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Impact of Care Bundles Prevention of Hospital-Acquired Pressure Injuries: A Systematic Review and Meta-Analysis

Ayse Silanur Demir | Ayise Karadag

School of Nursing, Wound Research Laboratory, Koç University, Istanbul, Türkiye

Correspondence: Ayse Silanur Demir (aysedemir20@ku.edu.tr)

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ABSTRACT

Aim: To describe and synthesise current literature on care bundles in preventing hospital-acquired pressure injuries and to present a meta-analysis of experimental studies evaluating the effects of care bundles.

Design: A systematic review and meta-analysis.

Methods: Pubmed, Cochrane Library, Scopus, Web of Science, CINAHL, Google Scholar and Medline (OVID), and relevant articles were identified from the inception of each database until June 5, 2024. This systematic review has been registered in PROSPERO (CRD42024554497). This study examined a multicomponent intervention care bundles consisting of three or more components that was implemented and compared with standard care. Outcomes were assessed using rates of hospital-acquired pressure injuries, length of hospital stay (days) and the number of pressure injuries. Study types included randomised controlled trials, nonrandomised studies, quasi-experimental studies, and cohort studies. After completion of the search, titles, abstracts and full texts were independently assessed by two researchers in consecutive rounds according to PICOS criteria; data were extracted and study quality was independently assessed by at least two researchers. A meta-analysis using random effects was conducted, where estimates were combined as odds ratios or risk differences, along with proportions and 95% confidence intervals were calculated.

Results: A total of nine published studies, including 29.572 patients (Control group: 56.8%; Intervention group: 43.2%) were included in this review. The meta-analysis results showed a significant effect of care bundle intervention on hospital-acquired pressure injuries rates, length of hospital stay and number of pressure injuries. According to the results of the study, care bundle application reduces the rate of hospital-acquired pressure injuries, shortens the duration of hospitalisation, and reduces the number and severity of pressure injuries.

No Patient or Public Contribution: Although patients and the public were not directly involved in the study, the research addresses key concerns about preventing hospital-acquired pressure injuries. By focusing on care bundles to improve patient safety and reduce pressure injury rates, this study aims to enhance the quality of care, shorten hospital stays and improve patient outcomes, ultimately benefiting both patients and the healthcare system.

Trial Registration: CRD42024554497

1 | Introduction

Pressure injuries (PIs), impacting around 2.5 million patients each year, are characterised as 'a localized injury to the skin and/or underlying tissue resulting from pressure or pressure-induced rupture' (Haesler 2019; EPUAP/NPIAP/PPPIA 2019). Hospital-acquired Pressure Injuries (HAPIs) describe any PIs that are not present at the time of hospital admission

(Haesler 2019). Despite technological and scientific advances, HAPIs are among the five most common causes of adverse patient outcomes (Floyd et al. 2021). Within 1 week of hospitalisation, approximately 15% of patients over the age of 60 have reportedly developed HAPIs (Khor et al. 2014). HAPI prevalence rates range from 3% to 17.6% in Australia, 12% to 17% in Europe, 3.8% to 19.7% in the USA, and 4.7% to 7.1% in the UK (Barakat-Johnson et al. 2019).

HAPIs reduce patients' quality of life, and they also result in unnecessary hospital stays, increased costs, and resource utilisation (Goodman et al. 2018; Padula and Delarmente 2019; Pittman et al. 2019). The average inpatient cost for patients with HAPI is $66,064, compared with $35,844 for patients without HAPI (Paul 2018). The National Database on Nursing Quality Indicators (NDNQI) estimated that the average HAPI costs approximately $50,000 to $150,000 per injury and has a 12% increased mortality rate. (Agency for Healthcare Research and Quality (AHRQ) 2020) In 2016, the average cost of caring for a patient with HAPI in the United States was $10,708, with a total of 2.5 million cases, resulting in an annual cost of more than $26.8 billion (Padula and Delarmente 2019). Therefore, early detection and prevention methods of HAPIs are essential for cost-effective and high-quality care.

The rate of HAPIs is an indicator reflecting the effectiveness of preventive care in hospitals (Baharestani et al. 2009). Evidence-based guidelines for PIs care (EPUAP/NPIAP/PPPIA 2019) provide recommendations for clinical practice, and HAPIs can be significantly reduced by implementing evidence-based practices throughout the hospital (Padula et al. 2015; Gaspar et al. 2019). At this point, one of the ways to disseminate evidence-based practices and standardise care protocols in clinical settings is through the use of care bundles (Tayyib et al. 2015). A bundle of care consists of three to five evidence-based interventions that, when used together, enhance care processes and improve patient outcomes. (Institute for Healthcare Improvement 2024) Care bundles were developed as a method for nurses and other healthcare professionals to standardise and improve preventive care practices (Institute for Healthcare Improvement 2024), including for individuals at risk of PIs (Chaboyer et al. 2016; Jafary et al. 2018).

Care bundles, which have been used intensively in providing quality nursing care in recent years, have been shown to reduce HAPI rates (Chaboyer et al. 2024). The aim of this systematic review and meta-analysis is to evaluate the effects of care bundles applied to patients on the rate of HAPI, length of hospital stay (LOS), and the number of developing PIs compared to previously determined standard care. In this context, this study aims to describe and synthesise the current literature on care bundles in the prevention of HAPIs and presents a meta-analysis of experimental studies evaluating the effects of care bundles.

1.1 | Research Questions

1. What is the effect of care bundles used to prevent HAPIs on the HAPI rate?
2. What is the effect of care bundles used to prevent HAPIs on the length of hospital stay?
3. What is the effect of care bundles used to prevent HAPIs on the number of PIs?

2 | Methods

2.1 | Study Design

This study reviewed experimental research examining the effectiveness of care bundles in preventing HAPIs. The study followed PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and used the appropriate checklist for developing the study protocol (PRISMA P, see Appendix A), conducting the research, and drafting the manuscript, as shown in Figure 1 (Page et al. 2021). The study protocol was registered in the PROSPERO database (Registration No: CRD42024554497).

2.2 | Search Strategy

The keywords were identified based on systematic reviews and the knowledge of two researchers. After final adjustments made in collaboration with an expert librarian, the librarian conducted a thorough search across PubMed, Cochrane Library, Scopus, Web of Science, CINAHL, Google Scholar and Medline (OVID), retrieving relevant articles from the start of each database up to June 5, 2024. A sample combination of consisted keywords used in reviewing included databases were (hospital acquired) AND ('pressure ulcer' OR 'pressure sore' OR 'bed sore' OR bedsore OR 'decubitus sore' OR 'decubitus ulcer' OR 'pressure injury' OR 'pressure injuries') AND (bundle OR 'care bundle' OR prevention OR improvement OR management OR guideline OR implemention OR intervention OR outcomes OR cost OR burden OR 'cost-effectiveness'). Information about the search strategy can be found in Appendix B.

2.3 | Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were determined by patient/population, intervention, comparison, and outcomes (PICOS) (Higgins et al. 2011) are represented in Table A1.

2.4 | Study Selection

Endnote 20 was used to manage the references for this study. Two members of the research team independently screened all titles and abstracts according to the established eligibility criteria. Data were reviewed for accuracy, and a procedure was set to address any discrepancies. Following this, both researchers conducted an initial screening of the full texts. During the full-text review, each article was independently evaluated by two team members for inclusion or exclusion based on the same eligibility criteria. In cases where both reviewers agreed, the study was excluded if ineligible. If the two reviewers disagreed, a third review team member resolved conflicts. Figure 1 outlines the key features of studies that

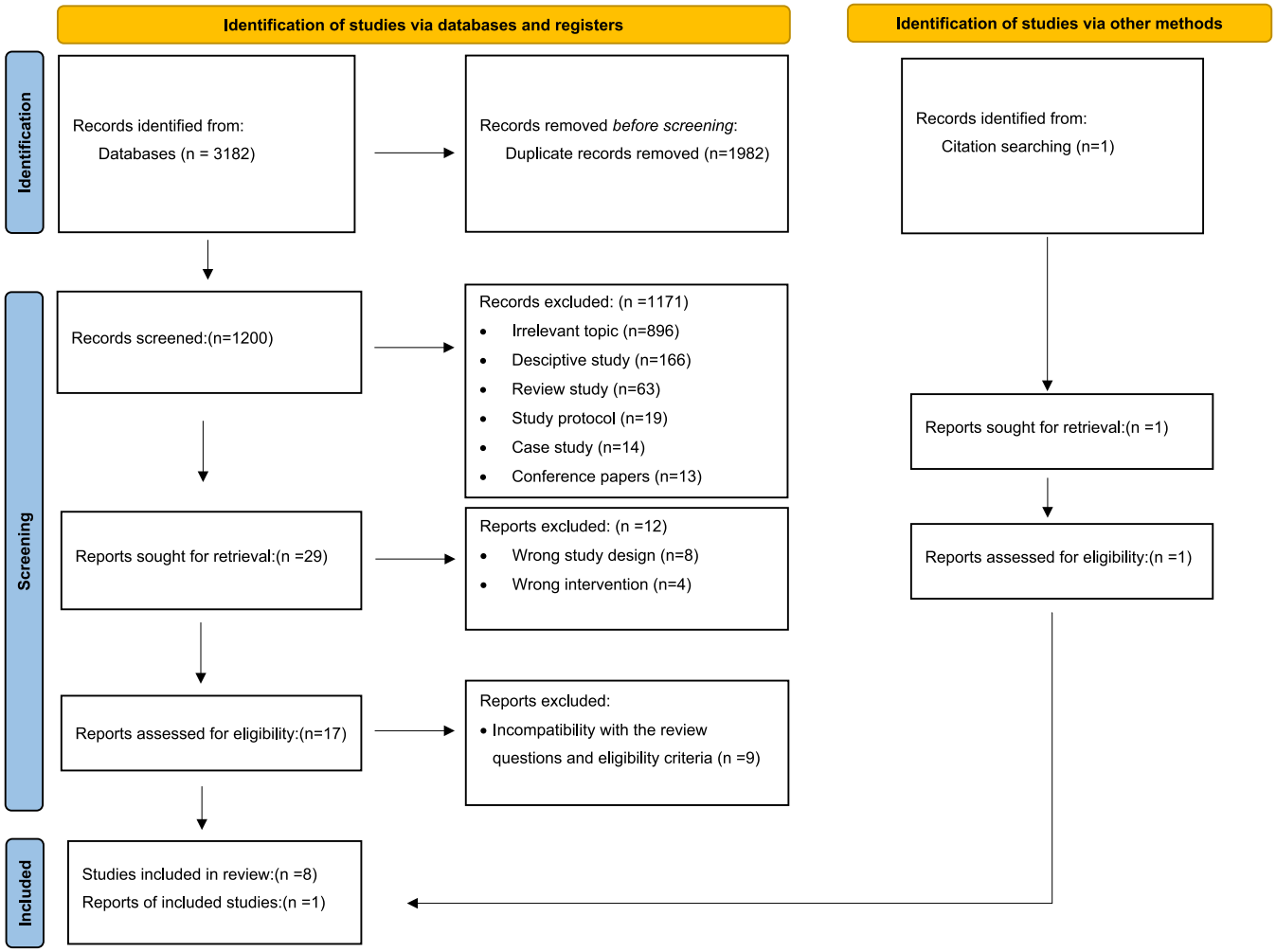

FIGURE 1 | PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources.

meet our eligibility criteria, focusing on the characteristics of included studies (Figure 1).

2.5 | Data Extraction

We extracted the data using a pre-designed form after screening, selecting, and evaluating the quality of selected studies. We recorded all studies as author, year/country, type of study, sample size, setting, LOS, follow-up time, aim, intervention procedure, standard care, measurement and results Table A2.

Data extraction was performed by the two authors, who then reviewed and discussed their findings together. Any disagreements were resolved through discussion until both researchers reached a consensus. We screened a total of 3182 articles from databases. After removing 1982 duplicates, 1200 articles were reviewed for relevance based on titles and abstracts. Of these, 29 were excluded for being off-topic or not meeting inclusion criteria, leaving 17 articles for further assessment. From these, eight were deemed relevant and evaluated for quality. Additionally, one study was included based on information from previously published systematic reviews. In total, nine articles were included in the systematic review (refer to Figure 1).

2.6 | Outcome Measures

This study used the HAPI rate, LOS and the number of PIs developed in patient results. The primary outcome of this study was to compare the incidence of HAPI in those who received a care bundle and those who received only standard care without a care bundle. The secondary outcome of this study was to compare the number of PIs and LOS in patients who received a care bundle and in patients who received standard care only without a care bundle. In all included studies, HAPI rates, length of stay and the number of PIs were recorded using forms created by the researchers.

2.7 | Methodological Quality Assessment of Studies

We used the RoB 2.0 tool to evaluate three cluster randomised controlled trials included in the review. This tool examines each study across five areas: the randomization process, the timing of identification and recruitment of individual participants in relation to the timing of randomization, deviations from the intended intervention, missing outcome data, and the selection of reported results. It also provides an overall bias assessment (Eldridge et al. 2016). For the six a quasi-experimental studies

included in the review, we used the risk of bias assessment tool for nonrandomized studies (ROBINS-I). This tool assesses the quality and risk of bias in nonrandomized interventional studies across seven domains: confounding, participant selection, intervention classification, deviations from the intended intervention, missing data, outcome measurement and result selection (Sterne et al. 2016). In this study, two researchers conducted independent quality assessments. Any discrepancies between their evaluations were addressed through a review of the original texts and resolved through discussion. The two authors worked separately on the assessments, and any disagreements were discussed and resolved, resulting in a summary report of their findings.

2.8 | Data Synthesis

The meta-analysis was performed using Comprehensive Meta-Analysis software version 3.3.070 (Biostat, Englewood, NJ). We calculated Hedges' g with 95% confidence intervals to estimate the true effect size across the studies. Similar to Cohen's d, Hedges' g can be interpreted using the same thresholds: 0.2 indicates a small effect, 0.5 a medium effect, and 0.8 a large effect. However, Hedges' g is preferred for its ability to adjust for biases in small sample sizes. To explore potential heterogeneity or inconsistencies in the size or direction of effects among the studies, we used Cochran's Q test ($p < 0.10$) and Higgins' I (EPUAP/NPIAP/PPPIA 2019) statistic. Heterogeneity was categorised as follows: 0%–40% as potentially unimportant, 30%–60% indicating moderate heterogeneity, 50%–90% suggesting substantial heterogeneity and 75%–100% indicating considerable heterogeneity (Higgins et al. 2011). An I2 value above 50% is usually regarded as indicating significant heterogeneity, which may raise concerns about the reliability of the study results (Bown and Sutton 2010). Due to the variations in populations across the studies, we employed a random effects model for the primary analysis, as it is frequently used in meta-analyses. This approach accounts for differences between studies more effectively than a fixed-effect model. All analyses were conducted using two-tailed tests, with statistical significance set at a p-value below 0.05.

3 | Results

A total of 3182 publications were identified at the seven electronic databases in the initial search, and nine studies were included according to the selection PICOS criterion. The flow diagram shows the selection process in Figure 1.

3.1 | Study Characteristics

The characteristics of included nine studies were described in Table A2. The total sample size in the nine studies was 29,572, with 56.8% ($n = 16{,}595$; range 102–18.900) in the control groups and 43.2% ($n = 13{,}022$; range 102–18,900) in the intervention groups. Of the studies included in the analysis, three were cluster randomised controlled trials (Tayyib et al. 2015; Chaboyer et al. 2016; Jafary et al. 2018), and six were pre- and post-intervention quasi-experimental studies (Gray-Siracusa and Schrier 2011; Anderson et al. 2015; Coyer et al. 2015; Al-Otaibi et al. 2019; Zhang et al. 2021; Aloweni et al. 2023). The studies were conducted between 2011 and 2023 in the USA ($n = 2$), Saudi Arabia ($n = 2$), Australia ($n = 2$), China ($n = 1$), Iran ($n = 1$) and Singapore ($n = 1$).

3.2 | Intervention Procedure

The intervention procedure included the implementation of care bundles. Most studies were conducted in Intensive Care Units (ICU) ($n = 6$) (Tayyib et al. 2015; Chaboyer et al. 2016; Gray-Siracusa and Schrier 2011; Anderson et al. 2015; Coyer et al. 2015; Zhang et al. 2021), and the follow-up time of the care bundles ranged from 2 weeks (Zhang et al. 2021) to 4 weeks (Tayyib et al. 2015; Coyer et al. 2015). The number of care bundle components in the included studies ranged from three to nine. Care bundle components generally included risk assessment, repositioning, use of appropriate support surfaces, skin care, and staff or patient education (Table A2).

3.3 | Standard Care/Control Procedure

The control group and the pre-intervention group received standard PIs prevention interventions implemented in the hospital at the beginning of the study, including weekly risk assessment with the Braden Scale and standard care procedures such as repositioning and skin care.

3.4 | Risk of Bias Within Studies

Figure 2 shows a summary of the risk of bias: 72.22% have low risk, 22.22% have some concerns and 5.56% have no information. The areas where risks of bias are most common are deviations from intended intervention (100%), missing outcome data (66.67% no information, 33.33% low risk) and measurement of the outcome (100%) (Tayyib et al. 2015; Chaboyer et al. 2016; Jafary et al. 2018).

Figure 3 shows a summary of the risk of bias: 85.71% have a low risk, and 14,29% have a moderate risk. The areas where risks of bias are most common are bias due to confounding (66,67%), bias due to selection of participants (33,33%), and bias due to missing data (16,67%) (Gray-Siracusa and Schrier 2011; Anderson et al. 2015; Coyer et al. 2015; Al-Otaibi et al. 2019; Zhang et al. 2021; Aloweni et al. 2023).

3.5 | Outcomes of Meta-Analysis

3.5.1 | HAPIs Rate

In a pooled meta-analysis of 29,572 patients from nine studies, a statistically significant difference was found in the odds of developing HAPIs between patients receiving a bundle of care and those receiving standard care ($p < 0.001$) (Tayyib et al. 2015; Chaboyer et al. 2016; Jafary et al. 2018; Gray-Siracusa and Schrier 2011; Anderson et al. 2015; Coyer et al. 2015; Al-Otaibi et al. 2019; Zhang et al. 2021; Aloweni et al. 2023). The odds of developing HAPIs were reduced by 57.6% after implementing care bundles compared to patients receiving standard care

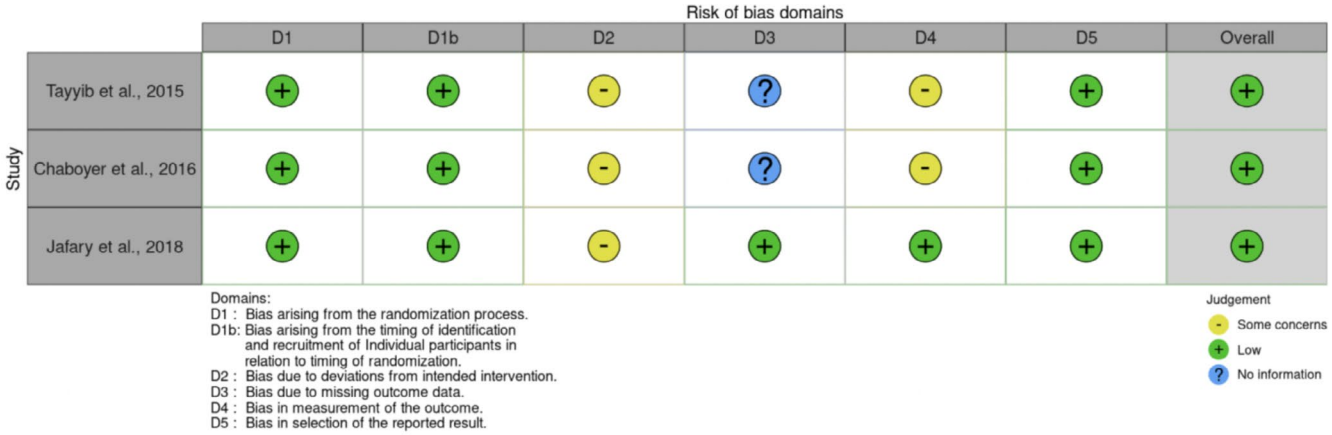

FIGURE 2 | Risk of Bias of the Randomised Controlled Studies.

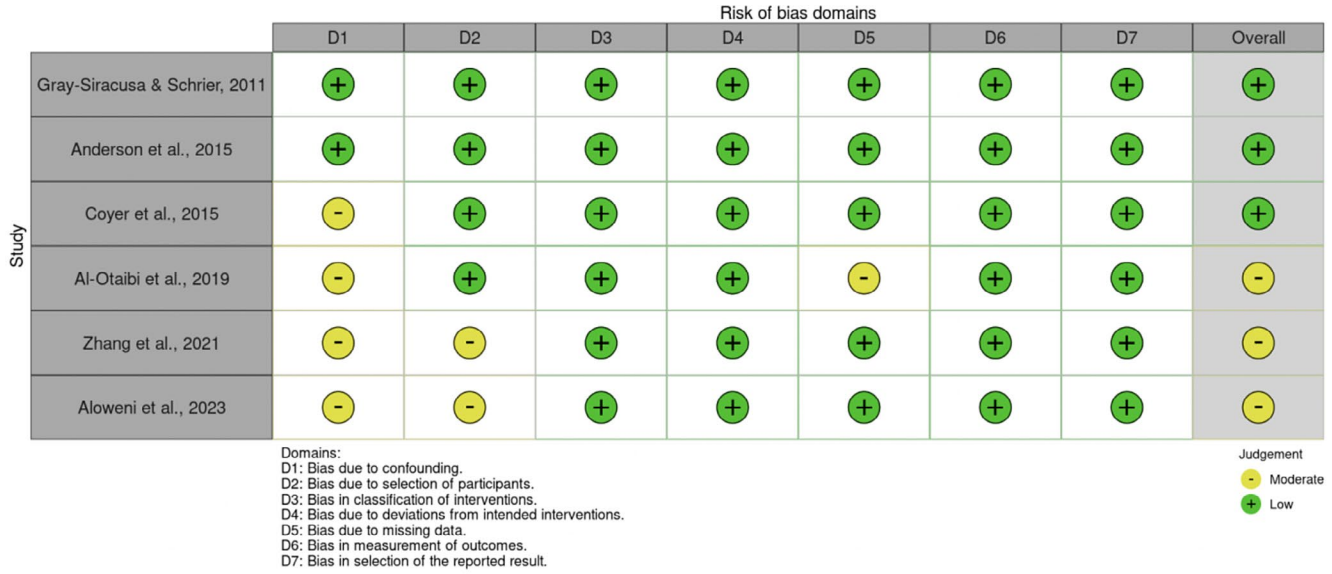

FIGURE 3 | Risk of bias of the non-randomised controlled studies.

(OR:−0.86, 95% CI: −1.428, −0.285) (Figure 4). Substantial heterogeneity was observed among studies ($Q = 95.317$, df = 8, I2 = 81.616 and $z = 2.938$), but the assessment of publication bias indicated no publication bias in terms of the probability of developing HAPIs (Egger's p-value = 0.114).

3.5.2 | Length of Stay

Of the nine included studies, 7 studies involving 26,468 patients were included in the meta-analysis for LOS (Tayyib et al. 2015; Chaboyer et al. 2016; Jafary et al. 2018; Anderson et al. 2015; Coyer et al. 2015; Zhang et al. 2021; Aloweni et al. 2023). A statistically significant difference was found in terms of length of hospital stay between patients who received a care bundle and patients who received standard care ($p < 0.001$). As a result of this meta-analysis, Hedges's g: −0.665, (95% CI −1.022, −0.307) was found as a medium effect size. Since Hedges's g values were negative, the length of hospital stay of patients who received a care bundle was reduced compared to standard care (Figure 5). Moderate heterogeneity was observed in the LOS data among studies ($Q = 41.671$, df = 6, I2 = 62.497% and $z = -1.938$), but assessment of publication bias showed that there was no publication bias for the LOS data (Egger's p-value = 0.72).

3.5.3 | Number of PIs

Of the six included studies, six studies involving 7568 patients were included in the meta-analysis for the number of PIs that were developed (Tayyib et al. 2015; Chaboyer et al. 2016; Anderson et al. 2015; Coyer et al. 2015; Zhang et al. 2021; Aloweni et al. 2023). As a result of this meta-analysis, there is a statistically significant difference in the number of PIs between the patient group receiving care bundles and the group receiving standard care ($p < 0.001$). Fewer PIs developed in patients receiving the care bundle compared to standard care (OR: −1.095, 95% CI: −1.776, −0.413) (Figure 6). Moderate heterogeneity was observed in the number of PIs data among the studies ($Q = 47.644$, df = 5, I2 = 60.505% and $z = -3.247$), but the evaluation of publication bias showed that there was no publication bias (Egger's p-value = 0.037).

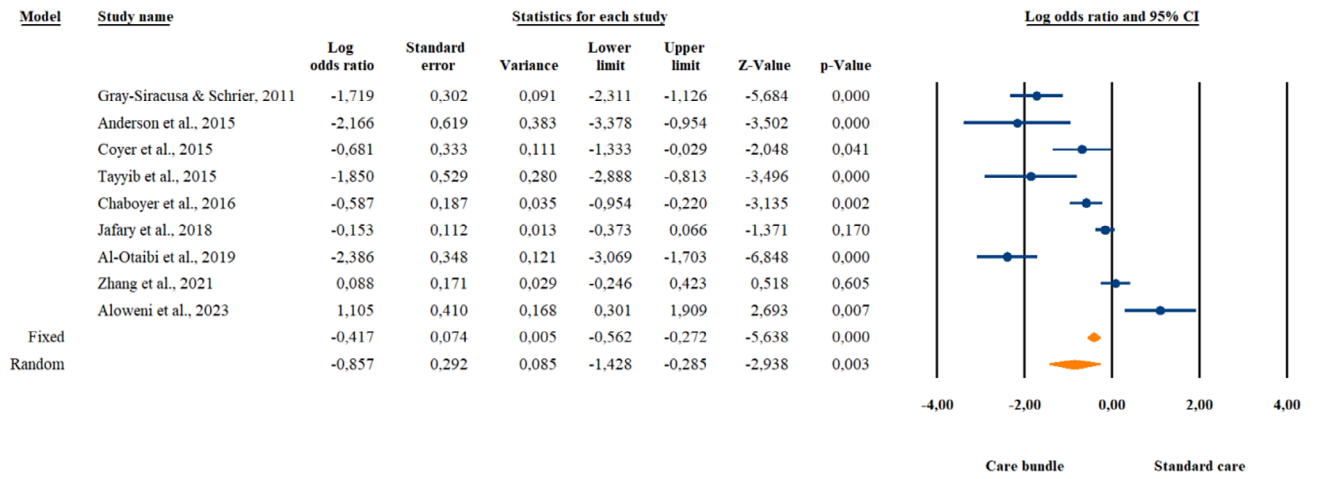

FIGURE 4 | Meta-analysis of HAPIs rate.

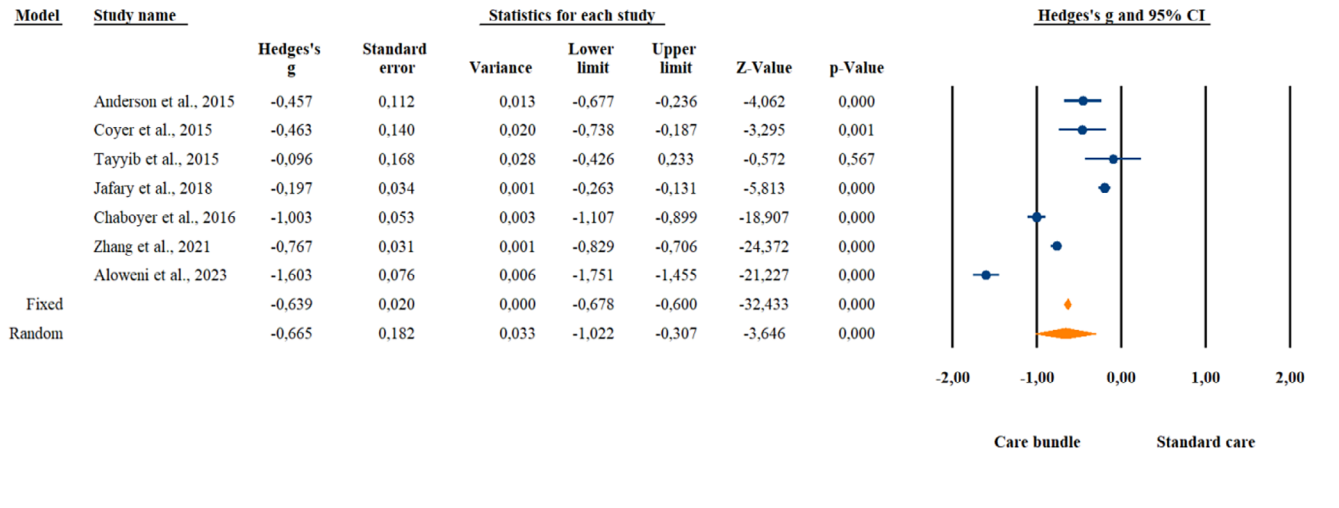

FIGURE 5 | Meta-analysis of length of stay.

4 | Discussion

Following the adoption of care bundles in clinical practice, they have become widely implemented for preventing PIs and HAPIs, with good results, improved patient prognosis, and improved quality of care (Chaboyer et al. 2024; Lin et al. 2020). This systematic review and meta-analysis evaluated the effects of care bundles implemented to prevent HAPIs. The meta-analysis results showed that the implementation of care bundles reduced the odds of developing HAPI in patients by 57.6%, shortened the length of hospital stay, and reduced the number of PIs.

The nine studies covering a total of 29,572 patients were examined and found that care bundles significantly reduced the odds of developing HAPIs. The log odds ratio values of the majority of studies were to the left of zero, indicating that the care bundles intervention was generally effective in reducing HAPIs. The log odds ratio values obtained in the studies by Anderson et al. (2015), Al-Otaibi et al. (2019) and Tayyib et al. (2015) were more negative, and these effects were statistically significant ($p < 0.05$), indicating the strong and significant effects of the care bundles intervention (Tayyib et al. 2015; Anderson et al. 2015; Al-Otaibi et al. 2019). The log odds ratio values close to zero or even positive in the studies by Zhang et al. (2021) and Aloweni et al. (2023) indicate that the care bundles were ineffective or less effective than standard care. Indeed, Zhang et al. (2021) reported that the incidence of HAPI decreased after the intervention, but the difference was not statistically significant ($\chi^2 = 4.46$, $p = 0.04$) (Zhang et al. 2021; Aloweni et al. 2023). In the study by Aloweni et al. (2023), the incidence of HAPIs decreased from 4.8% to 1.6% after the intervention. However, despite the decrease in incidence, the odds ratio was not significant, indicating that the clinical significance of the care bundle is unclear (Aloweni et al. 2023).

In a systematic review and meta-analysis study conducted by Chaboyer et al. (2024) including nine publications, the effects

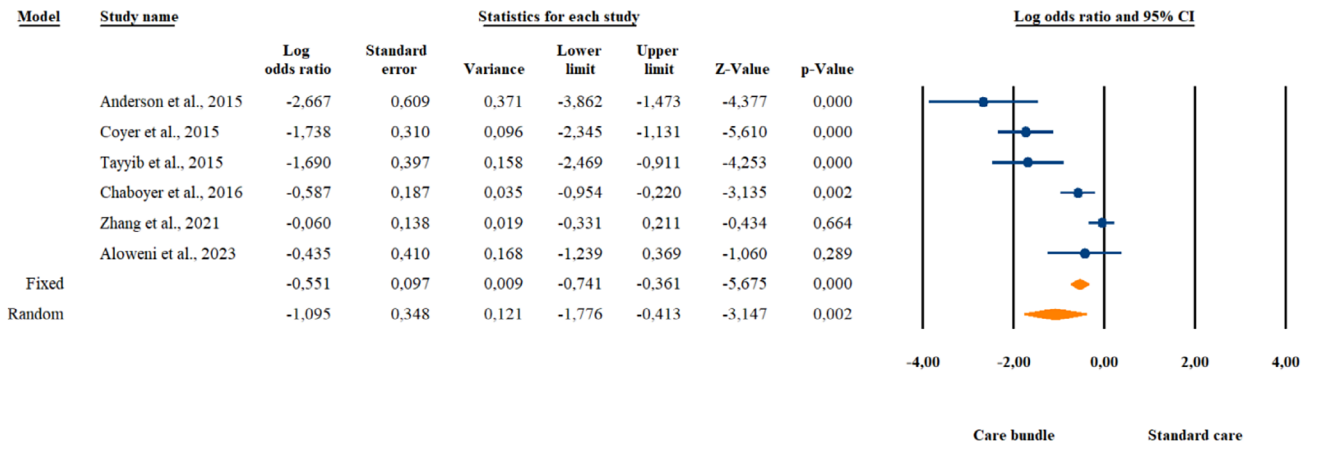

FIGURE 6 | Meta-analysis of number of PIs.

of PIs prevention care bundles on the prevalence, incidence and HAPI rates of PIs in hospitalised patients were evaluated. The study determined that care bundles were effective in reducing HAPIs (OR: 0.31 CI 95%0.12–0.83, $p=0.02$) (Chaboyer et al. 2024). In the systematic review and meta-analysis conducted by Lavallée et al. (2017), the effects of care bundles on patient outcomes were evaluated. The results show that the implementation of the care bundles reduces the incidence of PIs and HAPI (OR: 0.33, 95% CI 0.21–0.52; 3.157, $p=0.03$) (Lavallée et al. 2017). A systematic review and meta-analysis by Lovegrove et al. (2022) evaluated the effectiveness of care bundles to prevent PIs in adults. A total of 26 studies were included, and 10 different types of interventions were evaluated (support surfaces, prophylactic dressings, positioning, topical preparations, continence management, endotracheal tube fixation, heel cup devices, medications, non-invasive ventilation masks and bundled interventions). Although specific data on HAPI rates were not presented in this study, the meta-analysis results suggested that care bundles were effective in preventing PIs (Lovegrove et al. 2022). Trisnaningtyas et al. (2021) found in a systematic review of 17 publications that care bundles reduced the incidence of pressure injuries by 4.3%–36.2% in developed countries and 4.16%–25.72% in developing countries (Trisnaningtyas et al. 2021). All these systematic reviews and meta-analyses have presented positive results consistent with our findings, indicating that care bundles are an effective method for preventing and reducing the rates of HAPIs.

The LOS is a significant risk factor for the occurrence of HAPIs (Kim et al. 2022). Patients who stay in the hospital for a long time are at risk of developing both superficial (Stage 1 and 2 PI) and severe (Stage 3 and 4 PI, Deep Tissue PI, Unstaged PI). As the length of hospital stay increases, the development of both superficial (OR: 1.21, $p<0.001$) and severe (OR: 1.26, $p<0.001$) increases (Kayser et al. 2019). In a study conducted by Lin et al. (2020), an analysis was conducted to measure the effectiveness of multi-component care bundles for individuals in the ICU. This review, which included 21 studies, emphasised that care bundles implemented to prevent PIs have positive effects on patient and care process outcomes and contribute to shortening the LOS (Lin et al. 2020). Consistent with these findings, our meta-analysis results show that the LOS of patients implemented with care bundles is shorter than that of standard care (Hedge g: −0.665, 95% CI −1.022, −0.307).

The intensive efforts (various educational programs, quality improvement projects, awareness campaigns, legal regulations and policies) to reduce the number and severity of PI have been ongoing for a long time (Van Gilder et al. 2021). This systematic review and meta-analysis revealed that the group receiving the care bundle developed fewer PIs than the group receiving standard care ($p=0.002$, OR: −1.095). PI severity was reported in only seven of the nine publications we reviewed, and the data were not suitable for meta-analysis. According to these data, the randomised controlled trial conducted by Chaboyer et al. (2016) revealed that there was no significant difference in the severity of PIs between the intervention and control groups (intervention 3.3 + 0.77; control 3.0 + 0.97, $p=0.124$ Chaboyer et al. 2016). The results of other studies show that the use of the preventive care bundles reduces the severity of PIs in the intervention group. (Tayyib et al. 2015; Gray-Siracusa and Schrier 2011; Anderson et al. 2015; Coyer et al. 2015; Zhang et al. 2021; Aloweni et al. 2023) These findings are consistent with the results of the systematic review by Alshahrani et al. (2021) in which they included 14 publications. This review revealed that evidence-based PIs prevention care bundles are an effective strategy in reducing the number and severity of PIs (Alshahrani et al. 2021). In addition, Lin et al. (2020) systematic review similarly reported that the number and severity of PIs reported in patient outcomes decreased (Lin et al. 2020). The results of this systematic review and meta-analysis highlight the important role that care bundles play in preventing HAPIs and the potential benefits of introducing these approaches into standard practice in healthcare.

5 | Limitation

One of the strengths of this meta-analysis is the inclusion of experimental studies. The inclusion of experimental studies increases the methodological reliability of the results and the study. In addition, no evidence of publication bias was found according to Egger's test.

This indicates that the results of published studies are generally reliable and there is no systematic publication bias. However, there are several limitations that should be considered when interpreting this meta-analysis. This study showed significant heterogeneity among the included studies. Methodological differences and heterogeneity across studies may limit the generalisability of the results. This heterogeneity may be due to methodological differences across studies, variability in patient populations, or differences in care bundle components. This heterogeneity problem has also been seen in previous systematic reviews and meta-analyses of care bundles (Chaboyer et al. 2024; Lavallée et al. 2017).

6 | Conclusion

This systematic review and meta-analysis study, which included nine studies and covered 29,617 patient data, revealed that care bundles were effective in preventing HAPIs. According to the results of the study, care bundle application reduced the rate of HAPI, shortened the length of hospital stay, and reduced the number and severity of PIs. More studies should be conducted with more homogeneous patient populations and standard care bundles to reduce heterogeneity and increase the generalisability of the results. Well-designed, adequately powered randomised controlled trials with appropriate blinding and robust data analysis methods should be prioritised. HAPI has been reported to significantly increase healthcare resource use and costs (Whitty et al. 2017). Therefore, studies evaluating the long-term effects and cost-effectiveness of care bundles are needed. This may help optimise healthcare policies and practices. In particular, studies evaluating the effectiveness of care bundles in different healthcare settings and different patient populations will increase the generalisability of these findings.

Author Contributions

Ayse Silanur Demir contributed to study design, literature search, data extraction, data analysis, data entrance and writing of the manuscript. Ayise Karadag contributed to study design, supervision of the study, writing of the manuscript and approval of the final manuscript. Authors approved the content of the prepared manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Appendix A

TABLE A1 | PICOS inclusion and exclusion criteria.

Parameters	Inclusion Criteria	Exclusion criteria
Population	Male and female patients; Admitted to without a pressure injuries; Hospital acquired pressure injuries	Children and adolescents under 18 years of age
Intervention	Multicomponent (three or more components) intervention care bundle	Educational programs
Comparison	Standard care or comparison intervention reported in study	None
Outcome	Hospital acquired pressure injuries rates, lenght of stay (day), numbers of pressure injuries	None
Study types	Randomized controlled trials, and non-randomised studies (pre and post studies, quasi-experimental studies and cohort studies)	Uncontrolled studies with no comparison group, qualitative, descriptive, reviews, prospective, case–control, cross-sectional, cohort, summaries, retrospective, and non-English.

TABLE A2 | Descriptive characteristics of the study.

Author/Year/Country	Study design	Sample size	Setting	LOS (days)	Follow-up time (days)	Interventions		Conclusions
						Experimental/Post-Intervention	Control/Pre-intervention	
Gray-Siracusa and Schrier (2011) USA[24]	A quasi-experimental design	Total: 1199 Pre-intervention: 554 Post-intervention: 645	ICU	N/A	N/A	Pressure ulcer bundle (PUB) Components: 1. Risk assessment 2. Repositioning 3. Minimal head of bed elevation 4. Heel elevation 5. Nutrition assessment 6. Skin assessment 7. Sacral cleansing and Moisturizing HAPI rate: 2.19% Number of PIs: N/A	Standard care HAPI rate: 10.9% Number of PIs: N/A	• After implementation, HAPIs rates remained below 1% on a quarterly basis and remained at low levels throughout the year. • No PIs was observed in the first two months of implementation
Anderson et al. (2015) USA[25]	A quasi-experimental, pre-and post intervention design	Total: 327 Pre-intervention: 181 Post-intervention:146	ICU	Pre-intervention: 12.7 ± 5.2 Post-intervention: 10.4 ± 4.8	N/A	Universal pressure ulcer prevention bundle (UPUPB) Components: 1. Skin emollients 2. Assessment of skin head-to-toe 3. Floating heels off the bed 4. Early identification of sources of pressure, using pressure redistribution surfaces 5. Repositioning HAPI rate: 2.1% Number of PIs: 2.1%	Standard Care HAPI rate: 15.5% Number of PIs: 23.2%	• HAPIs incidence decreased from 15.5% to 2.1%. • Multivariate logistic regression model showed a statistically significant decrease in HAPIs ($p < 0.001$)
Coyer et al. (2015) Australia[26]	A pre- and post intervention design	Total: 207 Pre-intervention group :105 Post-intervention: group: 102	ICU	Pre-intervention: 27.7 ± 31.5 Post-intervention: 17.4 ± 7.6	28	Patient skin integrity care bundle (InSPiRE) Components: A. Assessment of skin integrity 1.Skin assessment on admission 2.Ongoing assessment B. Strategies to prevent Pressure injuries 1.Skin hygiene 2.Turning schedule 3.Elimination of pressure and friction 4.Elimination of heel pressure C. Protection against Forces of pressure and friction 1. Maintenance of stable skin temperature 2. Optimize nutritional status. 3. Promotion of mobility HAPI rate: 18,1% Number of PIs: 21.95%	Standard care HAPI rate: 30.4% Number of PIs: 55.8%	• The incidence of HAPIs was found to be 18,1%, while this rate was 30,4% in the control group. This difference was statistically significant ($\chi^2 = 4,3$, $P = 0.04$). • The development of PIs took longer in the intervention group (log rank = 11,842, df = 1, $p \leq 0.001$). • While each patient in the control group developed more than 3 PIs, very few patients in the intervention group reached this number

(Continues)

TABLE A2 | (Continued)

Author/Year/ Country	Study design	Sample size	Setting	LOS (days)	Follow-up time (days)	Interventions		Conclusions
						Experimental/Post-Intervention	Control/Pre-intervention	
Tayyib et al. (2015) Saudi Arabia[14]	A Two-arm cluster randomized control trial	Total: 140 Experimental group :70 Control group: 70	ICU	Intervention: 10.4 ± 7.69 Control: 11.2 ± 8.8	28	PU prevention bundle Components: 1. Risk assessment 2.Skin assessment 3.Skin care 4.Nutrition 5.Repositioning 6. Support surface Education and training 7.Care of medical devices HAPI rate: 7.4% Number of PIs: 17.1%	Standard care HAPI rate:32.86% Number of PIs: 52.8%	• The probability of developing HAPIs was found to be 70% lower in the experimental group. • Less and lower stage PIs developed in the experimental group (Stage I and II). • High level of compliance was found for the implementation of the PIs prevention care bundles. Average compliance score was 22.43 out of 30.
Chaboyer et al. (2016) Australia[16]	A cluster randomised trial	Total: 1600 Experimental group:799 control group: 799	General wards and ICU	Intervention: 10.46 ± 2.67 Control: 7.78 ± 2.67	28	Patient-centred pressure ulcer prevention care bundle (PUPCB) Components: 1.Patient education and participation: • Patients received a DVD, brochure, and poster focusing on three key messages: keep moving, look after your skin, and eat a healthy diet. 2.Nurse training: • Nurses were trained to partner with patients in their pressure ulcer prevention care 3. Standard care HAPI rate: 6.1% Number of PIs: 6.1%	Standard care HAPI rate:10.5% Number of PIs:10.5%	• The incidence rate of HAPIs was 14.4 per 1000 person-days; 9.6 per 1000 person-days in the PUPCB group and 20.1 per 1000 person-days in the control group (incidence rate ratio 0.48; 95% CI: 0.33, 0.69; $p < 0.0001$).
Jafary et al. (2018) Iran[17]	Stepped-wedge, cluster randomized controlled trial	Total: 18.900 Experimental group: 1657 Control group: 1855	General wards	Intervention: 19.5 ± 22 Control: 15.7 ± 16.5	15	Multifactorial intervention Components: 1. Patient education (pamphlets, poster) 2. Training session for staff Bed-side cards (high-risk sign) 3. Regular ulcer dressing 4. Repositioning the patient regularly 5. Using pressure-relieving beds for susceptible patients 6. Daily visits by pressure ulcer experts (wound care nurse) HAPI rate: 9.53% Number of PIs: N/A	Standard care HAPI rate: 10.94% Number of PIs: N/A	• The number of patients who developed PIs in the control period was 203 and in the experimental period was 158. • The PIs rates were found to be 5.49 in the control period, 5.68 in the training period and 4.62 in the experimental period (per 1000 patient-days)

(Continues)

TABLE A2 | (Continued)

Author/Year/Country	Study design	Sample size	Setting	LOS (days)	Follow-up time (days)	Interventions		Conclusions
						Experimental/Post-Intervention	Control/Pre-intervention	
Al-Otaibi et al. (2019) Saudi Arabia[27]	A quasi-experimental design	Total: 1905 Intervention group: 1537 Control group: 368	General wards	N/A	N/A	PIP (pressure injury prevention) bundle Components: 1. Daily risk assessment 2. Repositioning 3. Use of specialised Mattresses 4. Prophylactic dressing 5. Education and Support HAPI rate: 1.2% Number of PIs: N/A	Standard Care HAPI rate: 7.5% Number of PIs: N/A	• The incidence of HAPIs has decreased from 7.5% to 1.2%. • Norton risk assessment tool usage has reached 97%.
Zhang et al. (2021) China[28]	A quasi-experimental, pre- and post intervention design	Total: 4350 Pre-intervention: 2021 post-intervention: 2329	ICU	Pre-intervention: 25.1 ± 5.3 Post-intervention: 21.4 ± 4.2	N/A	Pressure Injury Care Bundle Components: 1. Risk identification 2.Skin assessment 3.Patient repositioning 4.Skin care 5.Pressure-reducing device 6.Nutrition HAPI rate: 1.59% Number of PIs: 22.0%	Standard Care HAPI rate: 2.25% Number of PIs: 27.0%	• The incidence of HAPIs decreased by 29.5% within 6 months. • The compliance rate of nurses increased significantly from 55.15% before the implementation of the care bundles to 60.15% after the implementation
Aloweni et al. (2023) Singapore[29]	A quasi-experimental, pre- and post intervention design	Total: 944 Pre-intervention: 396 Post-intervention: 548	General wards	Pre-intervention: 9 ± 4 Post-intervention: 4 ± 1	N/A	Perioperative HAPI Prevention care bundle Components: 1.Preadmission stage: Conduct a risk assessment 2.Preoperative stage: Apply prophylactic foam dressing on high-risk body areas 3.Intraoperative stage: • Prevent skin friction and shear • Protect high-risk pressure areas with padding • Position properly • Control moisture • Monitor core body temperature and prevent hypothermia • Monitor and maintain adequate hemodynamic status 4.Postoperative stage: • Use pressure-redistributing devices • Use a sliding sheet during transfer and positioning • Turn every two to three hours • Encourage early mobilization • Provide good nutrition (monitor intake and output) • Optimize postoperative pain management HAPI rate: 4.8% Number of PIs: 1.6%	Standard care HAPI rate: 1.6% Number of PIs: 4.8%	• The incidence of HAPIs was lower in the Post-Intervention group compared to the Pre-Intervention group (1.6% vs. 4.8%; $p < 0.001$).

Abbreviations: HAPIs: hospital-acquired pressure injuries; ICU, Intensive Care Units; LOS: length of stay; N/A, not available.