Science Midwifery, Vol 13, No. 6, February 2026 ISSN 2086-7689 (Print) | 2721-9453 (Online)

Contents lists available atIOCS

Science Midwifery

journal homepage:www.midwifery.iocspublisher.org

Analysis of hospital costs and insurance reimbursement systems for pneumonia patients: A literature review

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ARTICLE INFO

Article history:

Received Dec 31, 2025
Revised Jan 12, 2026
Accepted Jan 21, 2026

Keywords:

Diagnosis Related Groups
Hospital Costs
Insurance Reimbursement
Pneumonia

ABSTRACT

Pneumonia has remained one of the leading causes of global morbidity and mortality and has imposed a substantial clinical and financial burden on healthcare systems. The high cost of pneumonia care was influenced by disease severity, comorbidities, length of hospital stay, and the use of therapeutic and diagnostic interventions. The implementation of prospective payment systems, such as Diagnosis Related Groups (DRGs) and INA-CBG's, aimed to improve cost efficiency; however, it often resulted in gaps between actual hospital costs and reimbursement tariffs. This literature review aimed to analyze hospital costs and insurance reimbursement systems for pneumonia patients. A Systematic Literature Review was conducted following PRISMA guidelines through searches of PubMed and Google Scholar for publications from 2020 to 2025. Eleven articles met the inclusion criteria and were analyzed narratively. The findings indicated that length of stay, clinical complexity, and the use of broad-spectrum antibiotics were the main determinants of high costs. Package-based payment systems improved efficiency but continued to face underfunding challenges. This study concluded that optimizing pneumonia cost management required clinical efficiency, accurate claims coding, and technological support to ensure hospital financial sustainability.

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INTRODUCTION

Pneumonia is an acute respiratory tract infection that remains a leading cause of morbidity and mortality worldwide (Torres et al., 2021). According to the most recent Global Burden of Disease (GBD 2023) estimates, pneumonia caused 2.5 million deaths globally in 2023, including 610,000 deaths among children under five years of age and 79,000 deaths among children aged 5–14 years (Global Burden of Diseases, 2025). n Indonesia, national health profile data reported 309,838 pneumonia cases in 2020, followed by 278,261 cases in 2021 and an increase to 310,871 cases in 2022 (Kementerian Kesehatan RI, 2025).

The high incidence of pneumonia, particularly community-acquired pneumonia, has imposed a substantial clinical and operational burden on healthcare systems. Pneumonia has been associated with severe complications, including respiratory failure, sepsis, and death, with higher mortality rates observed among older adults and patients with comorbid conditions (Campling et al., 2020; Sarda & Rello, 2020; Theilacker et al., 2021). From an operational perspective, increased pneumonia admissions have led to higher bed occupancy rates, limited hospital capacity for other conditions, and intensified pressure on healthcare services amid competing demands. In broader public health contexts, such as maternal and child health, this burden has contributed to delays in non-pneumonia care. Moreover, long-term post-acute costs have been reported to be comparable to acute-phase costs, averaging approximately USD 32,446, thereby amplifying fiscal pressure on health systems (Kruckow et al., 2023; Weycker et al., 2021).

Pneumonia was selected as the focus of this review because it is among the most common causes of hospitalization across both pediatric and adult populations and is consistently associated with substantial acute and post-acute healthcare costs (Zilberberg et al., 2025). Unlike many chronic conditions, pneumonia frequently requires intensive inpatient management, including antibiotic therapy, diagnostic imaging, and prolonged length of stay, which contributes significantly to its economic burden (Lee, Noh, Lee, Choi, Kim, et al., 2025). Accordingly, this review considers pneumonia as a general clinical category encompassing hospitalized patients across age groups to reflect real-world case-mix patterns. However, this broad scope also represents a limitation, as variations in disease severity, etiology, and treatment pathways between children and adults, as well as between uncomplicated and complicated cases, may contribute to heterogeneity in reported cost and reimbursement outcomes (Adamu et al., 2022). Therefore, the findings should be interpreted as reflecting systemic cost–reimbursement dynamics rather than precise estimates for specific age groups or clinical subtypes.

From a financial perspective, pneumonia-related healthcare costs have varied considerably depending on disease severity, the presence of comorbidities, and the type of medical interventions provided. The use of broad-spectrum antibiotics, diagnostic examinations, and prolonged length of stay (LOS) have been identified as the primary drivers of high hospital costs (Joseph, 2025; Lee, Noh, Lee, Choi, Kim, et al., 2025; Wardati et al., 2023). Cost variation has also been influenced by the type of healthcare facility, with tertiary hospitals and urban-based facilities tending to incur higher costs (Lee, Noh, Lee, Choi, Kim, et al., 2025; Wang et al., 2022). Variability in clinical care processes has further contributed to unnecessary cost escalation, with extended LOS consistently reported as a key determinant (Lawrence et al., 2020; Lee, Noh, Lee, Choi, Kim, et al., 2025; Marin et al., 2020).

Hospital payment systems have gradually shifted from fee-for-service (FFS) models, which reimburse based on service volume, toward prospective payment systems such as Diagnosis-Related Groups (DRGs) or INA-CBG's in Indonesia, which reimburse based on case classification or diagnosis. Prospective payment systems have generally been associated with reductions in service overutilization compared to FFS models, which often incentivize overprovision, thereby enabling cost containment without substantial deterioration in service quality (Behzadi et al., 2022; Dyah et al., 2025; Ghazaryan et al., 2021; Li et al., 2022). However, in practice, discrepancies frequently occurred between actual hospital expenditures and insurance reimbursement tariffs, particularly in complex pneumonia cases requiring extensive resources (Ning et al., 2020).

Evidence from China indicated that higher reimbursement levels were associated with longer hospital stays for certain diseases; however, this relationship was not significant among pneumonia patients who died, highlighting the complexity of the relationship between cost and duration of care (Ning et al., 2020). The economic burden of pneumonia has also been shown to vary substantially across regions, with inpatient costs constituting the largest component and being strongly influenced by insurance status and LOS (Gao et al., 2023; Hu et al., 2024). Similarly, studies in Germany reported that the costs of treating pneumonia caused by drug-resistant bacteria

were often not fully covered by reimbursement tariffs, resulting in substantial funding deficits for hospitals (Jeck et al., 2022).

Negative gaps between actual hospital costs and reimbursement values have posed a threat to hospital financial stability. Therefore, optimization strategies have been increasingly emphasized. Improvements in medical and clinical coding accuracy have been shown to enhance claims efficiency and reduce the risk of underpayment, while the adoption of artificial intelligence (AI) and innovative diagnostic technologies has helped contain costs without compromising care quality (Amiri et al., 2025; Jyani et al., 2025). In addition, misalignment between internal hospital budgeting mechanisms and external reimbursement systems has limited the effectiveness of financial incentives, indicating the need for internal budget adjustments that better reflect changes in reimbursement contracts and tariff structures (Leeuwen et al., 2023, 2025).

Despite extensive research on pneumonia related healthcare costs and prospective payment systems, previous reviews have not specifically synthesized evidence on the discrepancy between actual hospital treatment costs and standardized DRG or INA CBG based reimbursement rates. Existing literature tends to address cost drivers or reimbursement mechanisms separately, without systematically examining the magnitude, direction, and determinants of cost reimbursement gaps across disease severity, case complexity, and healthcare settings. Furthermore, the implications of these gaps for hospital financial sustainability and efficiency incentives, particularly in low and middle income countries, remain insufficiently explored. This lack of integrated evidence limits the ability of policymakers to optimize tariff structures and payment reforms for pneumonia care.

Based on these considerations, this literature review aimed to analyze hospital costs and insurance reimbursement systems for patients with pneumonia.

LIITERATUR REVIEW

Definition of Pneumonia

Pneumonia is an acute infection of the pulmonary alveoli and distal airways caused by bacterial, viral, or fungal pathogens, resulting in inflammation that disrupts gas exchange and manifests clinically with symptoms such as fever, cough, and shortness of breath (Rafeq & Igneri, 2024; Torres et al., 2021). Pneumonia affects individuals across all age groups; however, it poses a higher risk of complications and mortality among young children, older adults, and individuals with chronic underlying conditions (Torres et al., 2021). Based on the setting of acquisition, pneumonia is commonly classified into community-acquired pneumonia and hospital-acquired (nosocomial) pneumonia, each characterized by distinct clinical features and healthcare service requirements (Torres et al., 2021).

Hospital Service Costs

Cost is defined as the monetary value expended to obtain goods or services that are expected to generate benefits for an organization in the present or future (Herlina et al., 2024). Hospital service costs refer to all expenditures incurred in the delivery of healthcare services to patients, encompassing both direct and indirect costs. Direct costs include expenditures related to medications, laboratory and radiological examinations, medical procedures, and inpatient care, whereas indirect costs comprise administrative expenses, healthcare personnel costs, and facility maintenance (Hani, 2020; Herlina et al., 2024). In pneumonia cases, hospital service costs tend to increase with greater disease severity, the use of broad-spectrum antibiotics, and prolonged length of stay (LOS) (Joseph, 2025; Lee, Noh, Lee, Choi, Kim, et al., 2025; Wardati et al., 2023).

Factors Determining the Cost of Pneumonia Services

Multiple factors influence hospital service costs for patients with pneumonia. Clinical factors include disease severity, the presence of comorbidities, and patient response to treatment. Service-related factors involve the type of healthcare facility, the intensity of diagnostic procedures,

and the duration of hospitalization. Previous studies have consistently identified length of stay as a major determinant of increased pneumonia treatment costs, as it directly reflects the extent of hospital resource utilization (Joseph, 2025; Lee, Noh, Lee, Choi, Kim, et al., 2025; Wardati et al., 2023).

Hospital Payment System

Hospital payment systems are generally categorized into two main models: fee-for-service (FFS), which reimburses healthcare providers based on the volume and type of services delivered, and prospective payment systems, which provide predetermined payments based on predefined classifications such as diagnosis-related groups (DRGs) or case-based groupings. DRG-based systems are widely implemented internationally and exhibit substantial variation in design and application across countries. Middle-income countries have increasingly adopted these systems to enhance cost control and improve efficiency in healthcare delivery (Y. Liu et al., 2024; Quentin et al., 2022). In Indonesia, the prospective payment system is implemented through INA-CBG’s as part of the National Health Insurance program (Haqiyah et al., 2025; Kelmaskosu, 2026).

Reimbursement mechanism in INA-CBG's

INA-CBG’s (Indonesia Case-Based Groups) is a diagnosis-based payment system used to determine reimbursement tariffs for hospital healthcare services (Haqiyah et al., 2025; Kelmaskosu, 2026). Variations between actual hospital costs and reimbursement values are influenced by several factors, including length of stay, disease severity, class of care, and specific cost components such as nursing services, radiological examinations, and laboratory tests, while pharmaceutical costs may partially offset these deficits in certain cases (Agung & Deddy, 2024; Haqiyah et al., 2025; Pradhana et al., 2024). Implementation challenges also arise from issues related to coding accuracy, staff training, and infrastructure limitations, all of which affect the proper application of the INA-CBG’s system and the reliability of reimbursement data (Putra et al., 2023; Rahmatiqa et al., 2021).

RESEARCH METHOD

This study employed a Systematic Literature Review (SLR) approach, which was a systematic and transparent research method used to identify, appraise, and synthesize scientific evidence from studies relevant to a specific topic (Page et al., 2021). The literature search and selection process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to identify evidence related to hospital costs and insurance reimbursement systems for pneumonia patients. The review process consisted of four stages: identification, screening, eligibility assessment, and study inclusion (Page et al., 2021).

Identifikasi

The literature search was conducted using the PubMed and Google Scholar databases with combinations of English and Indonesian keywords. The search was limited to publications published between 2020 and 2025. The keywords included *“adult pneumonia” AND “hospital cost” AND “insurance”*, *“pneumonia” AND “DRG” AND “reimbursement”*, *“hospital cost analysis” AND “pneumonia”*, *“cost of illness” AND “pneumonia”*, *“pneumonia dewasa” AND “biaya rawat inap” AND “BPJS”*, and *“biaya riil” AND “tarif INA-CBG’s” AND “pneumonia”*. The initial search yielded a total of 35,798 publications, comprising 333 records from PubMed and 35,465 from Google Scholar.

Filtering (Screening)

The initial screening stage applied a publication time limit of the last five years (2020–2025), resulting in the exclusion of studies published outside this range and leaving 20,140 articles. Subsequently, titles and abstracts were screened to remove duplicate records and studies not relevant to the research topic. After this process, the number of potentially relevant articles was reduced to 56 publications.

Feasibility Assessment (Eligibility)

Publications that passed the screening stage were reviewed in full text based on predefined inclusion and exclusion criteria. Inclusion criteria comprised studies published in English or Indonesian, available in full-text format, original research articles using quantitative, qualitative, mixed-methods, or literature review designs, and studies focusing on hospital costs, insurance reimbursement, and pneumonia patients. Studies were excluded if full-text access was unavailable, if cost or insurance aspects were not explicitly discussed, or if duplicate records were identified across databases. At this stage, 32 publications underwent detailed eligibility assessment.

Inclusion

Following the screening and eligibility assessment, studies that met all methodological and substantive criteria were included in the final analysis. A total of 21 articles were excluded due to incomplete data or misalignment with the study objectives. Consequently, 11 articles were included in the final narrative synthesis as the most relevant evidence to address the research question.

RESULTS AND DISCUSSIONS

Result

The review of 11 selected studies indicated that hospital costs for pneumonia patients varied substantially and were strongly influenced by clinical complexity and duration of care. The primary determinants of high actual costs were prolonged length of stay (LOS), particularly in complicated cases, and the use of broad-spectrum or last-resort antibiotics, whose costs frequently exceeded established reimbursement tariffs (Jeck et al., 2022; Kurniawati & Sugeng, 2024). From a clinical perspective, cost savings were achieved through more cost-effective therapeutic choices, such as the use of levofloxacin, which was shown to be more economical than ceftriaxone without compromising treatment effectiveness (Rahmawati & Nopitasari, 2021).

Regarding financing systems, the implementation of package-based payment policies such as Diagnosis-Related Groups (DRG) and Diagnosis-Intervention Packets (DIP) consistently demonstrated positive effects on hospital efficiency by reducing average inpatient costs and shortening length of stay (Chen et al., 2023; Fenga et al., 2024; Zhao et al., 2025). However, financial challenges persisted due to underfunding and negative gaps between actual hospital costs and insurance reimbursement rates, particularly among high-risk patients (Ahmad et al., 2021; Kurniawati & Sugeng, 2024). These losses were often exacerbated by inaccurate medical coding (underbilling) and redundancy in the use of medical equipment (Bellamkonda et al., 2025; Linying, 2025).

The literature further indicated that the integration of technological innovations, such as advanced diagnostic tools and artificial intelligence-based systems, contributed to hospital cost optimization of up to 12.3% by improving antibiotic stewardship and clinical decision accuracy (Schneider et al., 2022; Y. Wu et al., 2025). Therefore, effective management of pneumonia-related costs was highly dependent on the synergy between clinical operational efficiency, accurate insurance claims administration, and the strategic use of medical technological innovations. Table 1 presents a summary of the reviewed studies.

Table 1. Summary of literature review findings

No	Author (Year)	Title	Metodh	Key Findings
1	Kurniawati & Sugeng (2024)	Upaya Pengendalian Biaya Rumah Sakit terhadap Perbedaan Tarif Riil Rumah Sakit dengan Tarif INA CBG's Pasien Rawat Inap pada Kasus Komplikasi Pneumonia di RSUP Dr.	Quantitative descriptive study using secondary data from medical records and JKN claims of 52 hospitalized pneumonia patients with complications at a tertiary hospital (Jan–May 2024).	Actual hospital costs exceeded INA-CBG's tariffs, resulting in negative margins. Cost gaps were mainly driven by insufficient JKN coverage, prolonged length of stay (>12 days), and high procedural costs in complicated cases.

No	Author (Year)	Title	Metodh	Key Findings
		Sardjito		
2	Rahmawati & Nopitasari (2021)	Analisis Biaya Langsung Medis Terapi Seftriakson Dibandingkan Dengan Levofloksasin Pada Pasien Pneumonia Komunitas di Rumah Sakit Pemerintah X NTB	Comparative quantitative study using secondary data of 65 hospitalized patients from a public hospital, analyzed from the BPJS Health perspective.	Levofloxacin therapy generated significantly lower direct medical costs than ceftriaxone, indicating a more cost-effective treatment option without reducing clinical effectiveness.
3	Ahmad et al., (2021)	*Real-world evaluation of costs of illness for pneumonia in adult patients in Dubai—A claims database study*	Retrospective cohort study using insurance claims data (2014–2019), analyzing inpatient, outpatient, and emergency care costs before and after pneumonia episodes.	Healthcare costs increased by more than 45% following pneumonia episodes, with inpatient care contributing the largest share. High-risk patients incurred the highest expenditures.
4	Schneider et al. (2022)	*Cost Impact Analysis of Novel Host-Response Diagnostic for Patients with Community-Acquired Pneumonia in the Emergency Department*	Cost-impact modeling study comparing standard diagnostics with an additional host-response test, stratified by Pneumonia Severity Index and analyzed from payer and provider perspectives.	The diagnostic innovation reduced costs per patient by improving antibiotic stewardship, lowering hospitalization rates, shortening LOS, and optimizing DRG allocation.
5	Chen et al. (2023)	*Impact of Diagnosis-Related Groups on Inpatient Quality of Health Care: A Systematic Review and Meta-Analysis*	Systematic review and meta-analysis of 29 studies involving over 36 million patients, assessing LOS, readmission, and mortality outcomes.	DRG-based payment significantly reduced length of stay but showed no significant impact on readmission rates or mortality, indicating improved efficiency without compromising quality.
6	Bellamkonda et al. (2025)	*Optimizing Hospital Billing by Using Data from the Vascular Quality Initiative*	Retrospective observational study using Medicare-linked registry data from 40,822 patients across 230 hospitals, analyzed with logistic regression.	A substantial proportion of hospitals experienced underbilling. Accurate identification of comorbidities and complications significantly improved reimbursement through appropriate DRG coding.
7	Linying (2025)	*A Case Study on the Efficiency of Medical Insurance Cost Accounting in Public Hospitals Under DRG Policy — Taking XX Hospital as an Example*	Case study using Data Envelopment Analysis and Malmquist index to evaluate cost efficiency in a tertiary public hospital (2019–2023).	The hospital showed suboptimal efficiency due to drug and device redundancy and case-mix mismatch, leading to cost overruns in high-weight DRG conditions.
8	Fenga et al. (2024)	*Study on the cost-control effect of diagnosis-related groups based on meta-analysis*	Meta-analysis of 24 studies published between 2019 and 2023 evaluating the impact of DRG on LOS and inpatient costs.	DRG implementation significantly reduced length of stay and inpatient costs, although some studies reported potential declines in service quality.
9	Zhao et al. (2025)	*Impact of China's diagnosis-intervention packet payment reform on pediatric pneumonia hospitalization costs: an interrupted time series analysis*	Retrospective interrupted time series analysis of pediatric pneumonia inpatient costs before and after payment reform (2019–2023).	Payment reform significantly reduced hospitalization costs, particularly medication expenses, without negatively affecting quality indicators.
10	Jeck et al. (2022)	*Last Resort Antibiotics Costs and Reimbursement Analysis of Real-Life ICU Patients with Pneumonia Caused by Multidrug-Resistant Gram-Negative*	Retrospective analysis using real-world ICU cost and reimbursement data for pneumonia caused by MDR Gram-negative bacteria.	Reimbursement often failed to cover the cost of last-resort antibiotics, resulting in substantial underfunding and financial risk for hospitals.

No	Author (Year)	Title	Metodh	Key Findings
		Bacteria in Germany		
11	Wu et al. (2025)	*Evaluation of the Use of a Novel Intelligent Diagnosis and Cost Control System on Pediatric Bronchopneumonia Outcomes: Retrospective Cohort Study*	Retrospective cohort study of 4,543 pediatric patients comparing conventional care with an AI-based system.	The intelligent system reduced LOS and total hospital costs, increased reimbursement surplus, and decreased antibiotic use while maintaining high recovery rates.

Discussion

Major Components of Hospital Costs in Pneumonia Patients

Hospital expenditures for pneumonia treatment have been strongly influenced by length of stay (LOS), which directly contributes to increased operational costs, including accommodation, nursing services, diagnostic procedures, and administrative expenses. Numerous studies have demonstrated substantial variation in LOS and total pneumonia-related costs across healthcare facilities. Large hospitals and tertiary care centers have tended to report longer LOS and higher treatment costs, reflecting greater case complexity and more severe clinical conditions among patients (Lee et al., 2025; Lee, et al., 2025).

To control costs, package-based payment systems such as Diagnosis-Related Groups (DRG) and Global Budget (GB) have been introduced to limit LOS and improve service efficiency. Empirical evidence has shown that GB implementation was associated with reductions in LOS, hospital readmissions, and inappropriate antibiotic use, without compromising healthcare quality (Guan et al., 2020). Nevertheless, several studies have indicated that the effectiveness of package-based payment systems has often been constrained by clinical realities. Pneumonia patients with severe complications or multiple comorbidities have required prolonged hospitalization, frequently exceeding 12 days, resulting in actual service costs that surpassed predefined insurance reimbursement ceilings (Chen et al., 2023; Fenga et al., 2024; Kurniawati & Sugeng, 2024). Increases in LOS have consequently led to higher operational expenditures, particularly for inpatient accommodation, nursing care, and administrative services, which were often inadequately covered by insurance tariffs.

In addition to LOS, direct medical costs, including pharmaceutical therapy and diagnostic examinations, have constituted a significant proportion of pneumonia treatment expenditures. Antibiotic therapy has emerged as a major driver of pharmacy-related costs, making antibiotic selection a critical economic consideration (Joseph, 2025; Vinod & Sowmy, 2025). Cost differences among antibiotic regimens were evident, as levofloxacin therapy was reported to be more cost-efficient, with lower average expenditure per patient compared with ceftriaxone (Rahmawati & Nopitasari, 2021). Financial complexity increased further in cases of pneumonia caused by multidrug-resistant Gram-negative bacteria (MDR-GNB), particularly among patients admitted to intensive care units. The use of high-cost last-resort antibiotics in these cases was frequently insufficiently reimbursed, creating a substantial risk of financial loss for hospitals (Jeck et al., 2022). This condition was closely linked to disease severity, as high-risk patient groups incurred healthcare costs approximately 45% higher than those of low-risk patients due to the need for more intensive and complex medical interventions (Ahmad et al., 2021).

Effective cost control in pneumonia care therefore requires a comprehensive approach that integrates LOS management, rational antibiotic selection, accurate severity adjustment, and an understanding of the limitations inherent in package-based payment systems such as INA-CBGs in Indonesia. Consistent with findings from local studies, actual treatment costs have frequently exceeded reimbursement values received by hospitals. Accordingly, integrated strategies involving optimized clinical management, antimicrobial stewardship programs, and the development of standardized pneumonia clinical pathways are essential to balance cost efficiency, financial

sustainability, and healthcare quality, rather than relying solely on payment policy adjustments (Nathwani et al., 2001; Parikh et al., 2017; Rahardjoputro et al., 2024).

Effectiveness of Reimbursement Systems (DRG, INA-CBG's, and DIP)

Prospective payment systems, including Diagnosis-Related Groups (DRG), INA-CBG's, and Diagnosis-Intervention Packets (DIP), have been widely implemented as key mechanisms for controlling healthcare costs. These package-based payment models establish fixed tariffs based on specific diagnoses or interventions, thereby incentivizing hospitals to manage resources more efficiently. Numerous studies have demonstrated that the adoption of prospective payment systems is associated with reductions in average inpatient costs and shorter lengths of stay, indicating improved operational efficiency (Chen et al., 2023; Fenga et al., 2024).

Diagnosis-Related Groups (DRGs) and combined payment calculations have been shown to improve hospital efficiency by reducing length of stay and inpatient costs without statistically significant increases in readmission rates or mortality, indicating no deterioration in quality of care (Yue et al., 2025). Evidence from diagnosis-intervention packet reforms further supports these findings. In China, DIP implementation for pediatric pneumonia was associated with shorter length of stay and lower hospitalization costs, while maintaining stable ICU transfer rates and improving cure rates, suggesting preserved clinical outcomes (Zhao et al., 2025). Additional evidence from DIP reform studies reported reductions in short-term and 30-day all-cause readmission rates alongside stable or reduced medical expenditures among insured populations, indicating concurrent improvements in efficiency and maintained quality of care (Lin et al., 2024). More broadly, prospective payment mechanisms, including DRG-based tariffs, per-diem rates, and bundled payments, have been shown to enhance cost containment by encouraging hospitals and providers to limit unnecessary services and shorten hospital stays (F. Liu et al., 2023). In publicly funded healthcare systems, the implementation of integrated payment schemes has been reported to support sustainable cost control while simultaneously improving access and service quality, as providers are driven to compete on efficiency while operating under predetermined reimbursement rates (Wohlin et al., 2021).

Despite their effectiveness as cost-control instruments, prospective payment systems have frequently resulted in negative cost–reimbursement gaps or underfunding, posing significant financial challenges for healthcare providers. Empirical evidence from Indonesia, including findings from Dr. Sardjito General Hospital, as well as from several university hospitals in Germany, revealed substantial discrepancies between actual hospital expenditures and package-based reimbursement rates paid by insurers (Jeck et al., 2022; Kurniawati & Sugeng, 2024). In the Indonesian context, INA-CBG's tariffs under the National Health Insurance (JKN) scheme were reported to be approximately 32.5% lower than private hospital tariffs, particularly for high-cost inpatient services such as surgical procedures and accommodation (Fitri & Sundari, 2023).

This situation has been further exacerbated by reimbursement tariffs that remain relatively static and insufficiently responsive to case complexity or the adoption of advanced medical technologies, thereby increasing hospitals' vulnerability to financial losses. Evidence from the United States has similarly shown that hospital prices negotiated with commercial insurers can be nearly twice as high as those reimbursed under Medicare Advantage, reflecting differences in pricing incentives and regulatory frameworks (Meiselbach et al., 2023). Such tariff disparities ultimately influence service quality and access, as patients covered by public insurance schemes may face higher risks of complications and cumulative healthcare costs compared with privately insured patients (Allen et al., 2021; Ibrahim et al., 2021; Jacobs et al., 2023).

Strategies for Reimbursement Optimization and Cost Control

To mitigate the risk of financial losses associated with package-based payment systems, hospitals have needed to adopt practical strategies centered on optimizing clinical coding and administrative claims processes. Accurate documentation of comorbidities and complications has

been a critical determinant in ensuring that insurance claims adequately reflect disease severity and actual clinical workload. Inadequate documentation has frequently resulted in underbilling, leading hospitals to forgo legitimate reimbursement revenue (Bellamkonda et al., 2025). Within Diagnosis-Related Group–based payment systems, coding quality directly determines reimbursement levels, and inaccurate or incomplete coding has contributed to revenue losses. Evidence has shown that the use of more detailed clinical data and advanced analytical approaches improved coding accuracy by identifying comorbidities and complications that were commonly overlooked, thereby reducing underbilling and enhancing hospital revenue (Decicco et al., 2022; Dua et al., 2025). Similar findings have been reported in the Medicare Severity Diagnosis-Related Group system, where the utilization of granular data from clinical registries played a key role in minimizing financial losses related to suboptimal claims submission (Dua et al., 2025).

Beyond administrative measures, technological innovation and the application of artificial intelligence have contributed as preventive strategies for healthcare cost control. Diagnostic tools capable of differentiating host immune responses to infection, as well as AI-based clinical decision support systems, have facilitated earlier and more accurate diagnosis while reducing unnecessary antibiotic use. The implementation of these technologies was associated with hospital cost reductions of up to 12.3% without compromising the quality of patient care (Schneider et al., 2022; Y. Wu et al., 2025). At the managerial level, the standardization of clinical pathways has emerged as an essential strategy to minimize practice variation and reduce redundancy in resource utilization. Regional collaboration and performance benchmarking against industry standards have further supported the reduction of technical inefficiencies, which were reported to reach up to 18%, thereby strengthening hospital financial sustainability under package-based payment systems (Linying, 2025).

The standardization of clinical pathways has also been significantly associated with reductions in hospital costs, shorter lengths of stay, and improved clinical outcomes for patients. The effectiveness of this instrument has largely depended on the level of healthcare providers' adherence to established evidence-based clinical guidelines (Foni et al., 2020; Noba, 2020; Rotter et al., 2025). Low adherence to clinical pathways has increased variability in care delivery, which in turn has generated additional costs that were not fully compensated by bundled insurance tariffs. Conversely, the implementation of standardized care processes has reduced per-patient costs, lowered readmission rates, and minimized variation in service quality. Multiple studies have confirmed that higher levels of compliance with clinical pathways directly contributed to improved operational efficiency and optimized utilization of hospital resources (Bhatia & Swaminathan, 2025; Rachmawaty et al., 2025; S. Q. Wu et al., 2025).

CONCLUSION

Based on this literature review, pneumonia-related hospital cost management continues to face substantial challenges due to persistent mismatches between actual treatment costs and insurance reimbursement tariffs. Prolonged length of stay and the use of high-cost antibiotics and advanced medical technologies in severe and complicated cases were consistently identified as the main drivers of excess costs. Although package-based payment systems, including DRG, INA-CBG's, and DIP, have improved hospital efficiency and reduced average costs per patient, insufficient tariff calibration by disease severity and case mix exposes hospitals to ongoing financial risk.

From a policy perspective, payers and government authorities should prioritize severity- and case-mix–based reimbursement adjustments for pneumonia care, supported by routine updates of INA-CBG tariffs using empirical real cost data. Operational measures should include add-on payments or separate reimbursement mechanisms for high-cost antibiotics, intensive care services, and advanced diagnostic technologies to prevent systematic underfunding of severe cases. While pathway evaluation and coding improvements remain important for enhancing hospital-level efficiency, policy-level tariff recalibration based on severity-adjusted cost evidence is

essential to ensure financial sustainability while maintaining quality of care within the national health insurance system.

ACKNOWLEDGEMENTS

The authors would like to express their sincere appreciation to Universitas Ahmad Dahlan for the academic support provided throughout the preparation of this literature review. The authors also gratefully acknowledge the supervisors for their guidance, constructive feedback, and valuable scientific insights, which significantly contributed to the improvement of both the writing quality and the substance of this study.

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