

Assessing the Influence of Specialized Nursing Education on Nurses' Performance and Patient Satisfaction in Bone Marrow Transplant Units

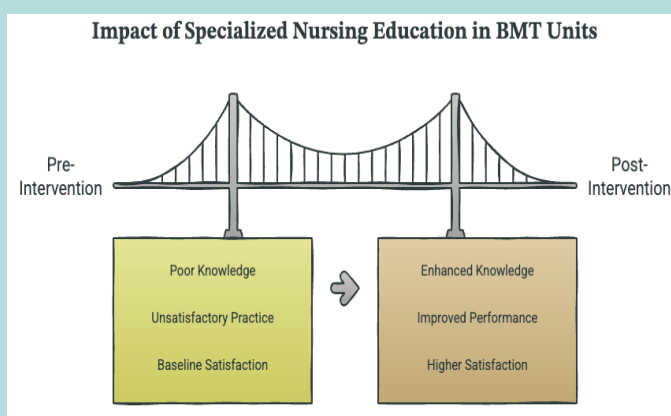
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Abstract: In bone marrow transplant (BMT) units, many nurses deliver this care without having received structured, transplant-specific training. **Objective:** This study aimed to evaluate the effect of specialized nurse education in enhancing nurses' performance regarding bone marrow transplantation care, as well as patients' satisfaction. **Methodology:** A quasi-experimental study employed a one-group pretest–posttest design at two specialized bone marrow transplant units: the Sheikh Zayed Specialized Hospital and the Oncology Centre at Mansoura University. A total sample of 98 nurses was evaluated for knowledge, practical skills, and attitude using validated instruments. The intervention consisted of four structured sessions supported by an Arabic-colored booklet. Additionally, 54 patients were recruited into two matched groups (n=27 each) to compare satisfaction before (Group A) and after (Group B) the nursing intervention. Outcomes were assessed at baseline, immediately post-intervention, and 3 months later. **Key findings:** Baseline assessments revealed predominantly unsatisfactory practice (88.8%) and poor knowledge (60.6%). Repeated measure ANOVA confirmed significant improvements in knowledge, attitude, and practice across all assessment intervals ($p < 0.001$), with gain sustained at follow-up. Knowledge positively correlated with attitude and practice throughout the study. Furthermore, Group B reported significantly higher satisfaction scores across all subscales compared to Group A ($p < 0.001$). **Conclusion:** The transplant-specialized nursing education effectively addressed improvement in nurses' performance and contributed to positive patient satisfaction.

Recommendation Routinely integrating structured educational intervention into BMT unit training and orientation is recommended.



Keywords: Hematopoietic stem cell transplantation; nursing education; nurses' knowledge; attitude; patient satisfaction; quality of health care; nursing performance

Introduction

Bone marrow transplantation, also referred to as haematopoietic stem cell transplantation (HSCT), is the procedure of providing functional stem cells to individuals whose own bone marrow is damaged or insufficient. HSCT has become a high-value therapy for numerous malignant and selected non-malignant disorders, with global activity more than doubling over the past decade to exceed 90,000 annual procedures (1). This sustained expansion is evident across Europe, in the United States, and in the Middle East, where increasing transplant rates in specialized tertiary centers highlight the critical necessity for high-standard nursing performance (2–4).

In this context, HSCT nurses have extensive technical and psychosocial responsibilities. They provide central-line care, chemotherapy support, transfusions, mucositis management,

infection control, patient education, and emotional support (5). Patients require substantial instruction regarding oral care, infection warning signs, protective measures, and early symptoms of graft-versus-host disease (GVHD), making structured nurse-led education essential (6).

For HSCT nurses, the knowledge domain normally covers transplant indications and types, conditioning-regimen toxicities, expected timelines for nadir and engraftment, early signs of sepsis, basic GVHD manifestations, and protective-isolation principles. Practice entails acting on this knowledge in the correct sequence and documenting it, and attitude is about consistency, vigilance, and patient-centered communication. Studies on transplantation nurse preparation have repeatedly shown that when nurses receive a transplant-specific education

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package, their knowledge scores increase and their observed practice becomes more complete, especially regarding infection control and oral-mucositis care (7).

Specialized continued education is crucial for ensuring safety and competence in bone marrow transplant nursing, given the complexity of treatment protocols, the risks associated with medications, and the delicate health conditions of patients (8,9). Ongoing training keeps nurses' knowledge up-to-date with the latest evidence-based practices, reducing procedural errors and improving clinical outcomes (10,11). The evolving nature of bone marrow transplant medicine necessitates continuous learning to keep pace with advancements in treatment protocols, prevent complications such as graft-versus-host disease, and utilize modern supportive therapies (8). Continuing education plays a vital role in developing critical thinking and clinical judgment skills, enabling nurses to manage sudden deterioration in patient conditions, detect subtle changes, and initiate timely, life-saving interventions (12).

Previous research consistently demonstrates that structured, transplant-focused training significantly improves nurses' knowledge and practice, often leading to enhanced patient satisfaction. Studies from various international settings, including those conducted in non-specialized hospitals, suggest that even short, targeted educational programs can effectively bridge the knowledge gap in BMT care. The findings indicate that nursing competency is primarily knowledge-dependent, suggesting that the primary barrier to high-quality care is a lack of specialized education rather than limitations in institutional infrastructure (13,14).

Evidence from advanced clinical settings further demonstrates the transformative power of specialized education. For instance, a targeted training package incorporating simulation and policy support has successfully enabled oncology nurses to safely perform high-risk procedures, such as the administration of cryopreserved haematopoietic stem cells, which were previously reserved for physicians. When integrated with regional findings from Egypt, India, and Iraq, these data suggest a consistent mechanism: at the foundational level, education addresses baseline knowledge deficits, while at the advanced level, it facilitates safe task shifting of complex procedures to nursing staff (15).

Consistent with global trends, regional evidence from Iraq and Egypt reinforces the efficacy of structured educational interventions in specialized nursing care. Studies conducted in diverse university-linked environments demonstrate that targeted training programs—covering pre-transplant preparation, infection control, and complication management—consistently bridge baseline knowledge and practice deficits (15,16). For example, evidence-based guidelines used in Tanta and Mansoura led to big changes from poor performance to high levels of clinical competency, and these improvements were often kept up through follow-up assessments. Collectively, these findings suggest that specialized education not only enhances nursing performance but also correlates with improved clinical outcomes and long-term knowledge retention (17,18).

Not all research teams have used the classic classroom format in their interventions. Ahmed (2023) built instructional guidelines for nurses caring for BMT recipients and delivered them through an in-service, social-media-assisted mode. Even with this lighter delivery, the study reported a statistically significant improvement in nurses' performance at post-test with $p < 0.001$. This suggests that the relevance of the content

provided matters much more than whether the material is shared in a lecture hall or through controlled online channels (19). A related Egyptian study on 'designed educational guidelines' for nurses caring for children undergoing BMT showed the same baseline weakness in nurses' knowledge and practice and the same strong post-intervention gains (20).

The practical challenges of randomization within specialized units often necessitate the prevalence of quasi-experimental designs in BMT nursing education studies. Such studies consistently report substantial post-intervention enhancements in knowledge and practice, often shifting from low baseline levels to high post-test rates. Moreover, several investigations have identified a reliable positive correlation between nurses' knowledge gains and their subsequent clinical performance (17,21).

In terms of patient satisfaction, this metric reflects the degree to which nursing care meets patient expectations and serves as a vital indicator of healthcare quality and service performance. Consequently, evaluating satisfaction is an essential approach to identifying patient needs and facilitating improvements in the overall provision of healthcare services (22).

Despite the documented efficacy of specialized training internationally and regionally, a significant evidence gap remains within the Egyptian healthcare context. While BMT units are expanding, standardized, unit-specific educational guidelines are not yet routinely integrated into nursing orientation or continuing professional development programs. Furthermore, much of the existing local research has focused primarily on nursing knowledge and practice score, with little investigation into how these improvements influence patient satisfaction outcomes.

Despite growing evidence that structured educational interventions improve transplant nurses' performance, few studies in Egypt have simultaneously examined nurses' knowledge, attitude, practice, and patient satisfaction in BMT units. Therefore, this study aimed to evaluate the effect of a specialized nursing education program on nurses' performance and patient satisfaction in two Egyptian bone marrow transplant settings.

Materials and Methods

A quasi-experimental one-group pretest–posttest follow-up design was used for nurses, with a matched comparison of patient satisfaction before and after the intervention. The study was conducted in two sites: the Oncology Center at Mansoura University, which comprises a total of ten beds across the eleventh and ninth floors, and the dedicated stem cell transplantation unit operates with a mandated nurse-to-patient ratio of 2:1 per shift, and Sheikh Zayed Specialized Hospital contains 5 beds for BMT patients.

Sample

A convenience sample of all eligible nurses working in the selected BMT units was recruited. Eligibility criteria included at least one year of BMT experience. Of 101 nurses screened, 99 were eligible and consented to participate; one nurse was lost during follow-up, resulting in a final sample of 98 nurses.

For patients: A total of 54 adult post-transplant patients were sequentially recruited and divided into two matched groups of 27 each. Group A received care before nurses' training, whereas Group B received care after the intervention.

Tools

Data collection was facilitated through three validated tools.

1. **Structured Interview Questionnaire:** This tool was developed by the researcher following an extensive review of literature. It was formulated in clear, accessible Arabic and comprised three sections:

Part I: Demographic characteristics of nurses collected essential background data, including age, gender, education level, experience, and prior BMT training.

Part II: Nurses' Knowledge Assessment Questionnaire. It contains 30 questions evaluating the understanding of BMT patient care across various domains (e.g., stem cell concepts, infection control, and nursing interventions). Knowledge was scored dichotomously, converted to percentages, and categorized as poor (<60%), fair (60–75%), good (>75%).

Part III: Nurses' Attitude Scale. This scale consisted of 15 statements based on (23) to assess nurses' attitudes toward stem cell therapy and its applications. Responses were recorded on a 4-point Likert scale ranging from strongly agree (4) to strongly disagree (1). Total scores ranged from 15 to 60, with attitudes classified as positive if $\geq 60\%$ and negative if $< 60\%$.

2. **Nurses' Practice Observational Checklist:** The researcher designed a checklist to assess nurses' practical performance across pre-, intra-, and post-transplant phases. Practices were scored: 2 for correct practice, 1 for needing more practice, or 0 for not done. Total scores were classified as satisfactory ($\geq 80\%$) or unsatisfactory ($< 80\%$).
3. **Patient Satisfaction Instrument (PSI)** Standard 25-item tool adopted from Hinshaw and Atwood (1982) (24), it is a self-reported measure designed to evaluate patients' satisfaction with nursing care. The PSI is classified into three subscales: technical–professional care (7 items), trust (11 items), and patient education (7 items). A five-point Likert scale was utilized for responses (5= strongly agree, 4= agree, 3= uncertain, 2= disagree, 1= strongly disagree), yielding a total score range of 25–125. Satisfaction levels were delineated by the following cut-off point: dissatisfaction (< 78), moderate satisfaction (78–104), or complete satisfaction (> 104).

Content validity was assessed by a panel of five experts in oncology and nursing education. Reliability testing showed acceptable internal consistency for all instruments (Cronbach's alpha was 0.80 to 0.87 and 0.85 for tool 1, tool 2, and tool 3, respectively). A pilot study was conducted on 10 nurses (approximately 10% of the estimated sample) to assess clarity, feasibility, and time required. Based on pilot feedback, minor wording changes were made. Pilot participants were excluded from the final sample.

Data Collection

After obtaining ethical approval, data collection initially began with explaining the purpose of the study to all participants in their clinical setting. And the pre-assessment was performed through the three tools.

The educational intervention consisted of four structured sessions, each lasting approximately 60 minutes and delivered over two weeks to groups of 6–8 nurses. Sessions covered transplant basics, patient preparation, post-transplant care,

complication monitoring, psychosocial support, and patient/family education. Demonstration of relevant clinical skills was included. An Arabic-language illustrated booklet and visual aids were used to support learning.

Following the intervention, an immediate post-assessment and a three-month follow-up evaluation were conducted. To minimize potential bias, one researcher delivered the educational sessions while another independently assessed the outcomes.

Outcome assessment: The primary outcome measurements included :

1. Nurses' Knowledge: assessed using the Nurses' knowledge Assessment Questionnaire
2. Nurses' Attitude: evaluated via Nurses' Attitude scale
3. Nurses' Practice: Measured using the Nurses' Practice Observational Checklist.
4. Patient satisfaction: Measured using the Patient Satisfaction Instrument from the patient

Patient satisfaction was assessed at baseline to establish a pre-intervention benchmark and again at a three-month follow-up to evaluate the impact of the nursing training program on perceived care quality. The entire data collection period spanned five months.

Ethical Consideration

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee, Faculty of Nursing, Mansoura University (No. 446). Written informed consent was obtained from all participating nurses and patients. Participation was voluntary, anonymity was preserved, and participants were informed of their right to withdraw at any time without penalty.

Statistical Analysis

Data were analyzed using SPSS version 26. Descriptive statistics were presented as frequency, percentage, mean, and standard deviation. Normality was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Repeated-measures ANOVA was used to compare mean scores across pre-, immediate post-, and three-month follow-up assessments. Independent t-tests were used to compare patient satisfaction between groups. Pearson and point-biserial correlations were used as appropriate. A p value < 0.05 was considered statistically significant.

Results and Discussion

Table 1 shows that the 98 participating nurses were predominantly young adults and mostly female. The largest age group (41.8%) was 25–<30 years, with a mean age of 27.54 ± 5.22 years. Regarding education, nearly half held a Bachelor of Nursing (49.0%), and almost half (46.9%) had 5–10 years of experience. Most nurses (90.8%) were staff nurses. The majority (64.3%) had never attended training in BMT care.

Table 1. Percentage distribution of the studied nurses according to their demographic data ($n = 98$).

Demographic data	No	%
Age		
20–<25 years	35	35.7
25–<30 years	41	41.8
30 years and more	22	22.4
Mean $\pm$ SD	27.54 $\pm$ 5.22	
Min–Max	20–40	

Demographic data	No	%
Sex		
Male	36	36.7
Female	62	63.3
Level of education		
Diploma of Nursing	39	39.8
Bachelor of Nursing	48	49.0
Postgraduate and higher	11	11.2
Years of experience		
<2 years	6	6.1
2–<5 years	37	37.8
5–10 years	46	46.9
>10 years	9	9.2
Position		
Staff nurse	89	90.8
Head nurse	9	9.2
Attended training courses regarding BMT		
Yes	35	35.7
No	63	64.3
Number of attended training courses (n = 35)		
One	24	68.6
Two	8	22.8
Three	3	8.6

Nurses' knowledge regarding BMT care improved markedly after implementation of the educational guidelines (Table 2). At baseline, the majority of participants (60.6%) had a poor knowledge level (mean 12.49 ± 7.61). Immediately after the education, a substantial shift was observed, with 86.9% of nurses achieving a good knowledge level and a significant increase in the mean score to 28.33 ± 2.68 ($p < 0.001$).

At the three-month follow-up, a slight decline was observed, with 10.1% classified as having poor knowledge; however, most nurses (74.7%) remained in the good knowledge category. The mean was 25.20 ± 5.90 . Repeated measures ANOVA indicated a significant difference over time ($F = 120.575$, $p < 0.001$).

Table 2. Level of total nurses' knowledge regarding care of patients undergoing bone marrow transplantation in pre-, immediate post-, and follow-up assessments (n = 98)

Knowledge level	No	%
Pre-education		
Poor	60	60.6
Fair	27	27.3
Good	12	12.1
Mean ± SD	12.49 ± 7.61	
Immediately after education		
Poor	0	0.0
Fair	13	13.1
Good	86	86.9
Mean ± SD	28.33 ± 2.68	
t-test (P1)	19.548 (<0.001)**	
Three-month post education (Follow-up)		
Poor	10	10.1
Fair	15	15.2
Good	74	74.7

Knowledge level	No	%
Mean $\pm$ SD	25.20 ± 5.90	
t-test (P2)	$12.200 (<0.001)^{**}$	
F (P value)	$120.575 (<0.001)^{**}$	

*P1 = pre vs. immediate; P2 = pre vs. 3 months; F = repeated-measures ANOVA; *significant at $p \leq 0.01$.

Nurses' practice showed a parallel improvement. At baseline, 88.8% had an unsatisfactory practice level. Immediately after training, 87.8% demonstrated a satisfactory practice level. At follow-up, most nurses still showed a satisfactory practice level (83.7%). Repeated measures ANOVA confirmed significant improvement ($p < 0.001$) as shown in Table 3.

Nurses' attitudes toward stem cell therapy also improved significantly. At baseline, 51.0% had positive attitudes, increasing to 95.9% immediately after the guidelines. At follow-up, the proportion remained high (91.8%) with a positive attitude. Repeated measures ANOVA confirmed significant improvement ($p < 0.001$). Mean attitude scores increased from 32.91 ± 12.21 pre-education to 45.76 ± 10.79 immediately after ($t = 19.868$, $p < 0.001$) and remained high at follow-up (44.16 ± 12.07). The overall difference was significant ($p < 0.001$) (Table 4).

Table 3. Level of total nurses' practice level regarding care of patients undergoing bone marrow transplantation pre, post, and three months after the implementation of educational intervention.

Practice level	No	%
Pre- education		
Unsatisfactory	87	88.8
Satisfactory	11	11.2
Mean ± SD	21.42±7.52	
Immediately after education		
Unsatisfactory	12	12.2
Satisfactory	86	87.8
Mean ± SD	33.83±6.18	
t-test (P1)	22.872 (<0.001) **	
Three-month post education (Follow-up)		
Unsatisfactory	16	16.3
Satisfactory	82	83.7
Mean ± SD	33.03±7.16	
t-test (P2)	22.097 (<0.001) **	
F (P value)	186.816 (<0.001) **	

*P1 = pre vs. immediate; P2 = pre vs. 3 months; F = repeated-measures ANOVA; *significant at $p \leq 0.01$.

Table 4. Level of attitude toward stem cell therapy among the studied nurses pre and post the implementation of educational guidelines.

guidelines.

Attitude level	No	%
Pre- education		
Negative attitude	48	49.0
Positive attitude	50	51.0
Mean ± SD	32.91±12.21	
Immediately after education		
Negative attitude	4	4.1
Positive attitude	94	95.9
Mean ± SD	45.76±10.79	
t-test (P1)	19.868 (<0.001) **	
Three-month post education (Follow-up)		
Negative attitude	8	8.2
Positive attitude	90	91.8
Mean ± SD	44.16±12.07	
t-test (P2)	14.745 (<0.001) **	
F (P value)	149.953 (<0.001) **	

*P1 = pre vs. immediate; P2 = pre vs. 3 months; F = repeated-measures ANOVA; *significant at $p \leq 0.01$.

Table 5 demonstrates statistically significant correlation among knowledge, attitude, and practice. At the pre-education phase, moderate positive correlations were observed between knowledge and attitude ($r = 0.421$, $p < 0.001$) and between knowledge and practice ($r = 0.371$, $p < 0.001$). Following the education, these relationships strengthened; knowledge showed positive correlations with both attitude ($r = 0.621$) and practice ($r = 0.571$) at the immediate post-test. These correlations remained significant throughout the follow-up phase.

Table 5. Correlation between nurses' total knowledge, attitude, and practice scores pre- and post-implementation (n = 98)

Variable	Total knowledge		
	Pre r (p)	Immediate r (p)	Follow-up r (p)
Total attitude	0.421 (<0.001)**	0.621 (<0.001)**	0.733 (<0.001)**
Total practice	0.371 (<0.001)**	0.571 (<0.001)**	0.574 (<0.001)**

**Correlation significant at $p < 0.01$.

Patients who received care from nurses after the guidelines reported significantly higher satisfaction across all subscales. Technical-professional care, trust, and patient-education scores were all significantly higher in the study group compared with the control group ($p < 0.001$). Total satisfaction was also markedly higher (104.37 $\pm$ 14.13 vs. 85.07 $\pm$ 13.16) (**Table 6**).

Table 6. Mean scores of patient satisfaction subscales among the study and control groups (n = 54)

Satisfaction subscale	Group A Mean $\pm$ SD	Group B Mean $\pm$ SD	t-test p value
Technical-professional care	24.41 $\pm$ 4.41	30.3 $\pm$ 4.81	4.687 <0.001**
Trust	38.48 $\pm$ 6.78	45.37 $\pm$ 5.63	4.060 <0.001**

Satisfaction subscale	Group A Mean $\pm$ SD	Group B Mean $\pm$ SD	t-test p value
Patient education	22.19 $\pm$ 4.31	28.7 $\pm$ 5.89	4.643 <0.001**
Total satisfaction	85.07 $\pm$ 13.16	104.37 $\pm$ 14.13	5.193 <0.001

t: Student t-test, * Statistically significant at $p < 0.05$

Discussion

This study revealed that although nurses in bone marrow transplant (BMT) units possessed substantial bedside experience, most lacked structured, transplant-specific preparation. A significant proportion of nurses lacked formal training, indicating that the persistent performance gap in transplant nursing may be attributed to deficiencies in educational exposure rather than inadequate staffing or motivation. Comparable findings in Iraq and Egypt demonstrated similarly low pre-training baseline scores despite routine clinical work, suggesting that HSCT nursing competency is knowledge-dependent and cannot be developed through exposure alone (16–18).

When the specialized education was implemented in the current study, nurses' knowledge significantly improved post-intervention, with gains sustained at three months. The significant improvement in knowledge observed post-intervention aligns with findings from similar regional studies in Iraq and Egypt, which consistently demonstrate that structured educational programs effectively bridge knowledge gaps in specialized nursing care (16–18). What makes the present study closer to the Egyptian follow-up model is that the gain was not only immediate; it was still statistically strong after three months. This is exactly what was shown in the larger Egyptian sample, where good knowledge rose sharply right after training and stayed high at follow-up(21). Together, these comparisons support the idea that BMT knowledge, when taught in a unit-specific, structured format, is retained and does not fade quickly.

Attitude toward stem cell therapy in this study followed the knowledge curve almost one-to-one. A substantial improvement in attitude was observed post-intervention, with gains largely sustained during the follow-up. The improvement in attitude observed in the present study is consistent with oncology nursing evidence showing that stronger knowledge is linked to more favorable attitudes toward specialized supportive care practices(21,25). It is also consistent with the experience of using social-media-assisted guidelines, where performance improved even though the delivery method was lighter, which suggests that clear, relevant transplant content can shift perceptions regardless of the channel (19). By demonstrating a statistically significant improvement in attitude score, the current study added quantitative support to what earlier authors had mostly described in narrative form.

Practice in the present study improved in the same direction as knowledge and attitude. Before the program, most nurses were unsatisfactory, mirroring the findings reported in Tanta before the implementation of evidence-based guidelines (17). After the program, most became satisfactory, and this improvement was still visible in the follow-up. This pattern was also shown in the Egyptian study that included a follow-up stage, where a significant increase in satisfactory practice was observed and maintained at follow-up (21). The interpretation in both cases is the same: nurses were not performing poorly because they were unable but because they had not been given a clear, standardized way of doing BMT care. The transition to

satisfactory practice suggests the “performance gap” stemmed from a lack of standardized, appropriate protocols rather than clinical inability. Delivering the intervention in the nurses’ specific unit addressed a key barrier to translating knowledge into practice.

A key finding was the positive correlation between knowledge, attitude, and practice scores. Both pre- and post-intervention. Notably, the relationship between knowledge and practice strengthened following the education program, suggesting that targeted training effectively bridges the gap between theoretical understanding and clinical performance. This aligns with similar observations in Egyptian and Canadian contexts, where very focused training enabled nurses to take over a high-risk step safely, showing that when knowledge is specific and tied to daily practice, performance follows it closely(15,21). These results support the premise that when knowledge is directly applicable to daily clinical tasks, it more effectively translates into satisfactory practice within the BMT environment.

On the patient side, the present study suggests that nursing education may positively influence patient perceptions of care. Because both groups were well matched demographically, the higher satisfaction among patients who were cared for by trained nurses may be associated with the nursing intervention. This is an important addition to earlier regional studies, because some of them reported that children’s clinical outcomes improved when nurses followed evidence-based guidelines, but they did not always measure patient satisfaction directly (17). This finding is important because patient satisfaction with nursing care is widely considered a meaningful indicator of perceived care quality and service performance (26). Others argued that improving nurses’ performance would reduce post-transplant complications, but again the focus was on clinical, not experiential, outcomes (21). In the present study, satisfaction with technical–professional care, trust, and education were all significantly higher, and the total satisfaction score was clearly better; this leads to empowering the patient’s journey through bone marrow transplant.

Beyond delivering technical care, BMT nurses must possess the professional knowledge, attitudes, and skills to provide comprehensive support. By utilizing a patient satisfaction instrument that evaluates technical-professional care, patient education, and interpersonal trust, this study demonstrates the training interventions were associated with an improvement in the perceived quality of care among post-transplant patients , shown as significant total satisfaction.

Conclusion

The specialized transplant-focused educational program significantly improved nurses’ knowledge, attitude, and practice in BMT units, with gains largely retained after three months. These improvements were also associated with higher patient satisfaction in technical-professional care, trust, and education. Structured transplant-specific education should be integrated into routine staff development in BMT settings.

Recommendation

Practice: mandatory orientation and periodic refresher training for BMT nurses.

Management: link competency appraisal to completion of BMT education.

Research: multicenter randomized or controlled studies with longer follow-up.

Limitation

Absence of Randomization:

quasi-experimental design without randomization, so causality is supported by the size and consistency of the effects but not guaranteed.

Convenience sample: This type of sample introduces potential selection bias and restricts the representativeness of the findings for the broader nursing population.

Small patient size: Such a sample may limit the generalization of the findings related to patient satisfaction.

Limited generalizability: data came from two hospitals only, which may limit generalizability to centers with different staffing ratios or case mixes.

Short follow-up period: It was relatively short (three months), and may be insufficient to evaluate the long-term sustainability and retention of the knowledge and skills achieved.

Potential observer bias: the observational checklist may introduce the possibility of observer bias.

So repeating the study with larger, multi-center patient cohorts would strengthen the external validity of the conclusions.

Disclosure Statements

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki, and ethical approval was obtained from the Research Ethics Committee, Faculty of Nursing, Mansoura University (no. 446). Informed consent was obtained from all participants. Participation was voluntary, anonymity was preserved, and data were used only for research purposes.

Consent for publication

All participants approve to publish this paper by all types of publications.

Availability of data and materials

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

Author's contribution

Conceptualization, all authors; methodology software, A.F.A. validation. A.F.A , H.A.S and H.M.S.; formal analysis, A.F.A , H.A.S and H.M.S. investigation , all authors; data curation, A.F.A , H.A.S.; writing—original draft preparation, H.A.S , A.F.A and H.M.S writing—review and editing all authors; visualization A.F.A , H.A.S and H.M.S; supervision, H.A.S and H.M.S, T .R.E project administration, all authors .

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Conflicts of interest

There is no conflict of interest regarding the publication of this article

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Source of research

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