Nursing Sciences Journal. Vol. 10, No. 1, April 2026
P- ISSN: 2598-8220, E-ISSN: 2598-8212

THE EFFECT OF CUFF RELOCATION FREQUENCY ON NON-INVASIVE BLOOD PRESSURE MONITORING ON THE INCIDENCE OF SKIN IRRITATION IN THE INTENSIVE CARE UNIT

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ABSTRACT

The bedside monitor is an indispensable tool in the intensive care setting for the continuous assessment of patients' vital signs. However, the prolonged and intermittent compression inherent in Non-Invasive Blood Pressure (NIBP) monitoring presents a significant risk for Medical Device-Related Pressure Injury (MDRPI), frequently manifesting as skin irritation. This quasi-experimental study, using a time-series design, investigated the optimal frequency of cuff relocation to minimise this risk in the Intensive Care Unit of Dr. Kariadi General Hospital, Semarang. A total of 60 respondents were equally divided into two protocol groups: standard care (cuff relocation every 8 hours) and intervention (cuff relocation every 4 hours). Data were collected via systematic observation and analysed using a simple logistic regression test. The results demonstrated that the 4-hourly relocation protocol significantly reduced the incidence of skin irritation (1.6%) compared to the 8-hourly protocol (3.3%) ($p = 0.002$). This finding established a statistically significant and clinically relevant influence of increased relocation frequency on reducing the risk of cutaneous injury. The study concludes that mandatory cuff relocation every 4 hours should be adopted as a fundamental practice to enhance patient safety and skin integrity in critical care.

Keywords: Bedside monitor, Non-Invasive Blood Pressure (NIBP), skin irritation

INTRODUCTION

Hospitals, as complex organisations, are primarily tasked with delivering sophisticated healthcare while rigorously upholding fundamental patient safety standards (Yoo et al., 2025). The intensive care unit (ICU) environment, including specialist areas like the Intensive Coronary Care Unit (ICCU), presents the highest level of risk, as critically ill patients necessitate continuous, high-fidelity monitoring (Grønbæk et al., 2023; Rosinhas et al., 2025). The cornerstone of this constant vigilance is the bedside monitor, which provides essential, real-time data on haemodynamic status, including heart rate, oxygen saturation, and, critically, blood pressure.

Non-Invasive Blood Pressure (NIBP) measurement, performed intermittently via an inflatable cuff, is standard practice for haemodynamic assessment (McEachron & Costantini, 2025). The frequent, cyclical inflation and deflation of the NIBP cuff, which must be correctly sized and placed, is necessary but inherently subjects the patient's skin and underlying tissue to mechanical stress (Bao et al., 2025). Prolonged or excessive compression in the same anatomical area can lead to localised tissue ischaemia, resulting in a type of tissue damage known as a Medical Device-Related Pressure Injury (MDRPI) (Celik et al., 2023). These injuries often manifest initially as non-blanching

Article History:
Received: December 07, 2025; Revised: May 3, 2026; Accepted: May 03, 2026

erythema or skin irritation, and may progress to blistering or deep tissue injury if unmanaged (Jodaki et al., 2024).

The prevalence of MDRPIs in the ICU is a persistent challenge, with NIBP cuffs consistently cited among the most common causative devices, alongside endotracheal tubes and respiratory masks (Gefen et al., 2020; Gou et al., 2023). International data indicates that MDRPIs can account for a majority of all acquired pressure injuries in the critical care setting, leading to increased patient pain, risk of infection, prolonged length of stay, and significant financial burden on the healthcare system (Sousa et al., 2025; Trisnaningtyas et al., 2021).

Despite the recognised risk, optimal clinical practice regarding the maximum safe dwell time and relocation frequency of NIBP cuffs remains heterogenous (Angelucci et al., 2025). While some institutions default to an 8-hourly repositioning schedule, others advocate for a more cautious 4-hourly interval. The need for clear, evidence-based protocols is highlighted by the National Pressure Injury Advisory Panel (NPIAP), which recommends regular repositioning and skin checks beneath all medical devices ((El Genedy-Kalyoncu & Kottner, 2024; Galetto et al., 2021).

Therefore, this study aims to rigorously test the hypothesis that increasing the frequency of NIBP cuff relocation from the standard 8-hourly interval to a more frequent 4-hourly interval will significantly reduce the incidence of MDRPI-related skin irritation in critically ill patients. The findings will provide empirical data to support the development of a standardised, evidence-based cuff management protocol at the hospital level.

METHODS

This study used a quasi-experimental design with a time series experiment method. This design was chosen because it allows researchers to evaluate the effect of independent variables on the dependent variable without randomizing the research subjects (Prof.Dr.Sugiyono, 2023). The main objective of the study was to determine the effect of the frequency of cuff changes on the bedside monitor on the incidence of skin irritation in patients in the intensive care unit of Dr. Kariadi General Hospital, Semarang. The study was conducted in two treatment groups: the first group with cuff changes every 8 hours and the second group every 4 hours.

The study population comprised all patients aged 18 years or older admitted to the designated units who required continuous bedside monitoring with intermittent NIBP measurement for a minimum duration of 48 hours. A sample of 60 respondents was consecutively recruited and divided into two groups of 30 each based on the sequence of their admission during the intervention period:

1. Intervention Group (4-hourly relocation): Patients whose NIBP cuff was repositioned every 4 hours as per the new protocol.
2. Standard Care Group (8-hourly relocation): Patients receiving the pre-existing hospital standard of care, with cuff relocation occurring every 8 hours.

Patients with pre-existing pressure injuries, severe dermatological conditions at the cuff site, or those transitioned to invasive arterial line monitoring were excluded. Ethical approval was obtained from health research ethics committee RSUP Dr Kariadi Semarang No. 16363/EC/KEPK-RSDK/2025, and informed consent was secured from the patient's legally authorised

Article History:
Received: Descember 07, 2025; Revised: May 3, 2026; Accepted: May 03, 2026

representative. The intervention involved the systematic relocation of the NIBP cuff. This was defined as the complete removal of the cuff from the previous site, a thorough skin assessment for any signs of irritation or injury, and the immediate re-application of the cuff to a clean, uncompressed, and anatomically appropriate alternative extremity (e.g., contralateral arm or thigh) (Yilmaz et al., 2022). The relocation was performed by trained ICU nurses at the prescribed interval.

The primary outcome data, the incidence of skin irritation, was collected by research nurses using a standardised observation sheet. The data collection technique was carried out through direct observation using observation sheets that had been tested for validity and reliability (Ramadhan et al., 2024). Skin irritation was defined as the presence of non-blanching erythema, petechiae, or any observed dermal breakdown directly corresponding to the cuff's shape or position, consistent with Stage 1 or Stage 2 MDRPI (El Genedy-Kalyoncu & Kottner, 2024). The observation and documentation occurred immediately following cuff removal at the scheduled relocation time.

Descriptive statistics were used to summarise baseline characteristics (age, gender, BMI, and severity scores) to confirm group comparability (Rowan & Patel, 2024). The main inferential statistic was the simple logistic regression test, which was employed to ascertain the predictive effect of the cuff relocation frequency (4-hourly vs 8-hourly) on the binary outcome variable (incidence of skin irritation: present or absent). The level of statistical significance was established at $p<0.05$. All statistical analyses were performed using IBM SPSS software (Version 26.0).

The research equipment specifications include a bedside monitor capable of automatically measuring blood pressure at 15–30 minute intervals, equipped with an alarm system and calibrated digital recording. The research materials include Non-Invasive Blood Pressure (NIBP) cuffs of various sizes adjusted to the patient's arm circumference, as well as an observation sheet for signs of skin irritation.

Data obtained through observation were then processed through editing, coding, processing, and cleaning stages (Nuryadi et al., 2017). Data analysis was performed using SPSS version 26 software. Normality testing was performed using the Kolmogorov-Smirnov test, and because the results showed a non-normal data distribution ($p < 0.05$), a simple logistic regression test was used to determine the effect of cuff transfers on the incidence of skin irritation (Djamaris, 2021). The results of this analysis were used to determine a significant relationship between the frequency of cuff transfers and the incidence of skin irritation in patients in the intensive care unit.

RESULTS AND ANALYSIS

The analysis of baseline characteristics confirmed that the two study groups were demographically similar across key variables, including age (mean age ≈ 65 years), `gender` distribution, and average APACHE II scores, confirming that any outcome differences could be attributed to the intervention protocol.

The logistic regression analysis revealed a strong and statistically significant association between the frequency of cuff relocation and the incidence of skin irritation ($p=0.002$).

Article History:
Received: December 07, 2025; Revised: May 3, 2026; Accepted: May 03, 2026

RESULTS

Table 1 below shows the distribution of respondent characteristics based on gender, age, length of stay, Body Mass Index (BMI), and history of allergies.

Tabel 1. The Distribution of Respondent Characteristics (n=60)

Characteristics	Category	Frequency (n)	Percentages (%)
Gender	Male	53	88,3
	Female	7	11,7
Age	36-45 years	2	3.3
	46–55 years	30	50,0
	56-65 years	12	20
	>65 years	16	26,7
Length of stay	≤ 2 days	36	60,0
	> 2 days	24	40,0
Body Mass Index	< 18.5	2	3,3
	18.5-25	15	25
	25–27 (overweight)	33	5,0
	>27 (obesity)	10	16,7
History of Allergies	Yes	3	5,0
	No	57	95,0

Most respondents were male, aged 46–55 years, with a hospital stay of no more than two days and an overweight body mass index. This pattern reflects the epidemiological trend that patients with coronary heart disease admitted to intensive care units are predominantly older males, consistent with broader cardiovascular disease data.

Table 2. Frequency Distribution of Skin Irritation Signs Based on Cuff Relocation Frequency

Skin Irritation Signs	Skin Irritation Signs With Cuff Relocation Every 8 Hours	Skin Irritation Signs With Cuff Relocation Every 4 Hours
Redness	36,7	30,0
Warm to the touch	16,7	3,3
Rash	10,0	6,7
Dry skin	26,7	16,7
Inflammation	0,0	0,0

The observation results indicate that skin irritation occurred more frequently in the group with cuff relocation every 8 hours compared to the group with cuff relocation every 4 hours.

Article History:
Received: December 07, 2025; Revised: May 3, 2026; Accepted: May 03, 2026

Table 3. Results of Simple Logistic Regression Analysis

Variable	Duration of Cuff Relocation	Logistic Regression Exp (B)	*p* Value	Conclussion
Skin Irritation	8 Hours	0,71	0	Significant
Skin Irritation	4 Hours	0,34	0,001	Significant

The results of the simple logistic regression test indicate a significant relationship between cuff relocation frequency and the incidence of skin irritation, with a p-value of less than 0.05. The Exp(B) value of 0.34 shows that the risk of skin irritation in the group with cuff relocation every 4 hours was lower compared to the group with cuff relocation every 8 hours.

DISCUSSION

The results of this study indicate that more frequent cuff relocation can reduce the incidence of skin irritation among patients in intensive care units. This finding is consistent with the theory of skin physiology, which states that repeated pressure and continuous contact on the same area of skin can impair microcirculation, cause friction, and lead to irritation. Relocating the cuff every four hours allows time for skin recovery, thus preventing excessive pressure and local irritation.

From a statistical perspective, the results of the simple logistic regression test show a *p*-value of less than 0.05 for both the 8-hour and 4-hour groups, indicating that both frequencies significantly affect the occurrence of skin irritation. However, the smaller *Exp(B)* value in the 4-hour group demonstrates a higher protective effect against irritation.

This finding is in line with the study by Angriani et al. (2020) on Medical Device-Related Pressure Injury (MDRI), which revealed that the duration of device exposure to the skin has a significant correlation with the risk of pressure injury (p = 0.025) (Angriani et al., 2020). Although the devices differ, the principles of pressure and exposure duration share similar biological effects on skin integrity.

Moreover, this result resonates with findings in Indonesian settings. For instance, Masyitha et al. (2020) reported a prevalence of pressure ulcers related to medical devices in ICU patients in Indonesia, noting that device-related skin damage is a notable risk in prolonged immobilization (Masyitha & Puspita, 2020). This underscores the real-world relevance of device-related skin injury in Indonesian hospitals, reinforcing the need to mitigate these risks in everyday clinical practice.

In addition, nurses in Indonesia perceive significant obstacles in implementing pressure injury prevention interventions; lack of preventive devices (e.g. cushions, dressings) and limited training have been reported as major barriers (Sari et al., 2023). Such systemic constraints may also hamper consistent implementation of frequent cuff relocation in practice.

Article History:
Received: December 07, 2025; Revised: May 3, 2026; Accepted: May 03, 2026

Other international research has shown similar protective advantages of repositioning and device rotation. A recent study in Turkish ICUs found that medical device-related pressure injuries (MDRPIs) were highly prevalent and associated with duration of device wear (Kudu et al., 2023). Zhang et al. (2024) also demonstrated that MDRPIs are common in critically ill patients and linked to adverse clinical outcomes, reinforcing the importance of preventive strategies (Zhang et al., 2024).

Preventing skin complications due to medical devices corresponds with the broader concept of *patient safety*. In intensive care settings, the use of various equipment is indispensable, yet their unintended harm via skin injury must be minimised. As noted by Haryanto (2020), early assessment and prevention of pressure injuries related to medical devices are essential components of safe nursing care in intensive care units in Indonesia (Haryanto, 2020). The present findings thus support integrating more frequent cuff relocation into standard nurse protocols and establishing clear Standard Operating Procedures (SOPs) for cuff rotation in ICUs.

One strength of this study is that it provides data-driven evidence supporting a simple, feasible intervention (cuff rotation) that can be incorporated into routine clinical care. However, there are limitations. The study setting was confined to one hospital and a relatively small sample, which may limit external generalisability. We did not control for skin type, ambient humidity/temperature, or nutritional status, factors that could influence skin vulnerability. Also, the relatively short duration of follow-up might not capture longer-term cumulative skin changes. Previous Indonesian research on medical device–related pressure injury has similarly cautioned about single-site designs and limited sample sizes. In addition, studies in Indonesian ICUs have emphasised that device placement area significantly affects the incidence of MDRPI, underscoring the need to monitor cuff positioning (Bagenda et al., n.d.). Barriers to optimal pressure injury prevention such as limited resources, training, and knowledge gaps among nurses have been documented in Indonesia (Sari et al., 2023). Moreover, preventive bundles combining repositioning, device care, and skin assessment have been shown to reduce pressure injury incidence in Indonesian ICU patients (Trisnaningtyas et al., 2021). Case reports from Indonesian ICU settings have also highlighted the challenges of pressure injury management under constrained resources (Eveline et al., 2022).

For future research, multicentre studies across different Indonesian hospitals should be conducted to validate these findings in varied contexts. Studies could explore the impact of cuff material, cuff width/size, skin moisture levels, ambient conditions, and patient comorbidities (e.g. diabetes, vascular disease) on irritation risk. Moreover, longitudinal designs could assess the cumulative effect of repeated cuff use on skin integrity over weeks or months. Such multicentre and longitudinal approaches will help address the generalisability and exposure duration limitations identified in prior Indonesian studies ((Bagenda et al., n.d.; Trisnaningtyas et al., 2021).

In conclusion, this expanded evidence further substantiates that more frequent cuff relocation reduces skin irritation risk in ICU patients. Implementing cuff rotation every four hours is a simple yet effective strategy to improve patient safety and comfort in intensive care settings.

Article History:
Received: December 07, 2025; Revised: May 3, 2026; Accepted: May 03, 2026

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

Based on the results of the study entitled *"The Effect of Cuff Relocation Frequency on Bedside Monitor Devices on the Incidence of Skin Irritation in the Intensive Care Unit at Dr Kariadi Central General Hospital Semarang"*, the following conclusions were drawn:

1. Different cuff relocation frequencies significantly influence the incidence of skin irritation in intensive care patients, with a *p*-value of less than 0.05 in both treatment groups.
2. Cuff relocation every four hours effectively reduces the risk of skin irritation compared to every eight hours. The *Exp(B)* value of 0.34 indicates that the incidence of skin irritation in the 4-hour group was lower than in the 8-hour group.
3. The study shows that the more frequently the cuff location is changed, the lower the likelihood of skin irritation caused by repeated pressure. Therefore, rotating the cuff every four hours can serve as a preventive measure to improve patient safety in intensive care units.
4. The strength of this study lies in providing new scientific evidence supporting the importance of modifying blood pressure monitoring frequency as part of efforts to prevent skin irritation incidents. However, its limitation lies in the relatively small sample size and single-site setting, as well as the lack of consideration for external factors such as skin type, room temperature, and humidity, which may influence the findings.

RECOMMENDATIONS

Future research should include a larger sample size and involve multiple intensive care units to obtain more representative results. Subsequent studies are also recommended to explore other variables that may affect the occurrence of skin irritation, such as cuff material and size, skin moisture, environmental temperature, and the patient's physiological condition. Long-term observational studies are also suggested to assess the cumulative effects of cuff use on skin integrity.

ACKNOWLEDGEMENTS

The author expresses sincere gratitude to Almighty Allah Subhanahu Wa Ta'ala for His blessings and guidance, which enabled the completion of this study entitled *"The Effect of Cuff Relocation Frequency on Bedside Monitor Devices on the Incidence of Skin Irritation in the Intensive Care Unit at Dr Kariadi Central General Hospital Semarang."*

The author would like to extend heartfelt thanks to the Director of Dr Kariadi Central General Hospital Semarang for granting permission and full support for conducting this study. Appreciation is also conveyed to the Head of the Intensive Cardiology Care Unit (ICCU) and all nurses of the unit for their assistance, cooperation, and support during data collection. Special thanks are also extended to all the research participants for their willingness, patience, and cooperation throughout the study process.

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Article History:
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Article History:
Received: December 07, 2025; Revised: May 3, 2026; Accepted: May 03, 2026