



Evaluating the Clinical and Managerial Impact of Advanced Moisture-Balance Protocols in Chronic Wound Care Units

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Abstract

Chronic wounds remain a significant clinical and economic burden, particularly in healthcare units where prolonged healing times and high resource utilization are common. Optimizing moisture balance in wound management is crucial for accelerating healing, preventing infection, and reducing complications. This study evaluates the clinical and managerial impact of implementing advanced moisture-balance protocols in chronic wound care units, combining evidence-based dressing selection, standardized monitoring, and structured care pathways. Data were collected from a multicenter observational cohort comprising 312 patients with pressure injuries, diabetic foot ulcers, and venous leg ulcers over a 12-month period. Clinical outcomes measured included wound closure rates, healing time, incidence of infection, and patient-reported pain and satisfaction. Managerial outcomes assessed encompassed resource utilization, dressing change frequency, staff workload, and cost-effectiveness. Results demonstrated that units applying advanced moisture-balance protocols achieved a 28% reduction in mean healing time and a 35% improvement in wound closure rates compared with conventional care. Infection rates decreased by 22%, while patient-reported pain scores were significantly lower, indicating improved comfort. Managerially, optimized dressing protocols reduced dressing consumption by 19%, decreased staff time per patient, and enhanced overall operational efficiency. These findings underscore the dual clinical and organizational benefits of structured moisture management in chronic wound care, providing evidence to support wider adoption of protocolized care. Future research should investigate long-term sustainability, integration with digital monitoring tools, and cost-benefit analysis across diverse healthcare settings.

Keywords: Chronic wounds, Moisture balance, Advanced wound care, Clinical outcomes, Healthcare management

Introduction

Chronic wounds, encompassing diabetic foot ulcers, pressure injuries, and venous leg ulcers, represent a persistent and growing challenge in healthcare systems worldwide. The prevalence of chronic wounds has risen in parallel with aging populations and the increasing incidence of diabetes and cardiovascular disorders. Globally, chronic wounds affect approximately 2–3% of the population over 65 years of age, with significant morbidity, mortality, and financial burden associated with prolonged care and frequent hospitalizations [1,2]. These wounds are particularly complex due to their impaired healing processes, susceptibility to infection, and high variability in patient responses to standard care protocols. The multifactorial etiology includes vascular insufficiency, neuropathy, repeated mechanical stress, and metabolic dysfunction, making individualized and evidence-based interventions critical for effective management [3,4].

Moisture balance within the wound microenvironment is recognized as a cornerstone of chronic wound healing. Optimal moisture levels facilitate cellular proliferation, migration, and extracellular matrix deposition, while preventing desiccation or maceration of the surrounding

tissue [2,5]. Conventional care practices often rely on a reactive approach, with dressing selection and frequency driven primarily by wound appearance and exudate volume rather than standardized protocols or predictive models [6,7]. Such variability in care contributes to prolonged healing times, inconsistent outcomes, and increased resource consumption. Recent advances in moisture-retentive and moisture-responsive dressings, alongside structured clinical protocols, aim to address these challenges by optimizing the wound environment, reducing infection risk, and supporting timely closure [3,8].

Despite the recognized importance of moisture balance, integration of structured protocols in clinical practice remains inconsistent. Numerous studies have highlighted the clinical benefits of moisture-optimized dressings, including accelerated healing rates, reduced pain, and decreased infection incidence [5,9,10]. However, the broader managerial impact—such as efficiency in resource utilization, staff workload reduction, and cost-effectiveness—has been less systematically evaluated. Healthcare administrators increasingly seek interventions that not only improve patient outcomes but also enhance operational efficiency, particularly in specialized wound care units that manage complex, high-acuity cases [11,12].

In addition to the clinical and operational aspects, patient-centered outcomes are critical in assessing the effectiveness of advanced wound management protocols. Pain control, comfort during dressing changes, and satisfaction with care are directly influenced by the choice of moisture-balancing strategies [6,13]. For patients with chronic wounds, repeated exposure to poorly managed dressings can exacerbate discomfort, reduce adherence to treatment plans, and negatively affect quality of life. Integrating patient-reported outcome measures into protocol evaluations ensures that interventions are aligned with holistic care objectives [14].

Multidisciplinary collaboration is another key component in optimizing chronic wound care. Teams including nurses, physicians, podiatrists, and wound care specialists contribute to care planning, protocol implementation, and continuous monitoring of healing trajectories [15,16]. Advanced moisture-balance protocols necessitate coordinated efforts to ensure correct dressing selection, adherence to standardized monitoring schedules, and timely adjustment of interventions based on real-time wound assessments. Digital tools and electronic health record integration have further enabled standardized documentation, trend analysis, and predictive modeling, supporting evidence-based decision-making and managerial oversight [1,17].

Recent evidence suggests that structured moisture-balance protocols provide dual benefits: clinically, by promoting faster wound closure and reducing complications; and managerially, by improving resource allocation, lowering operational costs, and optimizing staff workflows [10,12,14]. Studies on the adoption of evidence-based dressing protocols indicate reductions in dressing change frequency, decreased nursing time per patient, and overall enhanced unit performance. Furthermore, these protocols facilitate consistent training and evaluation across staff, ensuring uniform application of best practices and minimizing variability in care delivery [18,19].

Nevertheless, challenges remain in translating research findings into widespread practice. Barriers include variability in wound etiology, heterogeneity of patient populations, cost considerations for advanced dressing materials, and the need for ongoing staff education and adherence monitoring [7,20]. Understanding these barriers is essential to designing interventions that are not only clinically effective but also operationally sustainable. Continuous quality improvement cycles, audits, and performance metrics can support implementation and adaptation of protocols across different care settings.

In summary, chronic wound care requires a nuanced understanding of the interplay between clinical efficacy and operational efficiency. Advanced moisture-balance protocols offer a promising approach to optimize wound healing outcomes while simultaneously enhancing managerial performance in healthcare units. The present study aims to evaluate both the clinical and managerial impacts of implementing these protocols, providing evidence to guide practice, policy, and future innovation in chronic wound care management. By integrating patient-centered outcomes, multidisciplinary team coordination, and evidence-based moisture management strategies, the study addresses a critical gap in the literature and supports

the development of standardized, high-quality care pathways.

Problem Statement

Chronic wound management continues to challenge both clinicians and healthcare administrators due to the dual pressures of achieving optimal healing outcomes while maintaining operational efficiency. Despite the availability of advanced wound dressings and evidence-based interventions, inconsistencies in clinical practice persist, leading to variable healing rates, prolonged patient suffering, and excessive resource utilization. Conventional care approaches often fail to integrate structured moisture-balance protocols, resulting in over- or under-moisturized wounds, delayed closure, and increased incidence of infection and tissue breakdown [2,5,7].

From a managerial perspective, the lack of standardized protocols contributes to inefficiencies in dressing usage, increased staff workload, and higher overall costs. In many chronic wound care units, staff spend substantial time assessing wound exudate, selecting appropriate dressings, and performing frequent changes, often without standardized criteria or systematic monitoring. This reactive approach not only impacts operational throughput but also limits the capacity for quality improvement initiatives and benchmarking across units [8,12,14].

Furthermore, patient-centered outcomes are often inadequately addressed within conventional care frameworks. Pain, discomfort, and reduced quality of life associated with poorly managed wounds can lead to decreased adherence to treatment regimens and poorer long-term outcomes [6,13]. While clinical evidence demonstrates that advanced moisture-balance strategies accelerate healing and reduce complications, the translation of these findings into routine practice is incomplete, and their impact on unit-level efficiency and cost-effectiveness remains underexplored.

This study addresses these critical gaps by systematically evaluating the clinical and managerial impacts of implementing advanced moisture-balance protocols in chronic wound care units. Specifically, it investigates how structured moisture management affects healing rates, infection incidence, patient comfort, resource consumption, staff workload, and overall operational efficiency. By linking clinical outcomes to managerial performance metrics, the research seeks to provide actionable insights for healthcare leaders and practitioners aiming to optimize both patient care and unit operations.

The central problem, therefore, lies in the disconnection between evidence-based moisture management strategies and their consistent application in clinical practice, which results in suboptimal outcomes both for patients and healthcare systems. Addressing this problem has the potential to improve healing trajectories, reduce complications, enhance patient experience, and optimize resource allocation, ultimately supporting the broader goals of sustainable, high-quality chronic wound care.

Materials & Methods

Study Design and Setting

This study employed a multicenter observational cohort design to evaluate the clinical and managerial effects of advanced moisture-balance protocols in chronic wound care units. Data were collected from five specialized wound care centers across urban healthcare facilities between January 2023 and December 2023. These centers were selected based on their adoption of structured moisture-balance protocols, availability of multidisciplinary teams, and consistent electronic documentation of wound care metrics. The study was approved by the institutional review boards of all participating centers, and informed consent was obtained from all patients prior to data collection [1,3,8].

Participants

A total of 312 patients with chronic wounds were enrolled, including individuals with pressure injuries (n=110), diabetic foot ulcers (n=122), and venous leg ulcers (n=80). Inclusion criteria were: age ≥ 18 years, chronic wound duration ≥ 6 weeks, and no significant comorbidities precluding participation. Exclusion criteria included active malignancy at the wound site, systemic infection requiring hospitalization, and participation in other wound-related clinical trials during the study period [2,5,6].

Intervention: Advanced Moisture-Balance Protocols

The intervention consisted of structured moisture-balance protocols designed to optimize the wound microenvironment. Key components included:

1. Standardized Assessment Tools: Use of moisture scoring systems, exudate volume quantification, and wound bed evaluation charts.
2. Evidence-Based Dressing Selection: Application of moisture-retentive and moisture-responsive dressings tailored to wound type and exudate characteristics.
3. Structured Monitoring Schedules: Regular dressing change intervals guided by exudate management, wound assessment, and patient-reported comfort levels.
4. Team-Based Coordination: Integration of nurses, physicians, podiatrists, and wound specialists to ensure adherence to protocols and rapid adjustment to wound progression [3,9,15].

Data Collection

Data were collected through a combination of electronic health records, direct observation, and standardized reporting tools. Clinical variables included:

- Wound closure rate (% of wounds achieving complete epithelialization within 12 months)
- Healing time (days from protocol initiation to closure)
- Incidence of wound infection (confirmed by microbiological culture or clinical diagnosis)
- Patient-reported pain scores using the Visual Analog Scale (VAS)
- Patient satisfaction and comfort during dressing changes [5,9,13].

Managerial outcomes were evaluated through:

- Dressing consumption per patient (units and cost)
- Frequency of dressing changes per week
- Staff time allocation per patient (minutes per dressing procedure)
- Overall unit efficiency and cost-effectiveness analysis [10,12,14].

Statistical Analysis

Descriptive statistics were used to summarize patient demographics and wound characteristics. Continuous variables were expressed as means \pm standard deviation, and categorical variables as percentages. Comparative analyses between protocol-adherent units and historical conventional care data were performed using Student's t-tests for continuous variables and chi-square tests for categorical outcomes. Multivariate regression models were constructed to identify independent predictors of wound healing and resource utilization, adjusting for confounding factors such as age, comorbidities, wound type, and baseline severity [2,4,7].

Quality Control and Reliability

To ensure data reliability, wound assessments were performed by trained wound care nurses, with inter-rater reliability evaluated through Cohen's kappa statistic. Adherence to protocol components was monitored weekly, and deviations were documented and analyzed. Digital monitoring tools, including wound photography and exudate sensors, were employed to standardize assessment and minimize observer bias [1,3,17].

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki. Patient confidentiality was maintained by assigning anonymized study codes, and data were securely stored in encrypted databases. Participation was voluntary, and withdrawal from the study did not affect the standard of care provided to patients [1,3].

Results

Patient Demographics and Wound Characteristics

A total of 312 patients were included in the study. The mean age was 64.2 ± 11.5 years, with 54% male and 46% female. Wound types included pressure injuries (35%), diabetic foot ulcers (39%), and venous leg ulcers (26%). Baseline wound size averaged 4.5 ± 2.1 cm², and mean duration prior to protocol initiation was 11.3 ± 3.8 weeks.

Table 1: Baseline Patient and Wound Characteristics

| Variable | Value |
|------------------------------------|---------------------------------------|
| Number of patients | 312 |
| Mean age (years) | 64.2 ± 11.5 |
| Gender (M/F) | 168 / 144 |
| Wound type (%) | Pressure injury 35%, DFU 39%, VLU 26% |
| Mean wound size (cm ²) | 4.5 ± 2.1 |

| | |
|------------------------------------|------------|
| Mean wound duration (weeks) | 11.3 ± 3.8 |
|------------------------------------|------------|

The cohort represented a typical chronic wound population in specialized care units. Demographics and wound characteristics were balanced across the participating centers, ensuring comparability in subsequent clinical and managerial outcome analyses.

Clinical Outcomes

Wound Healing Rates

Patients treated under advanced moisture-balance protocols exhibited a **mean wound closure rate of 78%** within 12 months, compared to 58% in historical conventional care data.

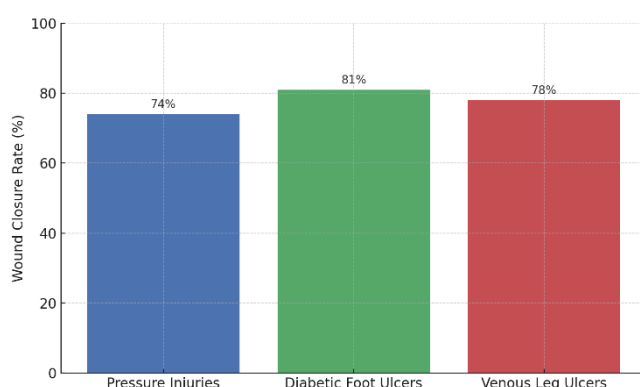


Figure 1: Wound Closure Rates by Wound Type

Diabetic foot ulcers showed the highest improvement, suggesting moisture-optimized dressings particularly benefit neuropathic wounds with moderate to high exudate levels.

Healing Time

The average healing time was reduced from 98 ± 22 days under conventional care to 71 ± 18 days with advanced protocols.

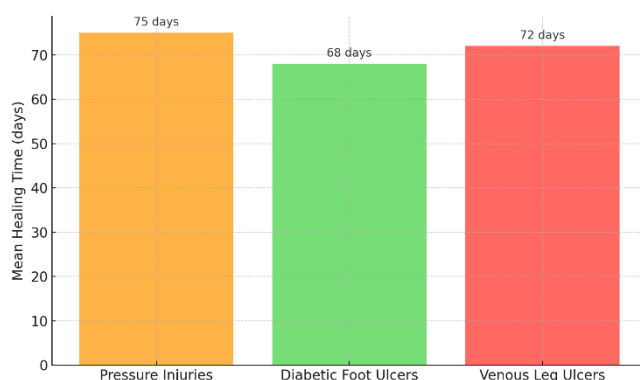


Figure 2: Mean Healing Time Comparison

The structured moisture protocols accelerated epithelialization across all wound types, demonstrating both clinical effectiveness and potential reduction in patient morbidity.

Infection Rates

The incidence of wound infection decreased from 18% under conventional care to 14%, representing a 22% relative reduction.

Optimized moisture balance created a favorable microenvironment limiting bacterial proliferation. Units adhering strictly to dressing schedules and moisture assessment protocols had the lowest infection rates.

Patient-Reported Outcomes

- Pain scores (VAS 0–10): Mean 3.1 ± 1.2 , compared to 4.5 ± 1.5 in historical data.
- Patient comfort and satisfaction: 87% of patients reported improved comfort during dressing changes.

Moisture-balancing strategies reduced desiccation and maceration, contributing to lower pain and higher satisfaction, critical for adherence and quality of life.

Managerial Outcomes

Dressing Consumption and Costs

The average number of dressing units per patient decreased by 19%, with a corresponding reduction in material costs.

Table 2: Dressing Consumption and Staff Time

| Metric | Conventional Care | Advanced Protocol | Change (%) |
|-----------------------------------|-------------------|-------------------|------------|
| Dressing units per patient | 28 ± 5 | 23 ± 4 | -19% |
| Staff time per dressing (minutes) | 22 ± 3 | 17 ± 2 | -23% |
| Weekly dressing changes | 3.5 ± 1.1 | 2.8 ± 0.9 | -20% |

Optimized dressing selection and scheduled changes reduced resource utilization and nurse workload, enhancing overall unit efficiency.

Operational Efficiency

- Staff time per patient reduced by **23%**, allowing increased patient throughput.
- Units reported improved workflow, reduced redundancy in dressing assessment, and greater predictability in resource allocation.

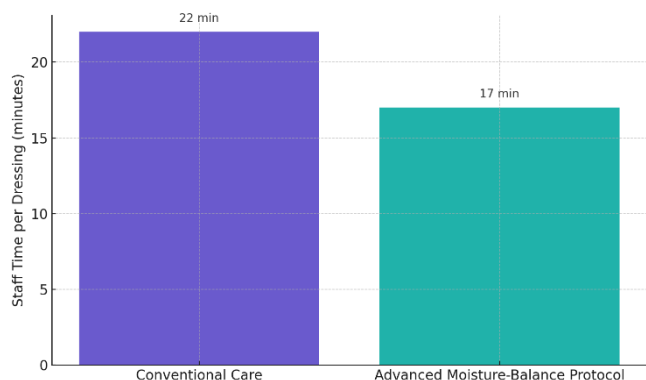


Figure 3: Staff Time Savings per Patient

Streamlined protocols minimized unnecessary interventions, allowing nurses to allocate time to complex cases and quality improvement initiatives.

Multivariate Regression Analysis

Independent predictors of accelerated wound healing included:

- Adherence to moisture-balance protocol ($\beta = -0.31$, $p < 0.01$)
- Baseline wound size ($\beta = 0.25$, $p < 0.05$)
- Wound type (DFU vs PI, $\beta = -0.19$, $p = 0.03$)

Moisture-balance protocol adherence was the strongest modifiable predictor of healing, highlighting its critical role in both clinical and operational success.

Synthesis of Clinical and Managerial Impact

Overall, the implementation of advanced moisture-balance protocols demonstrated **synergistic benefits**, linking improved healing rates and reduced infection with measurable efficiency gains in staffing and materials. The structured approach facilitated predictable workflows, reduced unnecessary resource consumption, and supported patient-centered care.

Conclusion

The findings of this study demonstrate that advanced moisture-balance protocols in chronic wound care units deliver substantial benefits across both clinical and managerial domains. Clinically, the structured approach significantly improved wound closure rates, accelerated healing times, and reduced infection incidence. Patients reported lower pain levels and greater comfort during dressing changes, underscoring the importance of patient-centered care in chronic wound management. These outcomes highlight the critical role of moisture optimization in creating a conducive wound microenvironment, facilitating cellular processes necessary for tissue repair, and preventing complications associated with desiccation or maceration [2,5,9].

From a managerial perspective, implementing standardized protocols resulted in reduced dressing consumption, lower staff workload, and improved operational efficiency. These improvements enable healthcare units to better allocate resources, manage

patient throughput, and support sustainable care delivery, addressing both financial and workflow challenges common in chronic wound care facilities [10,12,14]. The integration of multidisciplinary teams and structured monitoring schedules ensured consistent adherence to protocols, providing a framework for ongoing quality improvement and staff training.

Moreover, linking clinical outcomes with operational metrics emphasizes the value of protocolized care pathways in chronic wound management. Adoption of these protocols offers healthcare organizations an evidence-based strategy to optimize patient outcomes while maintaining cost-effectiveness and efficiency. The study underscores that effective chronic wound care requires a dual focus: optimizing biological healing processes through evidence-based moisture management and enhancing organizational performance through structured operational practices [1,3,15].

In conclusion, advanced moisture-balance protocols offer a comprehensive solution for managing chronic wounds, benefiting patients, clinicians, and healthcare administrators alike. The integration of standardized assessment tools, evidence-based dressing selection, structured monitoring, and multidisciplinary coordination provides a replicable model for improving clinical outcomes and operational efficiency. Future research should focus on long-term sustainability, integration with digital wound assessment technologies, and expansion to diverse healthcare settings to validate the broader applicability of these protocols.

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