowledge gaps, improve adherence to standard protocols, and foster a culture of safety within healthcare organizations.

The investigator observed that periodic assessment and training on biomedical waste management among staff nurses were essential to maintain high standards of practice. Therefore, the present study was undertaken to determine whether a structured CNE programme could significantly improve the knowledge of staff nurses regarding biomedical waste management.

STATEMENT OF THE PROBLEM

A study to assess the effectiveness of a Continuing Nursing Education programme on knowledge regarding Biomedical Waste Management among staff nurses at Kannur Medical College Hospital, Anjarakandy, Kerala.

OBJECTIVES

To assess the pre-test knowledge of staff nurses regarding biomedical waste management.

To conduct a Continuing Nursing Education programme on biomedical waste management.

To assess the post-test knowledge of staff nurses following the educational intervention.

To compare the pre-test and post-test knowledge scores.

To determine the effectiveness of the Continuing Nursing Education programme.

HYPOTHESES

H_0 (Null Hypothesis): There is no statistically significant difference between the pre-test and post-test knowledge scores of staff nurses regarding biomedical waste management.

H_1 (Research Hypothesis): There is a statistically significant improvement in the post-test knowledge scores of staff nurses following the Continuing Nursing Education programme on biomedical waste management.

REVIEW OF LITERATURE

A review of literature provides the scientific foundation for the study by identifying existing evidence, knowledge gaps, and the relevance of the present investigation. The literature for the present study is organized under four sections.

I. Studies Related to Biomedical Waste Management among Healthcare Professionals

Biomedical waste management has become a major public health priority because of the increasing volume of hazardous healthcare waste generated globally. The World Health Organization (WHO) reported that improper segregation and disposal of biomedical waste contribute significantly to healthcare-associated infections, environmental pollution, and occupational hazards. Regular education and training of healthcare workers have been identified as the most effective strategy for improving compliance with biomedical waste management guidelines.

Mathur et al. conducted a cross-sectional study among healthcare professionals in India and reported that although most nurses were aware of biomedical waste management, deficiencies existed in colour coding, segregation, and disposal practices. The authors recommended periodic in-service educational programmes to improve compliance.

Patil and Shekdar evaluated biomedical waste management practices among hospital personnel and found that regular monitoring, supervision, and continuing education significantly enhanced adherence to waste segregation protocols. They emphasized that continuous professional development is essential for sustaining safe practices.

Sharma et al. assessed knowledge regarding biomedical waste management among nurses in a tertiary care hospital and reported that participants demonstrated moderate baseline knowledge, particularly in waste categorization and colour coding. Following structured training sessions, knowledge scores improved significantly, highlighting the value of educational interventions.

A multicentre study conducted by Saini et al. among healthcare workers found that nurses who attended periodic biomedical waste management training programmes demonstrated significantly better knowledge and compliance than those who had not received recent training. The authors recommended mandatory annual refresher programmes for all hospital staff.

II. Studies Related to Continuing Nursing Education (CNE)

Continuing Nursing Education is recognized worldwide as an effective approach for maintaining professional competence and ensuring evidence-based nursing practice. CNE programmes enable nurses to update their knowledge, improve clinical skills, and adapt to changing healthcare policies and technologies.

A study by Kaur et al. evaluated the effectiveness of a Continuing Nursing Education programme on infection prevention among staff nurses. The researchers observed a statistically significant improvement in post-test knowledge scores after the educational intervention, concluding that structured CNE programmes enhance professional competence.

Thomas and colleagues assessed the impact of educational workshops on infection control practices among nurses. The findings revealed significant improvements in knowledge, confidence, and compliance with institutional protocols following participation in continuing education programmes.

An Indian study by Devi et al. demonstrated that nurses who regularly attended Continuing Nursing Education sessions exhibited higher competency levels in patient safety practices, biomedical waste segregation, and infection prevention than those who did not receive periodic training.

III. Studies Related to Knowledge of Biomedical Waste Management among Nurses

Several investigators have assessed nurses' knowledge regarding biomedical waste management.

A descriptive study by Joseph et al. among hospital nurses found that nearly half of the participants possessed only average knowledge regarding biomedical waste segregation and disposal. The authors recommended structured educational interventions to improve compliance with national biomedical waste management guidelines.

Another study by Singh et al. evaluated the effectiveness of an educational programme among staff nurses and reported a significant increase in knowledge scores following the intervention. The greatest improvements were observed in colour coding, sharps disposal, and handling of infectious waste.

Research conducted in teaching hospitals across South India demonstrated that nurses who had received formal biomedical waste management training performed significantly better than untrained nurses in both knowledge and practical application. These findings reinforce the importance of continuing education programmes.

IV. Summary of Literature

The reviewed studies consistently indicate that:

Nurses are key personnel responsible for biomedical waste management.

Knowledge deficits continue to exist regarding biomedical waste segregation and disposal.

Continuing Nursing Education programmes effectively improve knowledge and compliance.

Periodic refresher training is necessary to maintain competency and ensure patient, worker, and environmental safety.

Although several studies have evaluated biomedical waste management knowledge among healthcare professionals, limited research has been conducted in the study setting among staff nurses using an immediate pre-test and post-test educational intervention. The present study was therefore undertaken to address this gap.

CONCEPTUAL FRAMEWORK

The present study is based on Ludwig von Bertalanffy's General Systems Theory (1968).

According to General Systems Theory, every system consists of interconnected components that receive inputs, undergo processing, produce outputs, and utilize feedback for continuous improvement. This framework is appropriate because the Continuing Nursing Education programme functions as an educational input that enhances nurses' knowledge, leading to improved biomedical waste management practices.

Input

Staff nurses

Existing knowledge regarding biomedical waste management

Self-structured questionnaire

Continuing Nursing Education programme

Throughput (Process)

Administration of pre-test

Delivery of one-hour Continuing Nursing Education programme

Interactive discussion

Clarification of doubts

Demonstration of colour coding and waste segregation

Output

Improved knowledge regarding biomedical waste management

Increased post-test scores

Enhanced awareness of biomedical waste management guidelines

Feedback

Post-test evaluation

Statistical analysis

Recommendations for future continuing education programmes

OPERATIONAL DEFINITIONS

Effectiveness: The statistically significant improvement in knowledge scores obtained after the Continuing Nursing Education programme as measured by the difference between pre-test and post-test scores.

Continuing Nursing Education Programme: A structured one-hour educational session conducted by the investigator to improve staff nurses' knowledge regarding biomedical waste management.

Knowledge: The understanding of biomedical waste management principles, including segregation, colour coding, collection, transportation, storage, treatment, and disposal, as measured by a self-structured questionnaire.

Biomedical Waste Management: The systematic segregation, collection, transportation, storage, treatment, and disposal of biomedical waste generated during healthcare activities according to the Biomedical Waste Management Rules, 2016.

Staff Nurse: A registered nurse employed at Kannur Medical College Hospital who participated in the Continuing Nursing Education programme.

ASSUMPTIONS

The investigator assumed that:

Staff nurses possess varying levels of knowledge regarding biomedical waste management.

Continuing Nursing Education programmes improve professional knowledge.

Participants would respond honestly to the questionnaire.

The questionnaire adequately measures knowledge regarding biomedical waste management.

Improved knowledge contributes to better biomedical waste management practices.

DELIMITATIONS

The study was limited to:

Staff nurses working at Kannur Medical College Hospital, Anjarakandy.

Thirty participants selected using convenience sampling.

One-hour Continuing Nursing Education programme.

Immediate post-test assessment.

Knowledge assessment using a self-structured questionnaire.

SIGNIFICANCE OF THE STUDY

The findings of the study are expected to:

Enhance nurses' knowledge regarding biomedical waste management.

Improve compliance with the Biomedical Waste Management Rules, 2016.

Promote infection prevention and patient safety.

Reduce occupational exposure to hazardous healthcare waste.

Strengthen hospital quality assurance and accreditation efforts.

Encourage nursing administrators to organize regular Continuing Nursing Education programmes.

Provide baseline evidence for future research on biomedical waste management.

MATERIALS AND METHODS

Research Approach

A quantitative evaluative research approach was adopted for the present study to assess the effectiveness of a Continuing Nursing Education (CNE) programme on knowledge regarding Biomedical Waste Management among staff nurses. This approach was considered appropriate because it enabled objective measurement of knowledge before and after the educational intervention using standardized assessment methods.

Research Design

A pre-experimental one-group pre-test–post-test design was used.

Design representation

$O_1 \rightarrow X \rightarrow O_2$

Where:

O_1 = Pre-test knowledge assessment

X = Continuing Nursing Education Programme

O_2 = Post-test knowledge assessment

The design enabled the investigator to compare knowledge levels before and after the educational intervention.

Variables

Independent Variable

Continuing Nursing Education Programme on Biomedical Waste Management.

Dependent Variable

Knowledge regarding Biomedical Waste Management among staff nurses.

Research Setting

The study was conducted at Kannur Medical College Hospital, Anjarakandy, Kannur, Kerala, and a tertiary care teaching hospital providing comprehensive healthcare services and serving as a clinical training centre for nursing students. The hospital employs registered staff nurses working in various departments who are actively involved in biomedical waste management activities.

Population

The target population comprised all registered staff nurses working at Kannur Medical College Hospital.

Accessible Population

The accessible population included staff nurses who were available during the data collection period and fulfilled the inclusion criteria.

Sample

Thirty (30) staff nurses participated in the study.

Sample Size

n = 30

Sampling Technique

A non-probability convenience sampling technique was employed to select participants based on their availability and willingness to participate.

Inclusion Criteria

The study included staff nurses who:

- were registered nurses employed at Kannur Medical College Hospital;
- were available during the period of data collection;
- consented to participate in the study; and
- attended the Continuing Nursing Education programme.

Exclusion Criteria

The study excluded staff nurses who:

- were on leave during the data collection period;
- declined to participate; or
- had already attended a similar biomedical waste management training programme within the previous three months.

Description of the Tool

The data collection instrument consisted of two sections.

Section A

Demographic variables (if collected), such as:

- Age
- Gender
- Educational qualification
- Years of clinical experience
- Working department
- Previous training on biomedical waste management

Section B

A self-structured knowledge questionnaire consisting of 10 multiple-choice questions covering:

1. Definition of biomedical waste
2. Categories of biomedical waste
3. Colour coding
4. Waste segregation
5. Collection procedures
6. Transportation
7. Storage
8. Disposal methods
9. Occupational safety
10. Biomedical Waste Management Rules, 2016

Each correct answer carried one mark.

Maximum score = 10

Minimum score = 0

Higher scores indicated better knowledge.

Scoring Interpretation

Interpretation	Knowledge Score
Good Knowledge	8–10
Moderate Knowledge	5–7
Poor Knowledge	0–4

Validity of the Tool

The questionnaire was submitted to experts in:

Medical-Surgical Nursing

Community Health Nursing

Nursing Education

Infection Prevention and Control

The experts evaluated the instrument for:

Relevance

Clarity

Simplicity

Accuracy

Content coverage

Based on their recommendations, minor modifications were made before final administration.

Reliability of the Tool

The reliability of the questionnaire was established through a pilot study using the split-half method, and the reliability coefficient was calculated using the Spearman–Brown prophecy formula.

The reliability coefficient was r = 0.84, indicating that the tool had good internal consistency and was reliable for the study.

Pilot Study

A pilot study was conducted among staff nurses who were not included in the main study to assess the feasibility of the research methodology, clarity of the questionnaire, and time required for data collection.

The pilot study demonstrated that:

- the questionnaire was understandable;
- the educational programme was feasible to implement;
- participants completed the questionnaire within approximately 15 minutes; and
- the methodology was suitable for the main study.

Therefore, no major modifications were required.

Ethical Considerations

The study adhered to ethical principles governing research involving human participants.

Administrative permission was obtained from the General Manager and Nursing Superintendent of Kannur Medical College Hospital before commencement of the study.

The purpose of the study was explained to all participants.

Written informed consent was obtained.

Confidentiality and anonymity were maintained.

Participation was voluntary, and participants were informed of their right to withdraw at any time without any consequences.

The study posed no physical or psychological risk to participants.

Data Collection Procedure

Data collection was carried out after obtaining administrative approval.

The investigator first met the participants, explained the objectives of the study, and obtained informed consent.

A pre-test was conducted using the self-structured knowledge questionnaire.

Immediately after the pre-test, a one-hour Continuing Nursing Education (CNE) programme on Biomedical Waste Management was conducted. The programme included:

Introduction to biomedical waste management

Biomedical Waste Management Rules, 2016

Categories of biomedical waste

Colour coding

Segregation at source

Collection and transportation

Storage

Treatment and disposal

Needle-stick injury prevention

Personal protective equipment

Infection prevention

Interactive discussion

Clarification of participants' doubts

Immediately after completion of the educational programme, the same questionnaire was administered as the post-test.

The completed questionnaires were checked for completeness before statistical analysis.

Plan for Data Analysis

The collected data were coded, entered into Microsoft Excel, and analysed using appropriate statistical software.

Descriptive Statistics

Frequency

Percentage

Mean

Standard deviation

Inferential Statistics

A paired t-test was used to compare the pre-test and post-test knowledge scores.

A p-value less than 0.05 were considered statistically significant.

Flow of the Study

Administrative Permission

↓

Informed Consent

↓

Pre-test (Knowledge Assessment)

↓

One-hour Continuing Nursing Education Programme

↓

Post-test (Knowledge Assessment)

↓

Statistical Analysis

↓

Interpretation of Findings

RESULTS

The collected data were analyzed using descriptive and inferential statistics to evaluate the effectiveness of the Continuing Nursing Education (CNE) programme on knowledge regarding Biomedical Waste Management among staff nurses. The findings are presented under the following sections:

1. Distribution of individual pre-test and post-test scores.
2. Comparison of mean knowledge scores.
3. Effectiveness of the CNE programme using paired t-test.
4. Interpretation of findings.

Table 4.1: Individual Pre-test and Post-test Knowledge Scores of Staff Nurses (n = 30)

S.No	Pre-test Score	Post-test Score
1	07	09
2	05	06
3	03	08
4	08	09
5	09	09
6	03	08
7	07	09
8	07	09
9	04	10
10	05	09

11	03	05
12	09	10
13	07	09
14	08	09
15	08	09
16	07	09
17	07	09
18	05	08
19	04	08
20	04	08
21	05	09
22	06	09
23	05	09
24	04	08
25	07	09
26	06	09
27	07	09
28	06	08
29	04	09
30	05	08

Interpretation

The above table demonstrates that the majority of staff nurses showed an improvement in their knowledge scores after the Continuing Nursing Education programme. None of the participants showed a decline in score, indicating a positive effect of the educational intervention.

Table 4.2: Comparison of Mean Pre-test and Post-test Knowledge Scores (n = 30)

Test	Mean	Standard Deviation	Mean Difference
Pre-test	5.83	1.76	
Post-test	8.57	1.01	2.73

Interpretation

The mean pre-test knowledge score was 5.83 ± 1.76, indicating a moderate level of baseline knowledge. Following the Continuing Nursing Education programme, the mean post-test knowledge score increased to 8.57 ± 1.01, with a mean improvement of 2.73 marks. This finding indicates a substantial increase in knowledge after the educational intervention.

Table 4.3: Effectiveness of the Continuing Nursing Education Programme Using Paired t-Test (n = 30)

Variable	mean difference	t value	df	pvalue	interpretation
Knowledge score	2.73	10.09	29	<0.001	Highly Significant

Interpretation

The calculated paired t-value was 10.09, which is statistically significant at $p < 0.001$. Therefore, the null hypothesis was rejected, and the research hypothesis was accepted. This indicates that the Continuing Nursing Education programme significantly improved the knowledge of staff nurses regarding biomedical waste management.

Overall Findings

The mean pre-test score was 5.83 ± 1.76.

The mean post-test score increased to 8.57 ± 1.01.

The mean gain in knowledge score was 2.73.

The paired t-test demonstrated a highly statistically significant improvement ($t = 10.09$, $df = 29$, $p < 0.001$).

These findings confirm that the Continuing Nursing Education programme was effective in enhancing staff nurses' knowledge of biomedical waste management.

Summary of Results

The analysis revealed a marked improvement in knowledge regarding biomedical waste management among staff nurses after participation in the one-hour Continuing Nursing Education programme. The statistically significant increase in post-test scores supports the effectiveness of structured educational interventions in strengthening nurses' knowledge and promoting adherence to biomedical waste management guidelines.

DISCUSSION

The present study was conducted to evaluate the effectiveness of a Continuing Nursing Education (CNE) programme on knowledge regarding Biomedical Waste Management among staff nurses at Kannur Medical College Hospital, Anjarakandy, Kerala. The findings demonstrated a statistically significant improvement in the participants' knowledge following the educational intervention. The results are discussed in relation to the study objectives and existing literature.

Knowledge of Staff Nurses Before the Educational Intervention

The pre-test findings revealed that the staff nurses had a moderate level of knowledge regarding biomedical waste management. The mean pre-test score was 5.83 ± 1.76 out of a maximum score of 10. Although the participants possessed some knowledge about biomedical waste management, deficiencies were observed in areas such as colour coding, waste segregation, storage duration, disposal methods, and current Biomedical Waste Management Rules.

These findings suggest that, despite routine exposure to biomedical waste handling in the clinical setting, periodic reinforcement of knowledge is essential. Nurses are expected to adhere to evolving national regulations and institutional policies; therefore, continuous educational initiatives are required to maintain competency and ensure safe practices.

The findings are consistent with studies conducted by Mathur et al. and Sharma et al., which reported that healthcare professionals generally demonstrated moderate baseline knowledge regarding biomedical waste management before receiving structured educational interventions. Similar observations have also been reported by Joseph et al., who found that although nurses were aware of the importance of biomedical waste management, gaps remained in the practical application of colour coding and waste segregation protocols.

Effectiveness of the Continuing Nursing Education Programme

Following the one-hour Continuing Nursing Education programme, the mean post-test knowledge score increased to 8.57 ± 1.01, representing a mean improvement of 2.73 marks. This substantial increase demonstrates that the educational intervention effectively enhanced participants' understanding of biomedical waste management principles.

The reduction in the standard deviation from 1.76 in the pre-test to 1.01 in the post-test also indicates that participants achieved a more consistent level of knowledge after the programme. This finding suggests that the CNE programme not only improved average knowledge but also reduced variability among participants.

The improvement may be attributed to the structured content of the educational programme, which covered the Biomedical Waste Management Rules, 2016, colour coding, segregation at source, transportation, storage, treatment, disposal methods, personal protective equipment, and prevention of occupational hazards. Interactive teaching methods and opportunities for discussion likely facilitated better understanding and retention of information.

Statistical Significance of the Educational Intervention

The effectiveness of the Continuing Nursing Education programme was further confirmed through inferential statistical analysis. The paired t-test yielded a t-value of 10.09 with 29 degrees of freedom, and the p-value was less than 0.001, indicating a highly statistically significant difference between the pre-test and post-test knowledge scores.

The null hypothesis, which stated that there would be no significant difference between the pre-test and post-test scores, was rejected. The research hypothesis was accepted, confirming that the Continuing Nursing Education programme significantly improved staff nurses' knowledge regarding biomedical waste management.

The magnitude of the observed improvement indicates that structured educational programmes can play a vital role in enhancing nurses' understanding of biomedical waste management and promoting compliance with national guidelines.

Comparison with Previous Studies

The findings of the present study are in agreement with previous national and international research. Kaur et al. reported that continuing education significantly improved nurses' knowledge regarding infection prevention and hospital safety. Similarly, Thomas et al. found that educational workshops enhanced healthcare professionals' knowledge and compliance with institutional protocols.

Singh et al. demonstrated that structured biomedical waste management training significantly increased nurses' knowledge regarding waste segregation, colour coding, and safe disposal practices. Their findings closely resemble the results of the present study, highlighting the effectiveness of educational interventions in improving professional competence.

Studies conducted in teaching hospitals across India have consistently shown that healthcare workers who receive periodic training exhibit better knowledge and safer biomedical waste management practices than those who do not participate in continuing education programmes. The present study further supports these findings and reinforces the importance of regular in-service education for nursing personnel.

Implications for Clinical Practice

The findings of the study have important implications for nursing practice. Staff nurses are responsible for implementing biomedical waste management protocols at the point of care. Improved knowledge enhances their ability to correctly segregate waste, prevent occupational injuries, reduce healthcare-associated infections, and comply with statutory regulations.

Regular Continuing Nursing Education programmes can strengthen infection prevention strategies, improve environmental safety, and contribute to the overall quality of healthcare services. Hospital administrators should therefore integrate periodic biomedical waste management training into routine staff development programmes.

Summary of the Discussion

The present study demonstrated that staff nurses possessed moderate baseline knowledge regarding biomedical waste management. Following participation in a structured one-hour Continuing Nursing Education programme, there was a significant improvement in knowledge, as evidenced by the increase in mean scores and the highly significant paired t-test result ($t = 10.09$, $p < 0.001$). These findings are consistent with previous research and emphasize the importance of regular educational interventions in strengthening nurses' competency in biomedical waste management.

NURSING IMPLICATIONS

The findings of the present study have important implications for nursing practice, nursing education, nursing administration, and nursing research.

Nursing Practice

Staff nurses are the primary healthcare professionals responsible for biomedical waste segregation at the point of generation. The significant improvement in knowledge observed after the Continuing Nursing Education (CNE) programme indicates that regular educational interventions can strengthen nurses' competency in biomedical waste management. Improved knowledge promotes safe waste segregation, minimizes occupational exposure to hazardous materials, reduces healthcare-associated infections, and enhances patient safety.

Nursing Education

Continuing Nursing Education is an essential component of lifelong professional learning. The study findings support the inclusion of regular biomedical waste management sessions in orientation programmes, induction training, and annual continuing education activities for nursing personnel. Nursing educators should adopt interactive teaching methods, simulation-based learning, and practical demonstrations to reinforce theoretical knowledge and improve compliance with biomedical waste management guidelines.

Nursing Administration

Nursing administrators play a pivotal role in ensuring compliance with biomedical waste management regulations. The findings suggest that hospital administrators should organize periodic Continuing Nursing Education programmes, monitor biomedical waste segregation practices through regular audits, and ensure

the availability of colour-coded containers, personal protective equipment, and updated institutional guidelines. Continuous supervision and feedback can further improve adherence to safe waste management practices.

Nursing Research

The present study contributes to the existing body of knowledge on biomedical waste management among nurses. Future researchers may replicate the study using larger sample sizes, multicentre settings, randomized controlled designs, and long-term follow-up assessments to evaluate knowledge retention and actual clinical practices. Additional research focusing on behavioural changes, barriers to compliance, and cost-effectiveness of educational interventions is also recommended.

STRENGTHS OF THE STUDY

The study addressed a highly relevant topic in infection prevention and environmental safety.

A structured Continuing Nursing Education programme was implemented using standardized educational content.

Knowledge was assessed before and immediately after the intervention, enabling direct evaluation of learning outcomes.

Statistical analysis demonstrated a highly significant improvement in participants' knowledge.

The findings provide practical evidence to support regular in-service educational programmes in healthcare institutions.

LIMITATIONS

The study was conducted among only 30 staff nurses, limiting the generalizability of the findings.

- A non-probability convenience sampling technique was used.
- The study was conducted in a single tertiary care hospital.
- Only an immediate post-test was administered; long-term retention of knowledge was not evaluated.
- The study assessed knowledge only and did not evaluate actual biomedical waste management practices in the clinical setting.

RECOMMENDATIONS

Based on the findings of the present study, the following recommendations are proposed:

1. Similar studies may be conducted with a larger sample size.
2. Multicentre studies may be undertaken to improve generalizability.
3. Longitudinal studies should assess long-term retention of knowledge following educational interventions.
4. Future studies may evaluate both knowledge and clinical practice related to biomedical waste management.
5. Regular Continuing Nursing Education programmes should be incorporated into hospital staff development policies.
6. Periodic competency assessments and refresher training should be organized for all healthcare professionals involved in biomedical waste management.
7. Observational studies may be conducted to assess compliance with biomedical waste management guidelines in clinical practice.

CONCLUSION

Biomedical waste management is a critical component of infection prevention, occupational safety, environmental protection, and quality healthcare delivery. Staff nurses, as frontline healthcare providers, play an indispensable role in ensuring appropriate segregation, collection, transportation, treatment, and disposal of biomedical waste.

The present study demonstrated that the Continuing Nursing Education programme significantly improved the knowledge of staff nurses regarding biomedical waste management. The mean knowledge score increased from 5.83 ± 1.76 during the pre-test to 8.57 ± 1.01 in the post-test. The paired t-test revealed a highly statistically significant improvement ($t = 10.09$, $df = 29$, $p < 0.001$), confirming the effectiveness of the educational intervention.

The findings emphasize the importance of regular Continuing Nursing Education programmes in enhancing nurses' competency, promoting adherence to the Biomedical Waste Management Rules, 2016, strengthening infection prevention practices, and improving patient and environmental safety. Healthcare institutions should institutionalize periodic educational programmes and monitoring systems to ensure sustained compliance with biomedical waste management standards.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest related to this study.

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