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Construction and Validation of a Risk Prediction Model for Diaper Dermatitis in Critically Ill Patients in the Emergency Department

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Article

Keywords: Critically ill, Diaper dermatitis, Emergency department, Nomogram, Prediction model

Posted Date: November 13th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11377233/v1

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Additional Declarations:
No competing interests reported.

Tables are available in the Supplementary Files section.

Construction and Validation of a Risk Prediction Model for Diaper Dermatitis in Critically Ill Patients in the Emergency Department

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Abstract

Objective: To construct and validate a risk prediction model for diaper dermatitis in critically ill patients in emergency department.

Methods: A retrospective analysis was conducted using data collected from 501 critically ill patients admitted to the emergency department between February and August 2025. Enrolled patients underwent random allocation into a modeling group (n = 351) and a validation group (n = 150). Diaper dermatitis's independent risk factors were identified through univariate analysis and binary logistic regression analysis, and a nomogram prediction model was subsequently constructed using R software. The predictive efficacy of the established model was assessed based on sensitivity, accuracy, and the area under the receiver operating characteristic curve and DCA evaluates the clinical effects of the model.

Results: The incidence of diaper dermatitis among critically ill patients in the emergency department was 25.36%. Eight independent risk factors were including bed rest exceeding 7 days, the use of pull-up diapers for urine and fecal collection, skin cleansing with alcohol wipes, absence of skin protectant application, decreased albumin levels, a high-risk perineal assessment score, an extremely severe pressure injury score, and a severe dependence score for self-care ability. During internal validation, the area under the receiver operating characteristic curve reached 0.954, with a sensitivity of 87.60% and a specificity of 72.00%. During external validation, the area under the receiver operating characteristic curve was 0.827, with a sensitivity of 71.10% and a specificity of 73.00%. DCA showed that the model had good clinical benefits.

Conclusion: This study constructed a risk prediction model for diaper dermatitis in critically ill patients within the emergency department, which demonstrated good predictive value and clinical utility.

Keywords: Critically ill; Diaper dermatitis; Emergency department; Nomogram; Prediction model

Introduction

As the initial point of contact for patient admission, the emergency department assumes a critical responsibility for life-saving interventions and the mitigation of patient suffering[1, 2]. Due to the severity and urgency of their clinical conditions, patients admitted to the emergency department often exhibit extensive medical and nursing requirements and are maintained in immobilized and passive positions for extended durations to ensure patient safety and therapeutic effectiveness[3, 4].

To maintain treatment continuity, the patient is often bedridden, care pads, diapers, or pull-up diapers are frequently utilized by family members and healthcare professionals in the emergency department for the collection of patients' excreta[5]. Currently, a diverse range of diapers is available on the market, and selections are frequently made by family members without adequate consideration of patients' body characteristics and individualized needs[6, 7]. During diaper use, patients may experience skin erythema, increased skin temperature, and even skin disruption, which is recognized as diaper dermatitis, with an estimated incidence of approximately 25%.

Unlike incontinence-associated dermatitis (IAD)[8], which is primarily driven fecal incontinence and inflammatory skin reactions from prolonged exposure to urine and/or feces[9, 10], however, the skin condition observed in our bedridden emergency and critically ill patients does not necessarily stem from incontinence. In fact, not all of these patients are incontinent; many require diapers simply because their medical condition mandates prolonged bed rest, limited mobility, and reduced frequency of getting out of bed. Consequently, the dermatitis they develop is predominantly attributable to the continuous use of absorbent products. Therefore, this study specifically focuses on diaper dermatitis in this unique critically ill population[11, 12].

Diaper dermatitis develops when diaper-covered skin is exposed to a prolonged moist and occlusive environment and subjected to persistent irritation caused by excreta and mechanical friction[13–15]. Therefore, normal skin barrier integrity is compromised, resulting in irritant contact dermatitis in the perineal and buttock regions; in advanced cases, ulceration or epidermal detachment may occur[16].

Critically ill patients in the emergency department are often characterized by advanced age, decreased skin elasticity, reduced moisture retention capacity, and progressive impairment of sensory function[17, 18]. In this vulnerable population, the development of diaper dermatitis not only produces physical discomfort and emotional disturbances, including restlessness and irritability, but also contributes to delayed recovery and prolonged hospitalization[19]. Furthermore, severe cases may be complicated by secondary bacterial and fungal infections, potentially resulting in sepsis

and posing a threat to patient survival[20–22]. Therefore, effective prevention strategies for diaper dermatitis among critically ill patients in the emergency department warrant further investigation.

Nevertheless, existing research has predominantly focused on diaper dermatitis among infants and young children, for whom relevant expert consensus statements have been established[23, 24], whereas investigations involving adults have primarily concentrated on incontinence-associated dermatitis[25]. A nomogram is a predictive instrument that transforms regression equations into a visualized scoring system, allowing the contribution of individual risk factors and the corresponding overall probability of disease occurrence to be readily interpreted[26, 27]. Characterized by individualized prediction, operational simplicity, and avoidance of complicated calculations, nomograms are particularly applicable to the rapid clinical decision-making environment of emergency departments[28, 29]. To enable prompt bedside assessment, facilitate early recognition, and support precise intervention for patients at elevated risk of diaper dermatitis, a nomogram-based risk prediction model was developed in this study. This study aimed to develop and internally validate a nomogram for predicting the risk of dermatitis in critically ill patients in the emergency department, with the goal of providing a practical tool for early risk stratification.

Methods

Study design and participants

This retrospective study included patients admitted to the emergency department of a tertiary Grade A hospital in Shandong Province between February and August 2025. The inclusion criteria were defined as follows: ① age ≥ 18 years; ② duration of emergency observation > 48 h; ③ emergency department severity classification of Level I, Level II, Level III, or Level IV according to patients' consciousness status, self-care ability, and other relevant clinical factors, with Levels I and II classified as critically ill patients; ④ use of diapers as the primary device for urine and fecal collection, defined as the material initially in direct contact with patients' excreta, including pull-up pants, disposable diapers, or nursing pads; and ⑤ availability of complete clinical electronic medical record information. The exclusion criteria included: ① pre-existing impairment of skin integrity, including erythema or maceration, within the diaper-contact skin area during emergency observation; and ② refusal to participate or inability to cooperate with the study procedures. A total of 25 variables were initially considered for screening in this study, and 10 variables were expected to be incorporated into the final risk prediction model. Given the previously reported incidence of diaper dermatitis (ranging from 25% to 30%)[16] and a preliminary investigation showing a 25% incidence rate, the sample size was determined via the formula $10\times10\div0.25\div(1–10\%)$, accounting for a 10% attrition rate, which yielded

approximately 444 cases. Ultimately, 501 patients were enrolled in this investigation.

Ethical approval for this study was granted by the ethics review committee of the First Affiliated Hospital of Shandong First Medical University & Shandong Provincial Qianfoshan Hospital ([2026] Lunshen Document (S717)). This study followed the STROBE (The Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for reporting observational studies. Due to the retrospective nature of the study, the ethics review committee of the First Affiliated Hospital of Shandong First Medical University & Shandong Provincial Qianfoshan Hospital waived the need of obtaining informed consent.

Diagnostic criteria for diaper dermatitis

The scoring criteria established by Buckley were adopted to determine the occurrence of diaper dermatitis among patients[30]. The diaper dermatitis scoring system consisted of four assessment domains: A, the severity of erythema and irritation; B, the affected area of diaper dermatitis; C, the presence of papules and pustules; and D, the presence of open skin lesions. Component A was categorized into four severity levels: none, mild, moderate, and severe, with corresponding scores spanning 0 to 3. Higher scores represented greater disease severity. Component B included two evaluation categories: a score of 0 was assigned when less than 50% of the perianal-perineal-buttock and diaper areas were involved, whereas a score of 1 was assigned when 50% or more of these areas were affected. Component C was classified into two categories: a score of 0 indicated the presence of only a small number of papules and pustules, whereas a score of 1 indicated the presence of numerous or clustered papules or pustules that could not be accurately quantified. Component D was divided into two categories: a score of 0 indicated open skin breakdown considered to result from friction, injury, or causes unrelated to diaper dermatitis, whereas a score of 1 indicated the presence of any deep dermal open skin lesion caused by friction, injury, or causes unrelated to diaper dermatitis. The total score was calculated using the formula A+B+C+D. In this study, according to a comprehensive review of relevant literature [1–7] and expert consultation, a skin assessment score of 0 was classified as non-diaper dermatitis, whereas a score ≥1 was classified as diaper dermatitis.

Research instruments

General information

Drawing on an extensive review of the relevant literature[16, 31, 32], the researchers independently designed a structured questionnaire. The questionnaire collected general demographic and clinical-related information, including age, sex, height, weight, per capita monthly household income, family financial capacity for medical expenses, type of medical insurance payment, duration of bed rest, and

frequency of skin assessment.

Diaper-related information

The collected diaper-related information included the use of an air mattress, the type of diaper utilized for the initial urine collection, and the interval between diaper replacements.

Defecation and urination

The collected defecation- and urination-related information included the type of defecation and urination, the materials used for stool cleansing, whether timely skin cleansing was performed, and whether skin protectants were applied.

Laboratory test indicators at emergency department admission

The laboratory parameters collected at emergency department admission included hemoglobin, albumin, white blood cells, neutrophils, C-reactive protein, and lymphocytes.

Braden scale for predicting pressure injury risk

The Braden scale comprises six assessment domains: sensory perception, moisture, activity, mobility, nutrition, and friction and shear. Except for the friction and shear domain, which is scored from 1 to 3 points, each of the remaining five domains is rated on a scale of 1 to 4 points[33, 34]. Total scores span from 6 to 23 points, where lower values reflect an elevated risk of pressure injury. A total score of 15 to 18 points is considered indicative of mild risk, 13 to 14 points represents moderate risk, ≤12 points indicates high risk, and <9 points indicates extreme risk, for which the occurrence of pressure ulcers is highly probable. In this study, the Cronbach's α coefficient was 0.834.

Assessment of self-care ability (Barthel index)

The Barthel index comprises ten assessment items: feeding (10 points), bathing (5 points), grooming (5 points), dressing (10 points), bowel control (10 points), bladder control (10 points), toileting (10 points), transferring from bed to chair (15 points), walking on level ground (15 points), and climbing stairs (10 points)[35, 36]. The total score ranges from 0 to 100 points, with lower scores indicating poorer self-care ability. A score of ≤40 points is classified as severe dependence, 41 to 60 points as moderate dependence, 61 to 99 points as mild dependence, and 100 points as no dependence.

Perineal assessment tool

The perineal assessment tool comprises four evaluation items: intensity of the irritant, duration of exposure to the irritant, perineal skin condition, and related contributing factors (e.g., low albumin, antibiotics, and tube feeding)[37, 38]. Each item is assigned a score ranging from 1 to 3 points, resulting in a total score range of 4 to 12 points. A total score of 4 to 6 points is categorized as low risk, whereas a score of 7 to 12 points is classified as high risk. In this study, the Cronbach's α coefficient of the scale was 0.512.

Statistical analysis

Statistical analyses were conducted using SPSS 25.0. Measurement data exhibiting a normal distribution were denoted as ($\bar{x}\pm s$), and inter-group comparisons relied on the t-test along with analysis of variance. Data that did not conform to a normal distribution were denoted as M (P_{25}, P_{75}) and analyzed using nonparametric tests. Categorical data were denoted as frequencies and percentages, and differences between groups were assessed via the chi-square test. Statistical analysis of ordinal enumeration data was conducted using nonparametric tests. Variables demonstrating statistical significance in the univariate analysis were subsequently entered into binary logistic regression analysis. Statistical significance was defined as $P < 0.05$. The variables ultimately selected for the establishment of the risk prediction model were determined, and a nomogram was subsequently developed. *R* 3.4.1 was used to randomly allocate all samples into a modeling group (n = 351) and a validation group (n = 150) at a ratio of 7:3. The Bootstrap method with 1,000 resampling iterations served for internal validation. The area under the curve (AUC) of the receiver operating characteristic (ROC) curve and the Hosmer-Lemeshow goodness-of-fit test value were applied to assess the discrimination and calibration performance of the model. Generally, a value of AUC approaching 1 indicates stronger model discrimination, whereas an AUC > 0.70 is considered indicative of satisfactory discriminative ability. In the Hosmer-Lemeshow goodness-of-fit test, $P > 0.05$ is generally interpreted as demonstrating an acceptable model fit. DCA evaluates the clinical effects of the model.

Results

Data collection methods

The investigators consisted of clinical preceptors from the emergency department who had undergone standardized training before the initiation of data collection. Relevant information was extracted from electronic medical record systems, whereas data unavailable through these systems (e.g., average monthly household income per capita and family financial capacity for medical expenses) were obtained through telephone follow-up. In total, 517 questionnaires were retrieved, and 16 invalid ones were removed. Therefore, 501 valid questionnaires qualified for the final analysis, including 351 cases in the modeling group and 150 cases in the external validation group. The effective questionnaire recovery rate was 96.90%.

General patient characteristics

Among the 351 patients included in the modeling group, 209 (59.54%) were male and 142 (40.45%) were female, with a mean age of 74.02 ± 12.97 years. The five most frequently observed clinical diagnoses were severe pneumonia (72 cases, 20.51%), acute cerebral infarction (59 cases, 16.80%), gastrointestinal bleeding (23 cases,

6.60%), respiratory failure (17 cases, 4.80%), and heart failure (16 cases, 4.60%). Diaper dermatitis was identified in 89 patients, corresponding to an incidence of 25.36%, as presented in Table 1.

Univariate analysis of diaper dermatitis in critically ill patients in the emergency department

Statistically significant differences were identified between the non-diaper dermatitis group and the diaper dermatitis group regarding age, duration of bed rest, frequency of skin assessment, type of diaper used for initial urine collection, interval between diaper changes, defecation status, stool cleaning methods, timely skin cleansing, use of skin protectants, urination status, albumin, white blood cells, neutrophils, C-reactive protein, Braden score, self-care ability (Barthel) score, and perineal assessment score (all $P < 0.05$), as presented in Table 1.

Logistic regression analysis

With the occurrence of diaper dermatitis designated as the dependent variable, the 17 factors demonstrating statistical significance in the univariate analysis were incorporated as independent variables into binary Logistic regression analysis. The variable assignment methods were as follows: ① Original values were directly entered for age, albumin, white blood cells, neutrophils, and C-reactive protein; ② Dummy variables were established according to the classifications presented in Table 2. The results of Logistic regression analysis indicated that bed rest exceeding 7 days, use of pull-up pants for urine and fecal collection, absence of skin protectant application, low albumin levels, high-risk perineal assessment scores, extremely severe Braden scores, and severe dependence in self-care ability scores were identified as risk factors associated with diaper dermatitis among critically ill patients in the emergency department ($P < 0.05$), as presented in Table 3.

Construction and internal validation of the risk prediction model

Based on the results of logistic regression analysis, statistically significant risk factors were incorporated into the development of a nomogram for predicting the risk of diaper dermatitis among critically ill patients in the emergency department using R 3.4.1 software (Figure 1). For each variable included in the nomogram, a vertical line can be extended upward to determine the corresponding score, and the scores of all variables are then aggregated to calculate the total score for an individual patient. By extending a vertical line from the total score to the predicted probability axis, the corresponding predicted probability can be obtained. The Hosmer-Lemeshow goodness-of-fit test demonstrated a value of $\chi^2 = 11.817$ and $P = 0.160$, indicating that no statistically significant difference was observed between the diaper dermatitis risk

predicted by the nomogram and the actual observed risk. The discrimination ability of the model was evaluated using the ROC curve, and the maximum Youden index was applied to identify the optimal cutoff value of the prediction model. The final AUC was 0.954, with a 95% confidence interval (CI, 0.933, 0.974), a Youden index of 0.600, sensitivity of 87.60%, specificity of 72.00%, positive predictive value (PPV) of 95.00%, negative predictive value (NPV) of 77.50%, and overall predictive accuracy of 90.60%. These findings indicated that the model demonstrated favorable discriminative performance (Figures 2 and 3).

Internal validation of the risk prediction model for diaper dermatitis in critically ill patients in the emergency department

Among the 150 critically ill patients included in the emergency department validation group, 84 (56.00%) were male, and 66 (44.00%) were female, with a mean age of 75.21 ± 11.27 years. The five most frequently observed clinical diagnoses were severe pneumonia (45 cases, 30.00%), acute cerebral infarction (22 cases, 14.70%), heart failure (12 cases, 8.00%), gastrointestinal bleeding (10 cases, 6.70%), and acute coronary syndrome (10 cases, 6.70%). The Hosmer-Lemeshow test yielded $\chi^2 = 2.460$ and $P = 0.962$, indicating that the risk of diaper dermatitis predicted by the nomogram exhibited good agreement with the actual observed risk. The ROC curve analysis demonstrated an AUC of 0.827, a Youden index of 0.444, a sensitivity of 71.10%, a specificity of 73.00%, a PPV of 87.60%, an NPV of 66.70%, and an overall predictive accuracy of 81.30%. These findings indicated that the model demonstrated satisfactory discriminative performance, as presented in Figures 4 and 5.

Decision curve analysis of the nomogram prediction model in the modeling group

Decision curve analysis (DCA) of the internal validation cohort is presented in Figure X. The nomogram (blue line) demonstrated a consistently higher net benefit across the entire range of threshold probabilities (0% to 50%) compared with both the treat-all (red line) and treat-none (green line) strategies. Specifically, at clinically relevant threshold probabilities (e.g., 10% to 40%), the net benefit of the nomogram remained substantially higher than the default strategies. The treat-all strategy showed a net benefit of zero at a threshold of approximately 29%, whereas the nomogram maintained a positive net benefit even at a 50% threshold. These findings indicate that the nomogram provides superior clinical utility for guiding preventive interventions in critically ill emergency department patients, as presented in Figures 6.

Discussion

Incidence of diaper dermatitis in critically ill patients in the emergency department

Diaper dermatitis represents a prevalent dermatological condition among infants and young children, primarily due to the vulnerability of infant skin and limited abilities in autonomous excretion control and self-care[24, 39]. These characteristics result in prolonged exposure of the skin to a moist and occlusive environment, accompanied by continuous irritation from urine and feces and mechanical friction caused by diapers, ultimately contributing to the development of diaper dermatitis[40]. Previous international studies have reported that the incidence of diaper dermatitis among infants and young children ranges from 7% to 40%[41, 42], whereas studies conducted in China have demonstrated an incidence of 48% among children admitted to the pediatric intensive care unit (ICU). However, no studies specifically investigating diaper dermatitis among critically ill patients in the emergency department have been reported to date. The findings of the present study demonstrated that the incidence of diaper dermatitis among critically ill patients in the emergency department was 25.36%, indicating a relatively high occurrence rate. Most critically ill patients in the emergency department exhibit moderate to severe dependence or greater dependence in self-care ability. The use of disposable diapers or care pads for excreta collection may result in the formation of a closed and humid microenvironment in vulnerable skin regions, including the sacrococcygeal area and perineum. Additionaly, due to the requirements of disease management and treatment, patients are frequently maintained in passive positions for extended periods, leading to sustained local tissue pressure and an increased risk of diaper dermatitis. These findings suggest that diaper dermatitis occurs at a relatively high frequency among critically ill patients in the emergency department. Therefore, enhanced attention and early preventive interventions should be provided by medical staff and family members.

The DCA based on the internal validation cohort supported the clinical utility of the nomogram. Across threshold probabilities of 10%–40%, the nomogram yielded higher net benefits than both the treat-all and treat-none strategies. This suggests that risk-stratified prevention could reduce unnecessary interventions in low-risk patients while ensuring timely care for those at high risk. Given the limited resources in emergency settings, such an approach may help optimize clinical decision-making. Overall, these findings indicate that the nomogram could be incorporated into early nursing assessments to facilitate targeted dermatitis prevention in critically ill emergency patients.

Risk prediction model for diaper dermatitis in critically ill patients in the emergency department demonstrated good predictive performance and favorable clinical applicability

In this study, a nomogram-based risk prediction model for diaper dermatitis among critically ill patients in the emergency department was developed. Each risk factor

included in the model was assigned a corresponding score, allowing the total score to be calculated intuitively. The predicted probability derived from the total score represents the likelihood of diaper dermatitis occurrence in individual patients, thereby indicating the practical clinical utility of the model. The AUC of the ROC curve is widely recognized as an important indicator for evaluating the predictive performance of a model. Generally, an AUC ≥0.7 indicates acceptable predictive accuracy, an AUC ranging from 0.7 to 0.9 represents moderate predictive accuracy, and an AUC >0.9 reflects high predictive accuracy[43, 44]. In the present study, the AUC was 0.954, demonstrating that the model exhibited favorable discriminative performance. Sensitivity represents the probability that patients with diaper dermatitis are correctly identified, whereas specificity reflects the probability that patients without diaper dermatitis are correctly classified. The prediction model developed in this study achieved a sensitivity of 87.60% and a specificity of 72.00%, further supporting its satisfactory discriminative capability. Furthermore, external validation revealed an AUC of 0.827, a sensitivity of 71.10%, and a specificity of 73.00%. These findings further verified that the risk prediction model for diaper dermatitis among critically ill patients in the emergency department demonstrated reliable clinical applicability and predictive accuracy and could assist clinical medical staff in the rapid identification of high-risk patients.

Example of nomogram use

The nomogram was constructed using a point-scoring method, in which the regression coefficient of each predictor was converted into a score ranging from 0 to 100, and the total score corresponded to the predicted probability of dermatitis. The nomogram is used as follows: for each variable, locate the patient's value on the corresponding axis, draw a vertical line upward to obtain the score for that variable, and sum the scores of all variables to obtain the total score. Then, draw a vertical line downward from the total score axis to read the predicted probability of dermatitis for that patient. For example, for an emergency critically ill patient with bed rest exceeding 7 days, no using of skin protectant, albumin is 70g/L, pressure injury score indicating extremely severe and self-care ability score indicating severe, corresponding to a predicted risk of dermatitis of about 50%. For such high-risk patients, the emergency care team may consider early initiation of structured skin assessment, pressure-relief care, incontinence management, and nutritional support.

A self-care ability score indicating severe dependence, an extremely severe degree of pressure injury, and bed rest exceeding 7 days were identified as risk factors for diaper dermatitis in critically ill patients in the emergency department

The findings of this study demonstrated that a self-care ability score indicating

severe dependence was associated with an increased risk of diaper dermatitis among critically ill patients in the emergency department. In this population, severe dependence in self-care ability indicates substantial functional limitations[45, 46], resulting in prolonged bed confinement and reliance on diapers for the management of sweat, urine, feces, and other excretions. When these excretions are not removed promptly, the skin-covered areas remain in a humid and poorly ventilated environment, thereby increasing the likelihood of diaper dermatitis development.

An extremely severe degree of pressure injury was identified as a risk factor associated with diaper dermatitis among critically ill patients in the emergency department. Pressure injuries frequently occur at bony prominences and are characterized by erythema[47], skin breakdown, or ulceration involving previously intact skin[48, 49]. In critically ill patients with extremely severe pressure injuries, the use of diapers may further restrict ventilation and increase moisture accumulation in the affected areas, thereby contributing to the development of diaper dermatitis.

Bed rest exceeding 7 days was also identified as a risk factor associated with diaper dermatitis among critically ill patients in the emergency department. Critically ill patients in the emergency department are generally characterized by advanced age, dry and fragile skin, severe disease conditions, and extensive therapeutic requirements, resulting in prolonged periods of bed rest or immobilization[50, 51]. Continuous pressure on weight-bearing tissues may lead to reduced skin integrity, thinning of the skin structure, and increased susceptibility to injury[52]. When diapers are applied, the compromised skin may exhibit inflammatory responses, including erythema, swelling, warmth, and pain, ultimately promoting the occurrence of diaper dermatitis.

These findings indicate that increased attention should be directed toward critically ill patients in the emergency department with severe dependence in self-care ability. Appropriate skin cleansing should be performed according to individual conditions, bed unit hygiene should be maintained, and active participation of patients' family members should be encouraged to facilitate cooperation between medical staff and patients, thereby reducing the occurrence of diaper dermatitis. Meanwhile, for critically ill patients with an extremely severe degree of pressure injury or bed rest exceeding 7 days, standardized prevention and management strategies for pressure injuries should be strictly implemented, including timely repositioning, application of protective dressings, and prompt diaper replacement.

Use of pull-up diapers for urine and fecal collection as a risk factor for diaper dermatitis in critically ill patients in the emergency department

The findings of this study indicated that the use of pull-up diapers for urine and fecal collection was associated with an increased risk of diaper dermatitis among critically ill patients in the emergency department. Adult diapers are disposable paper-

based incontinence products, which are currently categorized into three primary types: pull-up diapers, tab-style diapers, and diaper pads or care pads. The inner layer of adult diapers is composed of non-woven fabric that is in direct contact with the skin; the middle layer consists of absorbent fluff pulp combined with superabsorbent polymer; and the outer layer is composed of a waterproof plastic film[25, 53]. These products are primarily designed for individuals with limited mobility or urinary and fecal incontinence. Compared with tab-style diapers, pull-up diapers are equipped with elasticized waistbands, which reduce the likelihood of lateral leakage due to the restrictive support provided by the waistband. However, because the size of the lateral sections cannot be adjusted in adults, pull-up diapers tend to fit closely against the skin, resulting in a more enclosed and less ventilated microenvironment and increased mechanical friction. Furthermore, temperature distribution within pull-up diapers is uneven during use, and the temperature of the covered areas increases with prolonged wear time. This effect is particularly evident in the groin region, thereby contributing to the development of diaper dermatitis among patients .

Cleaning the skin with alcohol wipes as a risk factor for diaper dermatitis in critically ill patients in the emergency department

The findings of this study indicated that skin cleansing with alcohol wipes was associated with an increased risk of diaper dermatitis among critically ill patients in the emergency department. Previously, toilet paper was commonly used for cleaning the perineal and excretion areas. However, with growing awareness of personal hygiene, wet toilet paper has become a commonly preferred cleansing product due to its soft texture, effective cleaning capability, and the convenience of being directly flushed into toilets for natural degradation[54]. In clinical settings, 75% alcohol wipes are primarily utilized for wiping object surfaces to achieve rapid cleaning and reduce the risk of infection transmission[55]. Given the diverse clinical conditions of patients admitted to the emergency department and the increased concern regarding cross-infection, patients' family members may mistakenly consider 75% alcohol wipes suitable for cleansing the excretion area. However, 75% alcohol wipes exhibit a certain degree of skin irritation potential and may trigger adverse skin reactions, including erythema, swelling, itching, and pain[56]. Therefore, the use of 75% alcohol wipes was identified as a risk factor associated with diaper dermatitis. These findings suggest that adequate health education should be provided by medical staff for critically ill patients in the emergency department, and patients and their family members should be advised to select non-irritating cleansing products, such as wet toilet paper or nursing wipes (a three-in-one product combining a cleanser, skin protectant, and emollient), thereby reducing skin damage and preventing the development of diaper dermatitis.

Absence of skin protectant use and low serum albumin concentration as risk factors for diaper dermatitis in critically ill patients in the emergency department

The findings of this study demonstrated that the absence of skin protectant application was associated with an increased risk of diaper dermatitis among critically ill patients in the emergency department, which was consistent with the findings reported by Chen. Effective skin management is considered an essential approach for preventing skin injury, and expert consensus has indicated that liquid dressings and skin protectants can provide preventive protection for skin integrity[16, 57]. Currently, Sanyrene skin protectant[58], a liquid dressing[59] widely used in emergency departments, consists of peroxidized corn oil combined with a small amount of anise. It has been reported to promote vasodilation and improve skin microcirculation, thereby reducing inflammatory responses[60]. Additionally, skin protectant film powder is frequently applied to damaged skin to maintain an appropriate dry environment[61]. For skin areas presenting with non-blanchable erythema, hydrocolloid dressings are commonly applied. These dressings are composed of sterile, semi-permeable adhesive materials, including an outer polyurethane backing layer with a thickness of 350 μm and a hydrocolloid adhesive component containing sodium carboxymethylcellulose. This structure forms a translucent protective film that reduces surface tension on the skin and contributes to skin protection, thereby decreasing the occurrence of diaper dermatitis[62]. For skin lesions that have progressed to ulceration, foam dressings may provide superior localized pressure reduction, close adherence, and sealing properties. These characteristics facilitate maximal absorption of inflammatory exudate and contribute to a reduced incidence of diaper dermatitis.

The findings of this study further indicated that low serum albumin concentration was associated with an increased risk of diaper dermatitis among critically ill patients in the emergency department. A cross-sectional survey conducted low albumin levels as a risk factor for diaper dermatitis[63]. This association may be explained by the reduced plasma colloid osmotic pressure observed in patients with decreased albumin concentrations, which increases susceptibility of the skin and mucous membranes to edema. Therefore, diaper use under these conditions may further elevate the risk of diaper dermatitis[64]. Furthermore, serum albumin concentration serves as an indicator of overall nutritional status to a certain extent, with lower levels reflecting poorer nutritional conditions[51]. When nutritional intake fails to meet physiological requirements, immune function may be impaired, and the capacity for tissue repair and maintenance of protective skin barriers may be reduced, thereby increasing susceptibility to diaper dermatitis. These findings suggest that, for patients at elevated risk of diaper dermatitis, appropriate skin protectants should be applied to prevent further progression of skin damage. Meanwhile, serum albumin concentrations should be regularly monitored, and nutritional supplementation should be provided in a timely

manner to reduce the likelihood of diaper dermatitis development.

A high-risk perineal assessment score as a risk factor for diaper dermatitis in critically ill patients in the emergency department

The findings of this study indicated that a high-risk perineal assessment score was associated with an increased risk of diaper dermatitis among critically ill patients in the emergency department. The perineal assessment tool primarily evaluates irritant intensity, duration of irritant exposure, perineal skin condition, and related contributing factors (e.g., low serum albumin, antibiotic use, and tube feeding)[65]. When unformed stool serves as the irritant, direct stimulation of the perineal skin may occur. To maintain skin cleanliness, patients' family members may increase wiping pressure during cleansing, which can compromise the protective function of the skin barrier. Furthermore, when erythema/dermatitis or peeling/erosion develops in the perineal region, adequate exposure of the affected area is required to prevent further skin damage caused by pressure[66]. Continued diaper use under these conditions may increase the likelihood of diaper dermatitis development[67]. Regarding associated contributing factors, including low serum albumin, antimicrobial drug use, tube feeding, and *Clostridioides difficile* infection, the coexistence of two or more factors may result in clinical manifestations such as malnutrition and impaired immune function, increasing the susceptibility of diaper-covered skin areas to diaper dermatitis when diapers are used[68]. These findings suggest that, in routine clinical practice, perineal assessment tools may be applied to identify patients at high risk of diaper dermatitis. Preventive strategies, including increasing diaper replacement frequency, exposing areas with impaired skin integrity, and applying protective agents, may subsequently be implemented to reduce the occurrence of diaper dermatitis.

Interpretation

In this study, a nomogram-based risk prediction model for diaper dermatitis was developed among critically ill patients in the emergency department, and eight risk factors were identified, including bed rest exceeding 7 days, use of pull-up diapers for urine and fecal collection, skin cleansing with alcohol wipes, absence of skin protectant application, low serum albumin levels, a high-risk perineal assessment score, an extremely severe pressure injury score, and a severe dependency score for self-care ability. The established model demonstrated satisfactory discrimination and calibration performance, enabling clinical medical staff to accurately identify high-risk populations. Furthermore, the model exhibited considerable predictive value and may serve as a reference for the development of targeted clinical interventions.

Limitations

However, several limitations should be acknowledged. The sample was obtained from a single center, specifically the emergency department of one hospital in Shandong Province, and the relatively limited sample size may have affected the generalizability of the findings. And this was a retrospective design, which may be subject to selection bias and information bias. Future multicenter prospective, large-scale, prospective study designs are needed to validate the nomogram.

Conclusion

In our study, we developed and internally validated a nomogram for predicting the risk of dermatitis in emergency critically ill patients based on variables available early after admission, which demonstrated good predictive value and clinical utility. Early identification of diaper dermatitis (DD) is vital for optimizing clinical outcomes and the quality of nursing care in critically ill emergency patients. The proposed prediction model integrates eight independent risk factors: bed rest exceeding 7 days, the use of pull-up diapers for urine and fecal collection, skin cleansing with alcohol wipes, absence of skin protectant application, decreased albumin levels, a high-risk perineal assessment score, an extremely severe pressure injury score, and a severe dependence score for self-care ability. The nomogram showed good discrimination and calibration and may serve as a bedside adjunctive tool for risk stratification in the emergency department, helping to identify patients at high risk of dermatitis. However, its clinical net benefit and cross-center generalizability require further investigation.

Clinical trial number: not applicable.

Availability of data and material

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

Financial support and sponsorship

This research did not get any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Human Ethics and Consent to Participate declarations

This study received approval from the Ethics Committee of the First Affiliated Hospital of Shandong First Medical University & Shandong Provincial Qianfoshan Hospital ([2026] Lunshen Document (S717)), and also followed the Declaration of Helsinki.

Consent to participate

No patients were directly contacted as part of this study. In accordance with Chinese regulations applicable to retrospective observational studies and clinical practice audits using anonymized data, individual patient consent was not required.

Consent for publication

All authors agree to its publication.

Competing interests

The authors declare no competing interests.

Acknowledgement

We really appreciated M.Sc. Pang for providing extensive guidance and all participants for assistance with data collection and analysis voluntarily in this study. And we also thank Bullet Edits Limited for the linguistic editing and proofreading of the manuscript.

Author's contributions

PQP and JRJ conceived and supervised the study. JRJ, WRX, ZLY and WW collected and analyzed the data. Initial and final version of the manuscript was written and read by JRJ and WRX. LJL and ZXJ performed and checked the results.

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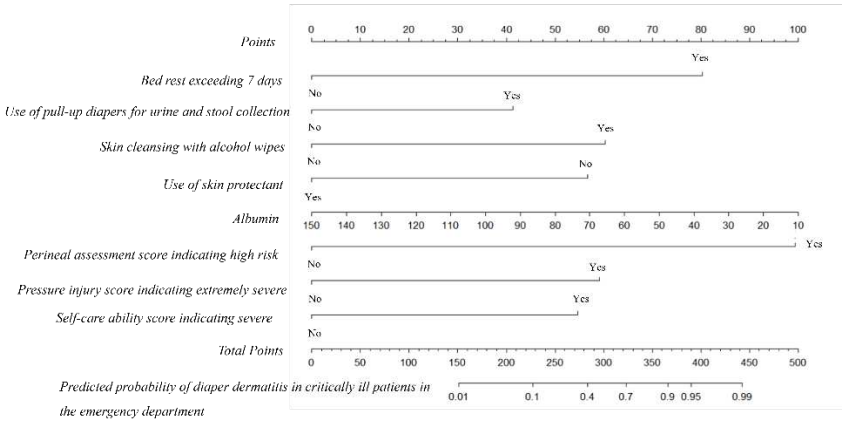


Figure 1. Nomogram for predicting the risk of diaper dermatitis in critically ill patients in the emergency department

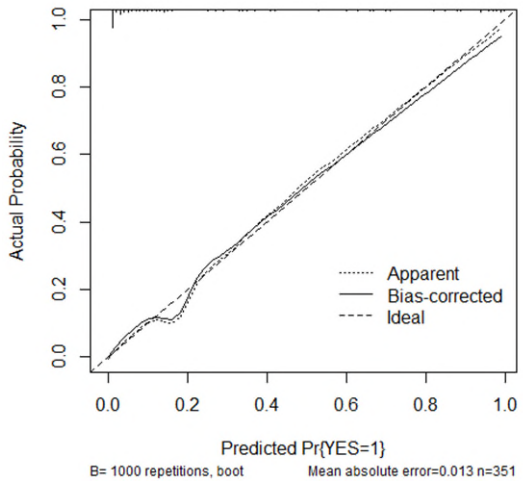


Figure 2. Calibration curve of the training group for predicting the occurrence of diaper dermatitis in critically ill patients in the emergency department

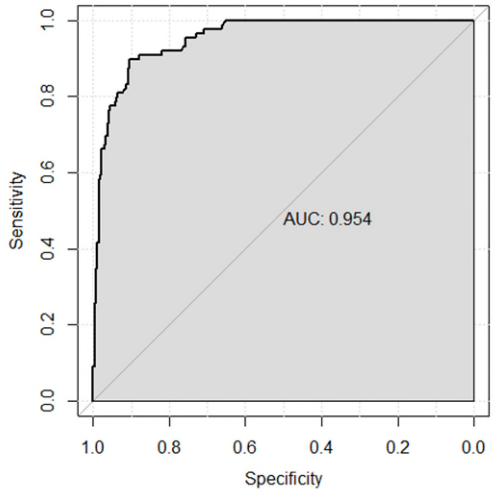


Figure 3. ROC curve of the training group for predicting the occurrence of diaper dermatitis in critically ill patients in the emergency department

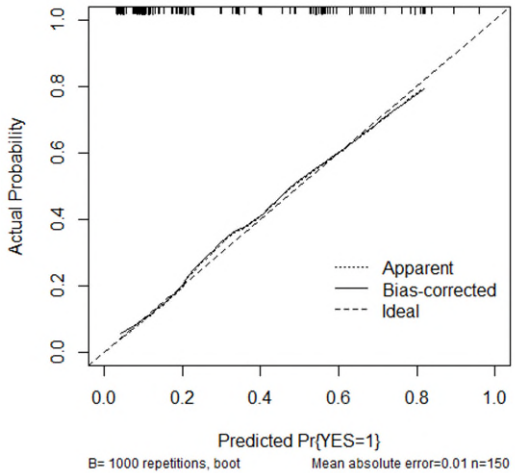


Figure 4. Calibration curve of the validation group for predicting diaper dermatitis in critically ill patients in the emergency department

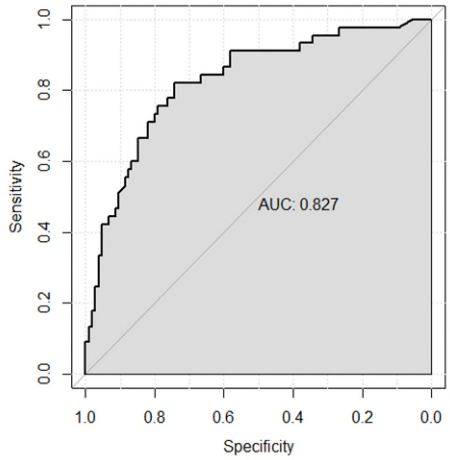


Figure 5. ROC curve of the validation group for predicting diaper dermatitis in critically ill patients in the emergency department

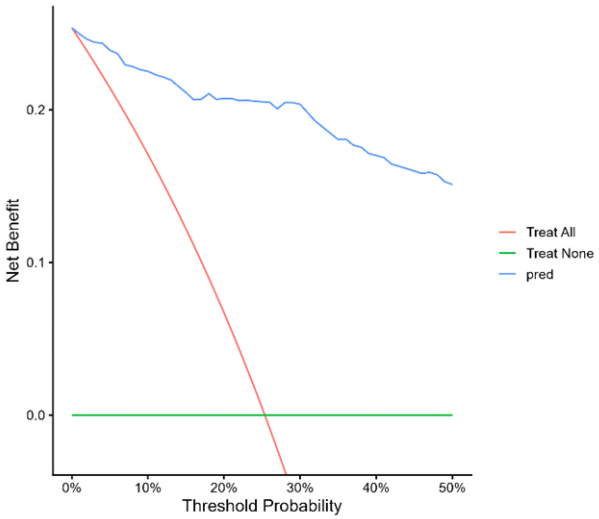


Figure 6. Decision curve analysis (DCA) of the nomogram in the internal validation cohort

Supplementary Files

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