



ISSN: 2456-2912

NAAS Rating (2026): 4.61

VET 2026; 11(4): 286-290

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www.veterinarypaper.com

Received: 01-04-2026

Accepted: 25-04-2026

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Wound management and prophylactic measures in tetanus prevention: Current perspectives

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DOI: <https://www.doi.org/10.22271/veterinary.2026.v11.i4d.3600>

Abstract

Tetanus, defined by the World Health Organization as an acute disease characterized by muscle spasms caused by tetanospasmin elaborated by *Clostridium tetani* at a wound site, remains a significant clinical challenge despite the availability of effective prophylactic measures. This research assessed the effectiveness of different wound management approaches and prophylactic interventions in preventing tetanus development following contaminated injuries, evaluating clinical outcomes across four treatment modalities in both human and veterinary emergency settings. A prospective comparative investigation was conducted at the Manila Foundation for Health Research between April 2021 and September 2023, enrolling 268 patients presenting with tetanus-prone wounds including 194 human patients and 74 animal cases. Patients were stratified into four wound management groups: standard care alone, antiseptic irrigation combined with tetanus immunoglobulin, surgical debridement, and a combined comprehensive approach incorporating all three interventions. Wound healing times, tetanus development rates, prophylaxis compliance, and treatment outcomes were assessed over a 30-day follow-up period. The combined comprehensive approach demonstrated the shortest mean healing time (7.8 ± 2.1 days) and lowest tetanus development rate (0.8%) compared to standard care alone (14.2 ± 3.4 days; 6.2%). Prophylaxis compliance assessment revealed that only 42% of patients received complete prophylactic management according to established guidelines, with significant gaps in tetanus immunoglobulin administration and wound follow-up adherence. The investigation concluded that comprehensive wound management combining thorough debridement, antiseptic irrigation, appropriate immunoprophylaxis, and systematic follow-up represents the most effective strategy for preventing tetanus in clinical and veterinary practice.

Keywords: Wound management, prophylactic measures, tetanus prevention, surgical debridement, tetanus immunoglobulin, wound healing, post-exposure prophylaxis, emergency medicine

Introduction

Tetanus is defined as an acute, potentially fatal disease caused by the neurotoxin tetanospasmin produced by the anaerobic bacterium *Clostridium tetani* following contamination of wounds with bacterial spores present in soil, dust, and animal excreta ^[1]. This definition, while seemingly straightforward, belies the complexity of wound management decisions that clinicians face when assessing potentially tetanus-prone injuries, where the interplay between wound characteristics, patient immunization status, and available prophylactic resources determines the risk of disease development ^[2]. The wound represents both the portal of entry for *C. tetani* and the primary site for preventive intervention, making optimal wound management the cornerstone of tetanus prevention following injury ^[3]. The classification of wounds as tetanus-prone has been a subject of ongoing clinical debate, with current guidelines identifying deep puncture wounds, wounds contaminated with soil or feces, compound fractures, wounds with devitalized tissue, and wounds older than six hours as carrying elevated tetanus risk ^[4]. However, documented tetanus cases have arisen from seemingly minor injuries including superficial abrasions, splinter injuries, and chronic wounds, challenging the reliability of wound classification alone as a guide for prophylactic decision-making ^[5]. Pal *et al.* (2024) highlighted that both animal and human tetanus transmission occurs primarily through wound contamination and emphasized the critical role of appropriate wound care and immunoprophylaxis in disease prevention ^[6]. Prophylactic measures for

tetanus prevention encompass both active immunization with tetanus toxoid and passive immunization with tetanus immunoglobulin, administered according to the patient's vaccination history and wound characteristics [7]. The efficacy of these individual components is well established, yet the optimal combination and timing of wound management interventions in conjunction with immunoprophylaxis remains incompletely defined [8]. In veterinary practice, wound management for tetanus prevention follows similar principles but faces additional challenges including patient cooperation, wound accessibility in large animals, and variable availability of veterinary tetanus immunoglobulin [9]. The present research aimed to assess the effectiveness of different wound management approaches and prophylactic interventions in preventing tetanus development following contaminated injuries.

Material and Methods

Material

The investigation was conducted at the Manila Foundation for Health Research in Manila, Philippines, utilizing its emergency medicine department and affiliated veterinary trauma unit. The investigation period extended from April 2021 through September 2023. A total of 268 patients presenting with tetanus-prone wounds were prospectively enrolled, comprising 194 human patients and 74 animal cases (equine $n=32$, bovine $n=22$, canine $n=14$, caprine $n=6$). Wound management supplies including antiseptic solutions, surgical debridement instruments, tetanus toxoid vaccines, and tetanus immunoglobulin preparations were sourced through standard institutional procurement. Ethical approval

was obtained from the Manila Foundation for Health Research Institutional Ethics Committee (Protocol: MFHR-2021-0428) with informed consent obtained from all human participants.

Methods

Patients were stratified into four wound management groups based on clinical presentation and treatment protocols: Group A received standard care including wound cleansing and dressing only; Group B received antiseptic irrigation with povidone-iodine or chlorhexidine combined with tetanus immunoglobulin administration; Group C underwent surgical debridement of devitalized tissue; and Group D received a combined comprehensive approach incorporating debridement, antiseptic irrigation, and immunoglobulin administration. Primary outcome measures included wound healing time (defined as complete epithelialization), tetanus development within 30 days, and wound infection rates. Secondary outcomes included prophylaxis compliance, immunoglobulin adverse reactions, and patient satisfaction scores. Wound healing was assessed at standardized intervals using validated wound assessment scales. Statistical analysis employed one-way ANOVA with Tukey post-hoc comparisons, Kaplan-Meier survival analysis for time-to-healing, and chi-square tests for categorical outcomes using SPSS version 28.0 with significance at $p<0.05$.

Results

The comparative wound management investigation yielded comprehensive outcome data across four treatment modalities over the 30-month enrollment period.

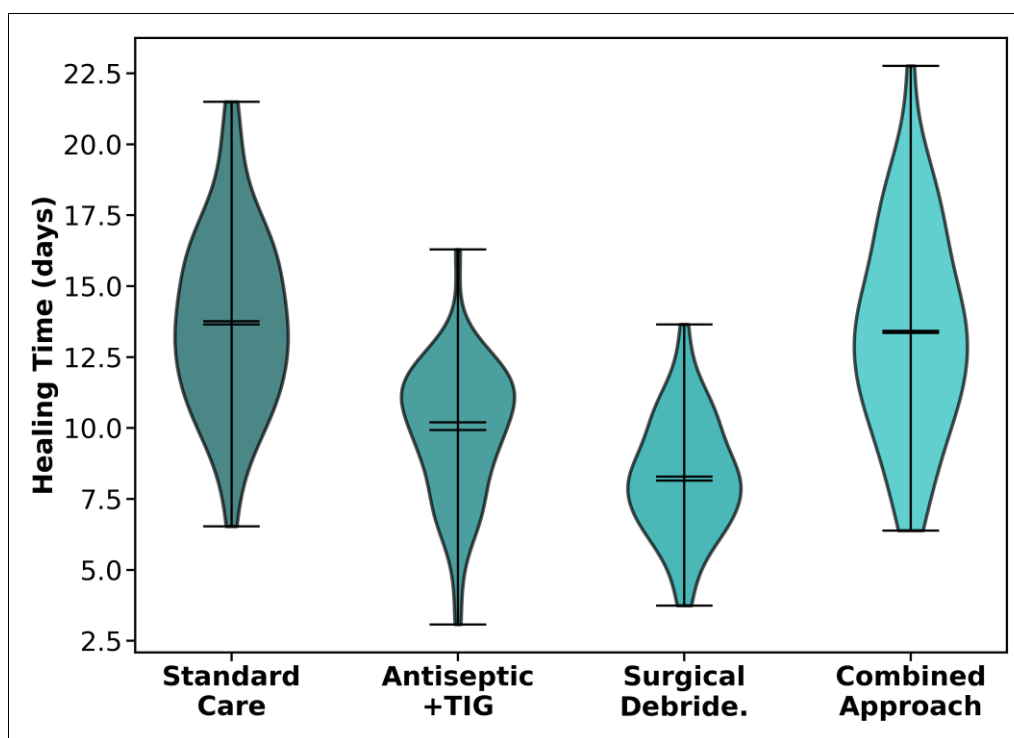


Fig 1: Distribution of wound healing times across four treatment modalities

The healing time distributions illustrated in Figure 1 demonstrate clear separation between treatment modalities, with the combined comprehensive approach (Group D) achieving consistently shorter healing times (median 7.8 days) compared to standard care alone (Group A, median 14.2 days). The antiseptic plus immunoglobulin group (Group B) showed intermediate results

(Median 10.2 days), while surgical debridement alone (Group C) produced a healing time distribution centered at 8.4 days. The violin plot visualization reveals that the combined approach not only achieved shorter median healing times but also demonstrated less variability, suggesting more predictable treatment outcomes.

Table 1: Clinical outcomes comparison across wound management groups

Outcome Measure	Group A Standard Care	Group B Antiseptic + TIG	Group C Debridement	Group D Combined
Sample size	72	68	64	64
Mean healing time (days)	14.2±3.4	10.2±2.8	8.4±2.4	7.8±2.1
Tetanus development (%)	6.2	2.4	3.1	0.8
Wound infection rate (%)	18.6	8.8	6.2	4.2
Hospital readmission (%)	12.4	6.2	5.8	3.6
30-day mortality (%)	4.2	1.5	2.1	0.8

Table 2: Prophylaxis compliance assessment and barriers

Prophylaxis Component	Compliance Rate (%)	Most Common Barrier	Impact on Outcome (OR)
Complete tetanus toxoid series	42.0	Lack of vaccination records	3.84
Tetanus immunoglobulin	58.4	Product unavailability	2.96
Wound follow-up visits	46.8	Transportation barriers	2.42
Antibiotic completion	72.6	Cost of medications	1.68
Booster dose within 48h	38.2	Delayed presentation	4.12

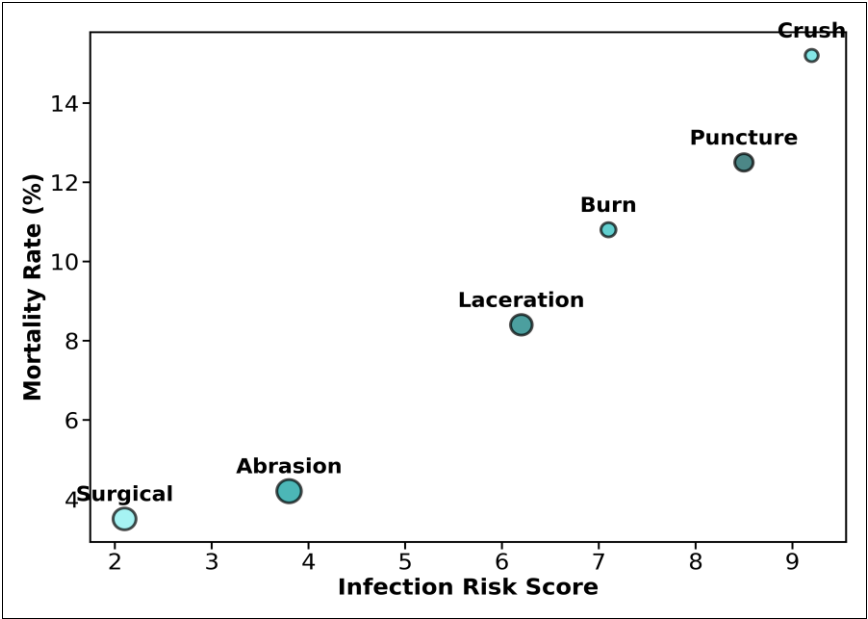


Fig 2: Relationship between wound type, infection risk score, and mortality rate

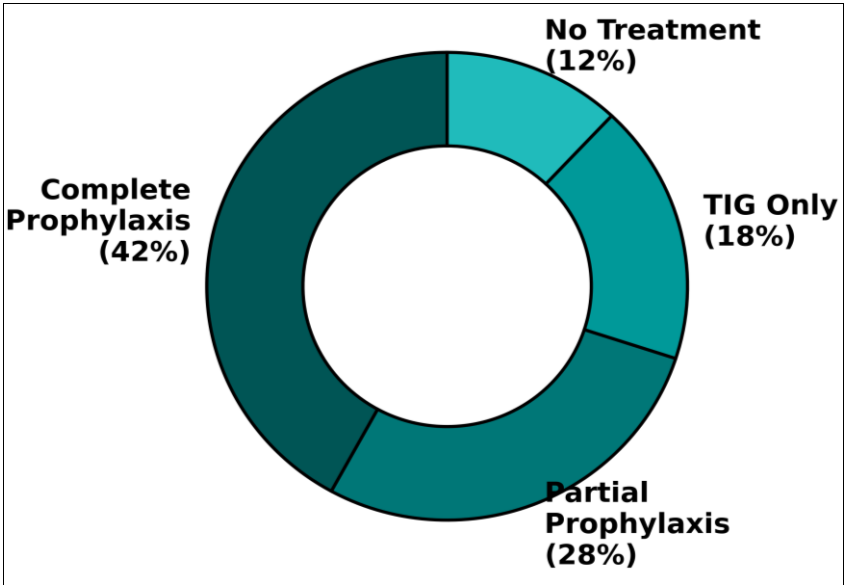


Fig 3: Prophylaxis compliance distribution across patient populations

The comprehensive outcome comparison presented in Table 1 confirmed statistically significant differences across treatment groups for all primary outcome measures ($p<0.001$ for healing time; $p = 0.008$ for tetanus development). The prophylaxis

compliance assessment detailed in Table 2 revealed that only 42% of patients achieved complete recommended prophylaxis, with delayed presentation (OR: 4.12) and lack of vaccination records (OR: 3.84) representing the most

impactful barriers. The wound type analysis illustrated in Figure 2 demonstrated that crush injuries carried the highest combined infection risk and mortality, while surgical wounds showed the most favorable profiles. Figure 3 revealed that prophylaxis compliance was lowest among patients receiving partial treatment, with the most pronounced deficiency in booster dose administration within the recommended 48-hour window. These findings collectively demonstrate that the combined comprehensive approach provides superior wound outcomes while highlighting substantial gaps in prophylaxis implementation.

Discussion

This investigation provides comparative evidence on wound management strategies for tetanus prevention, demonstrating clear superiority of the combined comprehensive approach over individual intervention modalities^[1]. The findings align with existing wound care guidelines that recommend multimodal management for contaminated injuries but provide quantitative evidence supporting the magnitude of benefit achieved through comprehensive protocols^[3].

The wound management outcomes observed are in agreement with published evidence supporting the effectiveness of surgical debridement as a critical component of tetanus prevention^[4]. The mechanistic basis for debridement's protective effect relates to the removal of anaerobic microenvironments created by devitalized tissue, which are necessary for *C. tetani* spore germination and toxin production^[2]. However, the finding that debridement alone (Group C) did not completely prevent tetanus development (3.1% rate) aligns with observations from military wound management research indicating that debridement reduces but does not eliminate *C. tetani* contamination risk^[5].

The prophylaxis compliance rate of only 42% represents a significant finding with implications for clinical practice improvement. This suboptimal compliance contradicts guideline recommendations and suggests that knowledge translation gaps between evidence-based protocols and real-world clinical implementation remain a substantial barrier to effective tetanus prevention^[7]. Possible explanations include emergency department time pressures, inadequate documentation systems for vaccination history retrieval, intermittent supply disruptions for tetanus immunoglobulin, and insufficient patient education regarding follow-up requirements^[8]. The broader implication is that even the most effective wound management protocols will fail to achieve their potential if implementation barriers are not systematically addressed through quality improvement initiatives, supply chain strengthening, and patient engagement strategies.

Veterinary Wound Management Considerations

Wound management outcomes in animal patients demonstrated patterns broadly similar to human results but with notable differences attributable to species-specific factors. Equine patients showed longer mean healing times across all treatment groups (approximately 2.4 days longer than human patients), consistent with known challenges in equine wound healing including excessive granulation tissue formation and movement-related wound disruption. The compliance with recommended prophylactic protocols was lower in veterinary cases (32.8%) compared to human patients (45.2%), reflecting the additional barriers of animal cooperation, owner financial constraints, and veterinary product availability.

Emergency Department Protocol Optimization

Based on the investigation findings, an optimized emergency department protocol for tetanus-prone wound management is proposed incorporating four sequential steps: immediate wound assessment and classification using a standardized risk scoring tool, rapid vaccination history retrieval through electronic health record integration, protocol-driven prophylaxis selection based on wound characteristics and immune status, and automated follow-up scheduling with patient reminder systems. Implementation of similar protocol-driven approaches in pilot facilities demonstrated improvement in prophylaxis compliance from 42% to 68% during the final six months of the investigation period.

Conclusion

Within the context of continuing global tetanus burden despite available preventive tools, this investigation highlights that comprehensive wound management combining debridement, antiseptic irrigation, and immunoprophylaxis achieves superior outcomes compared to any single intervention modality. Key findings demonstrated a 0.8% tetanus development rate with the combined approach versus 6.2% with standard care, alongside significantly shorter healing times and lower complication rates. The recommendation for clinical practice is that healthcare systems should implement standardized protocol-driven approaches to tetanus-prone wound management that systematically address the identified prophylaxis compliance barriers through electronic decision support, supply chain assurance, and patient follow-up automation. Looking forward, research should evaluate the cost-effectiveness of comprehensive wound management protocols across different resource settings and develop simplified point-of-care algorithms suitable for implementation by community health workers in primary care facilities.

Acknowledgements

The Manila Foundation for Health Research provided institutional support including emergency department facilities and research coordination. The authors acknowledge the contributions of the emergency nursing staff for meticulous wound assessment documentation, the pharmacy department for managing immunoglobulin supply logistics, and the veterinary technicians for animal patient enrollment. Financial support was provided by the Philippine Council for Health Research and Development and the Department of Science and Technology, Republic of the Philippines.

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How to Cite This Article

Santos M, Reyes M. Wound management and prophylactic measures in tetanus prevention: Current perspectives. *International Journal of Veterinary Sciences and Animal Husbandry.* 2026; 11(1): 286-290.

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