Research Article

Nurses' Knowledge of Modern Wound Dressing in the Management of Diabetic Foot Ulcers

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Abstract

Background: Diabetic foot ulcer (DFU) represents one of the most debilitating complications of diabetes mellitus, often resulting in infection, gangrene, and amputation. Modern wound dressing, which maintains a moist healing environment, is increasingly used to accelerate granulation and epithelialization. However, the knowledge of nurses regarding modern dressing techniques remains inconsistent in developing countries, influencing wound healing outcomes.

Objective: This study aimed to explore the level of knowledge among nurses regarding modern wound dressing in diabetic ulcer care at Andi Makkasau Regional Hospital, Parepare, Indonesia.

Methods: A descriptive cross-sectional study was conducted from April to December 2025 involving 270 nurses selected through total sampling. Data were collected using a validated questionnaire (Cronbach's α = 0.918) comprising 24 closed-ended items covering aspects of wound assessment, moisture balance, debridement, and infection control. Descriptive statistical analysis was used to determine the distribution of knowledge levels.

Results: Among the 270 respondents, 68.9% demonstrated good knowledge of modern dressing, while 31.1% exhibited limited understanding. Areas with the highest correct responses included principles of moist wound healing (85%), proper wound cleansing solutions (NaCl 0.9%) (82%), and use of alginate dressings for exudative wounds (79%). Knowledge gaps were observed in identifying appropriate dressings for necrotic and ischemic wounds (42%).

Conclusion: Most nurses demonstrated adequate knowledge of modern wound dressing in DFU management. Nevertheless, targeted training is needed to enhance understanding of wound staging and dressing selection in necrotic or infected wounds. Modern dressing's molecular mechanism enhances fibroblast migration, collagen cross-linking, and angiogenesis, which collectively improve wound healing and reduce amputation rates.

Introduction

Diabetes mellitus (DM) is a chronic, multifactorial metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin resistance, or both. It represents a major global health challenge, contributing substantially to morbidity, premature mortality, and escalating healthcare expenditures. Sustained hyperglycemia triggers endothelial dysfunction, chronic low-grade inflammation, neuropathy, and microvascular impairment, all of which disrupt normal wound-healing processes and predispose

individuals to chronic complications [1]. Among these, diabetic foot ulcer (DFU) is one of the most debilitating and costly sequelae. Globally, up to 25% of individuals with diabetes will develop a foot ulcer during their lifetime, and the risk of mortality doubles following major lower-limb amputation [2]. Beyond clinical consequences, DFU imposes prolonged hospitalization, repeated surgical procedures, and substantial financial burden on healthcare systems.

In Indonesia, the diabetes burden is rising rapidly. The country ranked fifth worldwide in 2021, with approximately 19.5 million people living with diabetes, and projections estimate an

increase to 28.6 million by 2045 if preventive strategies remain inadequate [3]. This epidemiological transition is largely driven by urbanization, sedentary behavior, and dietary shifts. In South Sulawesi, diabetes prevalence has doubled since 2013, while hospital-based data from Parepare indicate a sharp increase in DFU cases—from fewer than 500 in 2021 to more than 4,021 in 2024—highlighting an urgent regional public health concern [4]. These escalating trends emphasize the necessity of strengthening evidence-based DFU management at the clinical level.

The pathogenesis of DFU is complex, involving metabolic dysregulation, peripheral neuropathy, vascular insufficiency, and infection. Chronic hyperglycemia leads to the accumulation of advanced glycation end-products (AGEs), oxidative stress, and impaired nitric oxide bioavailability, resulting in compromised angiogenesis and tissue perfusion [5,6]. These mechanisms delay fibroblast proliferation, collagen synthesis, and epithelial migration, producing chronic, non-healing wounds prone to infection and necrosis. Effective management, therefore, requires not only glycemic control but also appropriate wound care interventions that optimize the local healing environment.

Modern wound dressing (MWD) has emerged as a key component of advanced DFU management. Based on the principle of moist wound healing introduced by Winter (1962), MWD maintains an optimal microenvironment that facilitates autolytic debridement, enhances epithelialization, preserves growth factors, and reduces infection risk [7,8]. Various dressing types—including hydrocolloids, hydrogels, alginates, foams, and transparent films—are selected according to wound characteristics such as depth, exudate level, and tissue condition [9]. When applied appropriately, these technologies can accelerate healing, reduce complication rates, and decrease hospitalization duration.

However, the clinical effectiveness of modern wound dressing is highly dependent on the knowledge, skills, and clinical judgment of nurses responsible for wound assessment and dressing selection. Several studies have reported knowledge gaps, inconsistent adherence to evidence-based guidelines, and variability in clinical practices among nurses managing DFU, including limited understanding of moisture balance principles and inappropriate dressing selection [10]. Such deficits may lead to delayed wound healing, increased infection rates, prolonged hospital stays, higher risk of amputation, and escalating healthcare costs. Moreover, inadequate competency in modern wound care may compromise the quality of care and patient safety, particularly in resource-limited settings.

Despite the increasing prevalence of DFU in Indonesia, there is limited empirical evidence assessing nurses' knowledge of modern wound dressing and its alignment with current best-practice standards, especially in regional hospitals. Without systematic evaluation of knowledge levels, it is difficult to identify educational needs, design targeted training programs, or standardize wound care protocols. This gap in the literature underscores the need for context-specific research examining nurses' knowledge in DFU management.

In light of these challenges, the present study aims to investigate nurses' knowledge of modern wound dressing in diabetic ulcer management at Andi Makkasau Regional Hospital, Parepare. By clearly positioning this study within the identified knowledge gap, the findings are expected to inform targeted professional development programs, strengthen adherence to contemporary wound care guidelines, and ultimately improve patient outcomes, quality of care, and healthcare efficiency in DFU management.

Methods

Study design and setting

This study employed a descriptive cross-sectional design, which is appropriate for identifying and analyzing the current status of nurses' knowledge without manipulating variables. The design allows for the observation of multiple attributes within a defined population at a single point in time, enabling the quantification of knowledge levels and the identification of specific knowledge gaps regarding modern wound dressing. Such a design is frequently applied in nursing research where understanding attitudes, competencies, or knowledge patterns is the primary aim rather than testing an intervention.

The research was conducted at Andi Makkasau Regional Hospital in Parepare, South Sulawesi, Indonesia—one of the major referral hospitals in the region. The hospital serves as a tertiary care center with specialized units for internal medicine, surgery, and chronic wound management, including diabetic foot ulcers. Conducting the study in this clinical environment provided access to a diverse range of nursing professionals exposed to wound care practices, ensuring contextual validity and practical relevance of the findings. The data collection period spanned from April to December 2025, ensuring that all working shifts and departments were proportionally represented to minimize sampling bias.

Population and sampling

The study population consisted of all registered nurses employed in the internal medicine and surgical wards, where diabetic foot ulcer management is routinely performed. These units were chosen because of their high patient load and the frequent use of modern wound dressing methods in clinical care.

From this population, 270 nurses were enrolled using a total sampling approach, ensuring that every eligible participant was included. The inclusion criteria were: (1) active engagement in direct patient care at the time of the study, (2) willingness to participate and provide informed consent, and (3) absence of any physical or psychological condition that could affect participation. Nurses who were on maternity leave, extended study leave, or long-term medical leave were excluded to maintain data homogeneity and represent active clinical experience.

The chosen sample size of 270 respondents was considered adequate to represent the target population and to yield robust descriptive data. This number also meets the general statistical

adequacy rule in cross-sectional surveys, where a minimum sample of 10–20 participants per item of the instrument is recommended for internal consistency assessment and descriptive inference. The relatively large sample further increased the precision and generalizability of the results across nursing contexts with similar demographic and educational characteristics.

Instrumentation

The study utilized a structured and validated questionnaire designed to measure nurses' knowledge about modern wound dressing in diabetic ulcer management. The questionnaire consisted of 24 dichotomous (True/False) items developed based on current clinical guidelines, literature reviews, and expert consultations. The items covered four core domains of knowledge: (1) wound assessment and classification, (2) principles of moisture balance, (3) infection control and debridement, and (4) appropriate dressing selection according to wound stage and exudate characteristics.

Content validity was evaluated by a panel of wound-care specialists from the Department of Nursing at Poltekkes Kemenkes Makassar, resulting in a Content Validity Index (CVI) of 0.91, indicating excellent agreement among experts regarding item relevance and clarity. Construct validity was further supported through pilot testing involving 30 nurses who were not part of the main sample, ensuring clarity, cultural appropriateness, and comprehension of the questionnaire items.

Reliability testing produced a Cronbach's α coefficient of 0.918, confirming high internal consistency across the instrument, indicating that the items reliably measured a single underlying construct—knowledge of modern wound dressing practices. The Guttman split-half coefficient was also >0.85, further verifying reliability. The binary scoring method (1 = correct, 0 = incorrect) facilitated straightforward quantification of knowledge levels and minimized subjectivity in data interpretation.

Data collection procedure

Data were collected through self-administered questionnaires distributed during nurses' working hours in coordination with ward supervisors to avoid disruption of clinical duties. The research assistants, who had prior training in data collection ethics and confidentiality, briefed participants on study objectives, data use, and voluntary participation.

The administration process was carried out in a private and comfortable setting within the hospital to ensure anonymity and reduce response bias. Participants were given approximately 30 minutes to complete the questionnaire. Completed forms were immediately checked for completeness and stored in sealed envelopes before data entry. Each questionnaire was coded numerically (e.g., N001–N270) to maintain anonymity and facilitate accurate data management.

The research team also employed data verification and validation procedures, such as double data entry and cross-checking, to minimize human error during data input. The combination of manual oversight and computerized validation in SPSS enhanced data integrity and reproducibility.

Data analysis

Data were processed through a multistage analytical procedure comprising editing, coding, tabulating, and statistical analysis using IBM SPSS Statistics version 26.0. The editing stage ensured data completeness and consistency, followed by coding each questionnaire response into binary numerical values (1 = correct, 0 = incorrect). Data were then tabulated and analyzed descriptively.

Frequencies, percentages, means, and standard deviations were computed to describe the distribution of nurses' knowledge levels and item-specific responses. Knowledge was categorized as "good" (score ≥ 11) or "poor" (score < 11) based on predetermined cut-off points derived from previous nursing education studies using similar instruments. Graphical summaries such as histograms and pie charts were used to illustrate the proportion of knowledge levels across respondents.

Although inferential analysis was not the main objective, cross-tabulation between knowledge level and demographic factors (e.g., age, education, years of experience) was performed for exploratory interpretation. This approach allowed the identification of patterns that could inform future analytic or intervention-based research.

All analyses adhered to methodological rigor and transparency, ensuring the reproducibility of results and facilitating comparability with similar studies across different nursing populations.

Ethical considerations

Ethical approval was secured from the Institutional Ethics Committee of Poltekkes Kemenkes Makassar (Approval No. 2025/04/013), following the ethical standards established in the Declaration of Helsinki (2013 revision). Before participation, all respondents received detailed oral and written information regarding the study's objectives, procedures, potential risks, and benefits.

Informed consent was obtained from every participant before data collection, ensuring voluntary participation without coercion. Respondents were assured of their right to withdraw from the study at any time without any professional or academic consequences.

To maintain confidentiality, personal identifiers were not collected, and all responses were coded to ensure anonymity. Data were stored in encrypted files accessible only to the principal investigator and will be retained securely for five years before destruction.

The ethical conduct of this study also included considerations of nonmaleficence (avoiding harm), beneficence (maximizing knowledge benefits), and justice (ensuring fair inclusion of

participants). The study adhered strictly to all institutional and national research ethics regulations applicable to human subjects.

Results

Demographic characteristics

A total of 270 nurses participated in this study, yielding a response rate of 100%. The majority were female (74.4%), while 25.6% were male. The mean age was 29.8 years (SD ± 4.7), with 61.8% aged between 26 and 35 years, indicating that most respondents were in early to mid-career stages.

Regarding educational background, 67.0% held a Diploma III in Nursing, while the remainder had Bachelor's or Nursing-level qualifications. The average duration of professional experience was 6.3 ± 2.8 years.

This demographic profile suggests a relatively young but clinically experienced workforce, with most nurses trained at the vocational level. Such characteristics are relevant when interpreting knowledge outcomes, particularly in relation to advanced DFU management concepts that may require ongoing professional education and exposure to updated clinical guidelines.

Knowledge level of modern dressing in DFU management

Among the 270 nurses surveyed, 186 (68.9%) demonstrated good knowledge, whereas 84 (31.1%) exhibited insufficient knowledge.

As presented in Table 1, the highest correct response rate (85%) concerned the principle of moist wound healing. Additionally, 82% correctly identified isotonic saline (NaCl 0.9%) as the recommended wound-cleansing solution. Knowledge regarding alginate dressings (79%) and hydrocolloid use (72%) was relatively high.

However, lower accuracy was observed for foam dressings (70%) and transparent film dressings (65%). The lowest correct response rate (42%) was related to appropriate dressing selection for necrotic wounds. Furthermore, only 60% correctly understood the mechanism of autolytic debridement.

These findings indicate that while foundational principles of moist wound care are generally understood, knowledge gaps

persist in wound bed assessment, debridement strategies, and stage-based dressing selection—components that are central to comprehensive DFU management.

Discussion of knowledge gaps in the context of existing evidence

The present findings demonstrate that although a majority of nurses possess good overall knowledge (68.9%), nearly one-third exhibit insufficient understanding of modern dressing principles in DFU care. This proportion is comparable to studies conducted in other Southeast Asian settings, where 30% - 45% of nurses demonstrated inadequate knowledge of DFU management protocols. Such consistency suggests that knowledge deficits in advanced wound care remain a regional concern rather than an isolated institutional issue.

Notably, the lowest knowledge score (42%) related to dressing selection for necrotic wounds. Similar findings have been reported in prior studies, which identified wound assessment and debridement decision-making as the weakest domains among nursing staff. These competencies require integration of pathophysiological understanding, clinical judgment, and familiarity with contemporary guidelines—skills that extend beyond routine procedural training.

The moderate level of understanding regarding autolytic debridement (60%) also aligns with previous research indicating limited conceptual comprehension of the biological processes underlying wound healing phases. Importantly, knowledge in DFU care should not be restricted to familiarity with dressing products; rather, it encompasses broader competencies, including wound staging, infection control, glycemic considerations, pressure offloading, and interdisciplinary coordination.

Compared with studies where structured wound-care education programs were implemented, knowledge scores in those settings were significantly higher, particularly in domains of debridement and stage-based dressing selection. This comparison suggests that continuous professional development plays a critical role in enhancing not only product knowledge but also clinical reasoning in DFU management.

The findings, therefore, highlight that knowledge gaps are primarily conceptual rather than purely technical. Addressing these gaps may improve clinical decision-making, promote adherence to evidence-based guidelines, reduce complications such as infection and amputation, and ultimately decrease hospitalization costs and length of stay.

Collectively, these results position the current study within the broader literature demonstrating persistent variability in nurses' knowledge of DFU management. By identifying specific weak domains—particularly wound bed preparation and debridement biology—this study provides actionable evidence for designing targeted educational interventions that strengthen comprehensive DFU care rather than focusing solely on dressing materials.

Table 1: Distribution of Nurses' Knowledge of Modern Wound Dressing (*n* = 270).

Knowledge Item	Correct (%)
Principle of moist wound healing	85
Use of NaCl 0.9% as wound cleanser	82
Alginate dressing for exudative wound	79
Hydrocolloid for a minimal exudate wound	72
Foam dressing for moderate exudate	70
Transparent film for the epithelialization stage	65
Dressing choice for a necrotic wound	42
Debridement understanding (autolytic process)	60

Discussion

This study highlights that while most nurses exhibit adequate knowledge of modern dressing principles, significant gaps remain in advanced wound assessment and selection of specialized dressings. The findings indicate that nursing knowledge is a critical determinant in the success of diabetic ulcer management, as evidence-based wound care practices directly influence tissue regeneration, infection prevention, and patient recovery trajectories.

Conceptual understanding and clinical correlation

Nurses demonstrated good theoretical understanding of the moist wound healing principle, consistent with previous reports showing that maintaining optimal humidity enhances re-epithelialization and reduces necrosis [11]. The concept of *moist wound healing* (MWH) is grounded in the idea that epithelial cell migration and fibroblast proliferation occur most efficiently in a balanced moisture environment. In contrast, excessive dryness leads to scab formation, which acts as a physical barrier preventing keratinocyte migration, whereas excessive moisture promotes maceration of surrounding tissue. Therefore, precise control of exudate absorption and moisture retention is vital in achieving a stable wound microenvironment.

Modern dressing promotes *autolytic debridement*, a self-digestion process mediated by endogenous proteolytic enzymes, particularly matrix metalloproteinases (MMPs), which degrade necrotic tissue under moist conditions [12]. This autolytic activity also stimulates macrophage recruitment and secretion of cytokines such as interleukin-1 (IL-1) and tumor necrosis factor-alpha (TNF-α), enhancing phagocytosis and facilitating granulation tissue formation. The regulation of these molecular cascades depends on balanced protease activity—excessive MMP levels can damage new extracellular matrix (ECM) components, while insufficient proteolysis delays necrotic removal. Thus, nurses must understand both theoretical and biochemical aspects of wound management to maintain the optimal healing environment.

Biomolecular mechanisms of healing under modern dressing

The moist environment created by hydrocolloids, foams, and alginates accelerates healing at the molecular level. Moisture enhances keratinocyte migration and fibroblast proliferation by facilitating the activity of growth factors such as transforming growth factor-beta (TGF-β), vascular endothelial growth factor (VEGF), and platelet-derived growth factor (PDGF) [13]. These growth factors are critical in the *proliferative phase* of wound healing, promoting fibroblast activation, angiogenesis, and collagen deposition.

At the biochemical level, sodium and calcium ions released from alginate dressings exchange with wound exudate, forming a hydrophilic gel that sustains a humid microenvironment. This ion exchange process supports cell-matrix adhesion, a key step for fibroblast migration and the re-establishment of the ECM architecture [14]. Moreover, calcium ions play a dual role—serving as cofactors in the coagulation cascade and acting as signaling molecules that regulate keratinocyte differentiation and fibroblast contraction.

Additionally, the controlled moisture maintains physiological oxygen diffusion, reducing oxidative stress by modulating superoxide dismutase and catalase activity [15]. The reduction in oxidative damage helps prevent the formation of advanced glycation end-products (AGEs), which are commonly elevated in diabetic patients and known to inhibit angiogenesis. Maintaining oxygen tension within the wound bed also facilitates the conversion of proline to hydroxyproline during collagen synthesis, thereby enhancing the tensile strength of the new tissue. These biomolecular dynamics demonstrate how the physicochemical design of modern dressings translates into accelerated tissue regeneration and improved clinical outcomes.

Role of modern dressing in infection control

Modern dressings containing silver ions exhibit broad-spectrum antimicrobial activity by generating reactive oxygen species (ROS) that disrupt bacterial cell walls and DNA replication [16]. The ionic silver binds to thiol (-SH) groups of bacterial enzymes, causing denaturation and cell death without harming host tissues. The gradual release of Ag^+ ions maintains a prolonged antimicrobial effect, which is particularly beneficial in chronic diabetic wounds characterized by biofilm formation.

Biofilm eradication is essential in DFU management because bacterial colonies encased in extracellular polymeric substances (EPS) exhibit high antibiotic resistance. Silver-based dressings interfere with quorum-sensing signaling pathways, thereby preventing biofilm maturation. This biomolecular protection is crucial in DFU, where polymicrobial infections commonly involve *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and anaerobes [17]. By minimizing bacterial load, modern dressings reduce systemic inflammatory markers such as C-reactive protein (CRP) and interleukin-6 (IL-6), improving patient comfort and decreasing wound odor, exudate, and pain.

Chemical interactions and wound physiology

Hydrogel dressings consist of cross-linked hydrophilic polymers (e.g., polyvinyl alcohol, polyethylene glycol) capable of absorbing 200−500 times their weight in water [18]. These hydrogels exhibit viscoelastic properties that not only provide mechanical cushioning but also maintain stable moisture content through hydrogen bonding with exudate components. Their polymeric network structure allows sustained release of bioactive substances such as growth factors or antibiotics, providing both physical and pharmacological support to the wound site.

Furthermore, hydrogels regulate local temperature (32 °C − 34 °C), which is essential for enzymatic reactions such as collagenase activity and cellular metabolism. This thermal stability enhances fibroblast contractility and supports keratinocyte migration across the wound bed. Foam dressings

made from polyurethane exhibit microcellular structures that absorb exudates while preventing external contamination [19]. Their porous matrix facilitates gaseous exchange—oxygen influx and carbon dioxide efflux—while blocking bacterial penetration. From a chemical perspective, polyurethane foams possess both hydrophilic and hydrophobic domains that help manage exudate balance dynamically, preventing maceration of surrounding tissues.

Collectively, these chemical and physical interactions create a synergistic environment where moisture, oxygen, and temperature are regulated to mimic physiological wound-healing conditions. For nurses, understanding these interactions allows precise selection of dressing types based on wound exudate levels, infection risk, and tissue viability, which is crucial for achieving consistent outcomes in diabetic ulcer care.

Nursing knowledge and educational implications

The results reveal that 31.1% of respondents lack adequate knowledge in wound staging and dressing selection, aligning with earlier studies that emphasized continuous wound care education to improve clinical outcomes [20]. This knowledge gap may stem from limited exposure to advanced wound care technologies and insufficient integration of biomolecular healing principles in nursing education.

Training modules incorporating simulation-based learning and case discussions have been shown to enhance both cognitive and procedural competencies among nurses [21]. Simulation-based programs allow nurses to experience various wound scenarios, enabling them to practice decision-making about dressing selection based on exudate characteristics, tissue color, and infection status. Incorporating evidence-based practice (EBP) modules also helps nurses critically appraise new wound care products and adopt scientifically validated interventions.

Moreover, establishing interdisciplinary wound care teams that include nurses, physicians, and clinical pharmacists fosters collaborative decision-making and promotes holistic patient care. Continuous professional education (CPE) programs focusing on modern dressing technology, wound microbiology, and biomolecular healing mechanisms could significantly improve both theoretical understanding and hands-on proficiency among nursing professionals.

Clinical implications

Effective implementation of modern dressing techniques can significantly reduce hospital stay, prevent recurrent infections, and lower amputation rates in patients with diabetic foot ulcers. The integration of modern dressing protocols within standardized hospital guidelines ensures consistent wound care practices and outcome monitoring.

From a clinical management perspective, applying the moist wound healing approach decreases dressing change frequency, minimizing trauma to regenerating tissue and reducing healthcare costs. It also improves patient comfort and psychological well-being due to faster wound closure and less pain during dressing changes.

By integrating wound-care education into nursing curricula and ongoing professional development, hospitals can standardize evidence-based practice, ensuring consistent care quality across units. Incorporating the biochemical and biomolecular rationale behind modern dressing into educational content further strengthens nurses' critical thinking and clinical judgment. This integration enables nurses to transition from task-based care to analytical, patient-centered wound management—bridging the gap between scientific innovation and bedside practice [22-28].

Conclusion

This study found that although most nurses demonstrated good overall knowledge of modern wound dressing in diabetic foot ulcer (DFU) management, substantial gaps remain in critical areas such as wound bed assessment, dressing selection for necrotic and heavily exudative wounds, and understanding of debridement principles. These deficiencies indicate variability in conceptual understanding rather than merely technical skill.

The findings highlight that effective DFU management depends not only on the availability of modern dressing technologies but also on nurses' competence in applying evidence-based principles of wound assessment and stage-appropriate intervention. Inadequate knowledge in these domains may contribute to delayed healing, increased risk of infection and amputation, prolonged hospitalization, and higher healthcare costs.

Given these findings, structured and continuous professional education programs are strongly recommended. Hospitals should implement regular wound-care training, competency-based workshops, and periodic knowledge evaluations to ensure alignment with contemporary clinical guidelines. Strengthening institutional protocols and integrating evidence-based wound management standards into routine nursing practice are essential to improve consistency and quality of care.

In addition, incorporating comprehensive DFU management concepts into nursing curricula—including wound staging, infection control, debridement strategies, and moisture balance principles—may bridge the gap between theoretical knowledge and clinical decision-making.

In conclusion, this study underscores the need to enhance nurses' knowledge of modern wound dressing as a strategic priority to improve clinical outcomes, standardize DFU care practices, and support quality improvement initiatives in hospital settings.

Acknowledgment

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