Case Report

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Spatial Distribution and Temporal Trends of Pneumonia in Indonesia: Descriptive Analysis of Early Warning and Response System (SKDR) Data, 2022-2024

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ABSTRACT

Background: *Pneumonia remains a significant public health burden in Indonesia. This study aims to analyze the spatial distribution and temporal trends of pneumonia in Indonesia using data from the Early Warning and Response System (SKDR) for the period 2022–2024.*
Methods: *This descriptive study utilized secondary aggregate data from the Indonesian Ministry of Health's SKDR, covering all 38 provinces from 2022 to 2024. Analyses were performed on the annual and cumulative distribution of pneumonia cases across provinces, visualized through ranking tables and choropleth maps, followed by a temporal analysis of quarterly trends*
Results: *The SKDR recorded 1,204,023 pneumonia cases during the study period. Temporally, a significant yearly increase was observed, alongside a predictable seasonal pattern, with Quarter 2 consistently the period of lowest incidence. Spatially, extreme disparities were found, with the highest case hotspots concentrated predominantly on Java Island. Conversely, coldspots in Eastern Indonesia (e.g., Southwest Papua, Maluku) more likely reflect limitations in surveillance and healthcare access, indicating the presence of hidden high-risk areas.*
Conclusion: *Pneumonia in Indonesia exhibits dynamic temporal patterns and sharp spatial concentration. These findings underscore the necessity of differentiated control strategies: proactive interventions based on seasonal patterns, intensive resource allocation in hotspots to control transmission, and strengthened surveillance systems and healthcare access in coldspots to address hidden high-risk areas.*

INTRODUCTION

Pneumonia remains a leading global cause of morbidity and mortality, particularly among vulnerable populations such as children and the elderly [1,2]. According to the World Health Organization (WHO), it is the single largest infectious cause of death in children worldwide, accounting for approximately 740,180 deaths in children under five in 2019 alone [3]. This acute infection of the lung parenchyma, caused by a variety of pathogens, poses a significant public health challenge due to its potential for severe complications and substantial health system costs [4].

In Indonesia, the burden of pneumonia remains substantial. Data from the 2023 National Health Survey (SKI) revealed a symptom-based prevalence of 10.8%, underscoring the disease's widespread occurrence in the population [5]. Alarmingly, pneumonia persists as a significant cause of mortality among toddlers (12-59 months), accounting for 1.6% of deaths in this age group in 2023 [6]. Furthermore, a critical challenge is the low case detection rate of only 36.95% in children under five, indicating a substantial number of undiagnosed and untreated cases [5]. Compounding this issue are the pronounced geographical disparities in disease burden across the archipelago, suggesting uneven resource allocation, healthcare access, or environmental risk factors [7].

Understanding the complete epidemiological profile of pneumonia, including its burden, distribution patterns, and temporal trends, is crucial for developing effective control strategies and resource allocation.

To monitor potential outbreaks, the Indonesian Ministry of Health established the Early Warning and Response System (SKDR), which collects comprehensive weekly pneumonia case data from all 38 provinces [8]. While the Early Warning and Response System (SKDR) represents a rich and valuable data source for epidemiological intelligence, its potential has not been fully realized. A critical gap exists in the spatial and temporal analysis of this national data. Most existing reports are limited to descriptive summaries and lack the integration of these dimensions, which is crucial for understanding disease dynamics. Consequently, key questions remain unanswered: Where are the persistent hotspots of pneumonia? What are the specific seasonal patterns and temporal trends in different regions of Indonesia? Answering these questions through a focused descriptive analysis is essential, as it has proven to be significant for identifying high-risk areas, informing targeted surveillance, and guiding resource allocation for maximum public health impact [9].

To address this gap, this study aims to perform a descriptive analysis of pneumonia cases in Indonesia from 2022 to 2024 using SKDR data. Specifically, we seek to: (1) Describe the national and quarterly temporal trends of pneumonia cases. (2) Map the geographical distribution and identify high-risk clusters (hotspots) and low-risk areas (coldspots). (3) Synthesize these findings on spatial distribution and temporal trends to provide evidence for targeted public health interventions and resource prioritization.

METHODS

This study employed a descriptive design using secondary aggregate data from the Indonesian Ministry of Health's Early Warning and Response System (SKDR). SKDR collects pneumonia surveillance data through mandatory weekly reporting from health service facilities, including primary health centers (Puskesmas), hospitals, clinics, and affiliated community health networks. Case reporting follows the national pneumonia case definition, and data are submitted electronically via the SKDR platform, using real-time or near-real-time inputs from trained surveillance officers. These reports undergo routine validation at district and provincial levels before being aggregated at the national level [10].

The analysis focused on two complementary components. First, an interprovincial distribution analysis was conducted by summarizing annual and cumulative case counts for all 38 provinces and visualizing them through ranking tables and choropleth maps to identify spatial clusters of high and low burden. Second, a temporal analysis was performed using quarterly national trends across the three years (2022–2024) to detect seasonal patterns, peak periods, and year-to-year shifts in incidence. All analyses were descriptive and based on aggregated data, without individual-level inference. This study adopted a descriptive design because the available data consist of routinely collected aggregate surveillance reports across defined geographical and temporal units. The strength of this approach lies in its ability to rapidly provide a comprehensive overview of disease distribution, both spatially and temporally, which is essential for immediate public health prioritization and targeted resource allocation. However, this design inherently limits causal inference. It carries the risk of ecological fallacy, meaning findings at the provincial level cannot be extrapolated to individual risk, thus positioning the results as hypotheses for future analytical research. The analysis included all reported pneumonia cases from 38 provinces in Indonesia from 1 January 2022 to 31 December 2024 (Epidemiological Week 1 of 2022 to Week 52 of 2024).

The dataset consisted of weekly aggregate reports by province, containing the variables: year, province, epidemiological week, and number of cases. For trend analysis, weekly data were aggregated into quarterly and annual totals. Quarterly periods were defined as follows: Quarter 1 (Weeks 1–13), Quarter 2 (Weeks 14–26), Quarter 3 (Weeks 27–39), and Quarter 4 (Weeks 40–52). The national total cases were calculated as the aggregate of weekly reports from all 38 provinces during the study period.

Given the use of secondary aggregate data, several aspects related to data quality and potential reporting biases were considered. Data cleaning involved standardizing geographical units following provincial boundary changes during the study period and checking for extreme outliers in weekly reporting that may indicate data-entry errors; however, no data points were excluded, as the analysis aimed to capture the full reported burden. The validity of the aggregate SKDR data is acknowledged to be subject to under-reporting bias, particularly in rural and remote areas (Coldspots). This is due to limited healthcare access, low awareness, and potential delays or incomplete electronic submissions by surveillance officers under resource constraints. Conversely, over-reporting bias or misclassification may be more common in areas with highly motivated reporting units, though less so. Crucially, the SKDR system is designed to track syndromic trends rather than absolute incidence; therefore, the low case counts observed in Eastern Indonesia are more likely an artifact of surveillance deficiency (detection bias) than a true reflection of low disease burden. We relied on the routine validation steps already implemented at the district and provincial levels by the Ministry of Health before data aggregation.

The analysis was conducted by time and place. Temporal analysis was performed using nationally aggregated quarterly data, visualized through a line chart to describe case trends over time. For spatial analysis, three-year cumulative cases per province were calculated and presented in ranking tables of the ten provinces with the highest and lowest case burdens. A choropleth map was generated in QGIS, a geographic information system, to illustrate the geographical distribution of pneumonia. All data processing and descriptive analyses were performed using Microsoft Excel and QGIS.

RESULTS

Overview of Pneumonia Cases in Indonesia (2022–2024)

During the three-year study period, from January 1, 2022, to December 31, 2024, the Early Warning and Response System (Sistem Kewaspadaan Dini dan Respon, SKDR) recorded a total of 1,204,023 pneumonia cases across 38 provinces in Indonesia, averaging 401,341 cases per year. This figure represents a substantial national disease burden and highlights the importance of continuous surveillance of pneumonia trends in Indonesia.

Distribution of Pneumonia Cases by Province

The distribution of pneumonia cases across 38 provinces in Indonesia during 2022–2024 is presented in Table 1. Overall, the number of cases exhibited a consistent annual upward trend, with almost all provinces showing increases over the three years. The highest absolute disease burden was recorded on Java Island, where West Java, Central Java, and East Java consistently ranked as the top three provinces throughout the study period. These provinces contributed the largest share of the national total, forming the primary high-risk cluster (hotspot) of pneumonia in Indonesia.

Conversely, provinces in eastern Indonesia, such as Southwest Papua, Maluku, and West Sulawesi, consistently ranked among the lowest across the three years. The low number of reported cases in these areas may not solely reflect a lower disease burden but could also indicate disparities in surveillance and case reporting capacity between regions.

Cumulatively, 1,204,023 pneumonia cases were recorded nationwide during the 2022–2024 period. The concentration of cases in Java and parts of western Indonesia underscores the geographical disparity in disease burden, showing a clear gradient from west to east.

Table 1. Comprehensive Ranking of Pneumonia Cases by Province (2022, 2023, 2024, and Cumulative)

Rank	Province	2022 Cases	2023 Cases	2024 Cases	Cumulative Number of Cases (2022-2024)
1	West Java	41668	65512	110638	217818
2	Central Java	40937	65946	85287	192170
3	East Java	37861	55734	73116	166711
4	Jakarta	13427	21737	38237	73401
5	Banten	12270	21685	33960	67915
6	West Nusa Tenggara	12789	17977	21928	52694
7	South Kalimantan	9660	14468	17737	41865
8	DI Yogyakarta	1984	12544	23181	37709
9	North Sumatra	4241	12580	15788	32609
10	East Nusa Tenggara	8885	11124	11417	31426
11	South Sulawesi	5802	8125	16748	30675
12	Central Sulawesi	6504	8102	10348	24954
13	Central Papua	6155	6942	7760	20857
14	Bali	972	6404	11431	18807
15	West Sumatra	2390	6596	9644	18630
16	East Kalimantan	2231	5367	10972	18570
17	Gorontalo	3632	5001	5722	14355
18	West Kalimantan	2954	4773	5347	13074
19	Southeast Sulawesi	2775	3843	4893	11511
20	Lampung	3465	3309	3803	10577
21	Papua	1548	3943	4503	9994
22	Riau Islands	482	2663	6326	9471
23	Riau	991	2477	5532	9000
24	South Papua	2069	3201	2946	8216
25	North Maluku	1223	3006	3334	7563
26	Bangka Belitung	1977	2338	2906	7221
27	North Sulawesi	832	1826	4288	6946
28	West Papua	1724	2268	2010	6002
29	Central Kalimantan	946	1857	3024	5827
30	Aceh	1304	1900	2250	5454
31	South Sumatra	1616	1707	2038	5361
32	Jambi	1773	1733	1771	5277
33	North Kalimantan	1115	1669	1707	4491
34	Highland Papua	1497	1203	1744	4444
35	Bengkulu	1389	1074	1258	3721
36	West Sulawesi	542	570	2240	3352
37	Maluku	744	1163	1081	2988
38	Southwest Papua	790	830	747	2367

This pattern confirms the significant geographical disparities between western and eastern Indonesia, where densely populated, highly urbanized areas tend to report substantially higher case numbers than less-populated regions [11].

Spatial Distribution of Pneumonia Cases

Spatial visualization in Figures 1–3 illustrates the interprovincial dynamics of pneumonia distribution across study years.

In 2022 (Figure 1), pneumonia cases were highly concentrated on Java Island, particularly in West Java, Central Java, and East Java. Additional areas with very high disease burdens were also observed in West Nusa Tenggara and East Nusa Tenggara, forming a secondary cluster in the southern region. Outside these primary clusters, South Sulawesi and parts of South Kalimantan exhibited high disease burdens. At the same time, Bali, Maluku, Papua, and North Kalimantan fell into the low-to-moderately low disease burden category. Overall, the 2022 spatial pattern demonstrated that the national pneumonia burden was dominated by western and southern regions, with decreasing intensity toward the eastern islands.

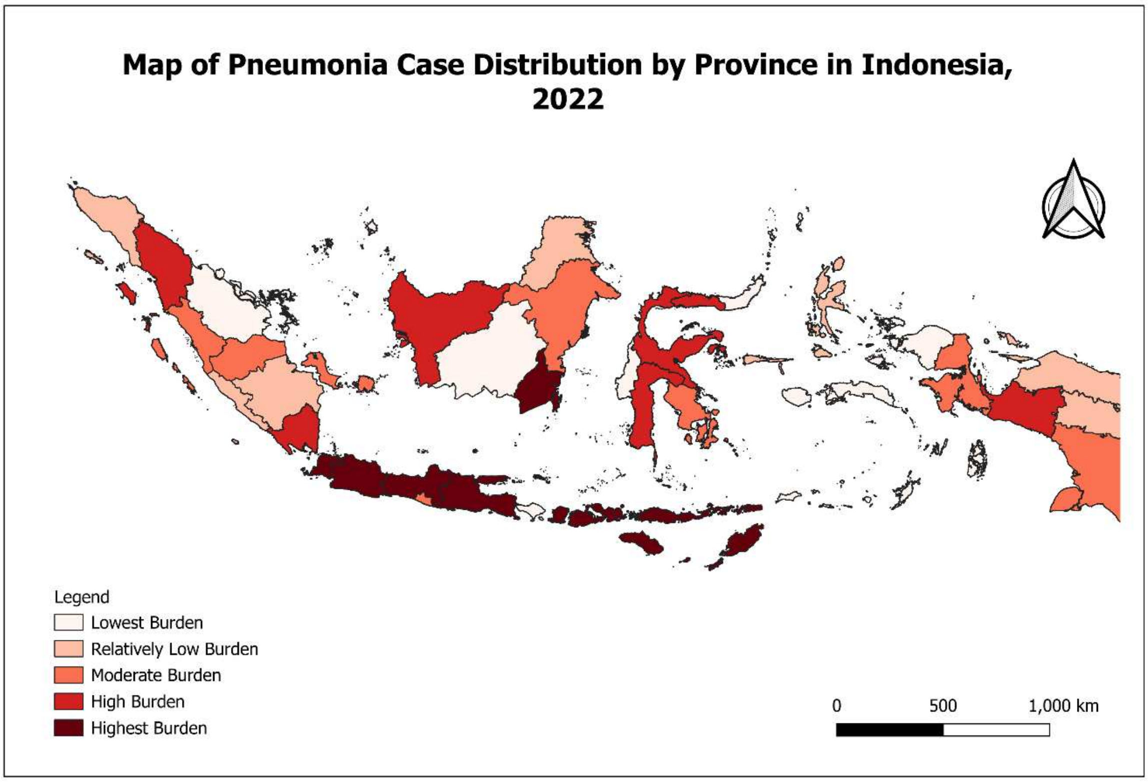

Figure 1. Spatial Distribution of Pneumonia Cases by Province, Indonesia, 2022

In 2023 (Figure 2), the spatial pattern remained dominated by very high-risk clusters in West Java, Central Java, and East Java. Although Java continued to dominate, other regions showed increased intensity, indicating an expansion of the disease burden. Notably, North Sumatra rose to the "very high" category, joining South Kalimantan, which maintained its status from the previous year. Additionally, the southern cluster, including Bali, West Nusa Tenggara, and East Nusa Tenggara, collectively sustained and reinforced their high-burden categories, suggesting a continued expansion of pneumonia risk beyond Java.

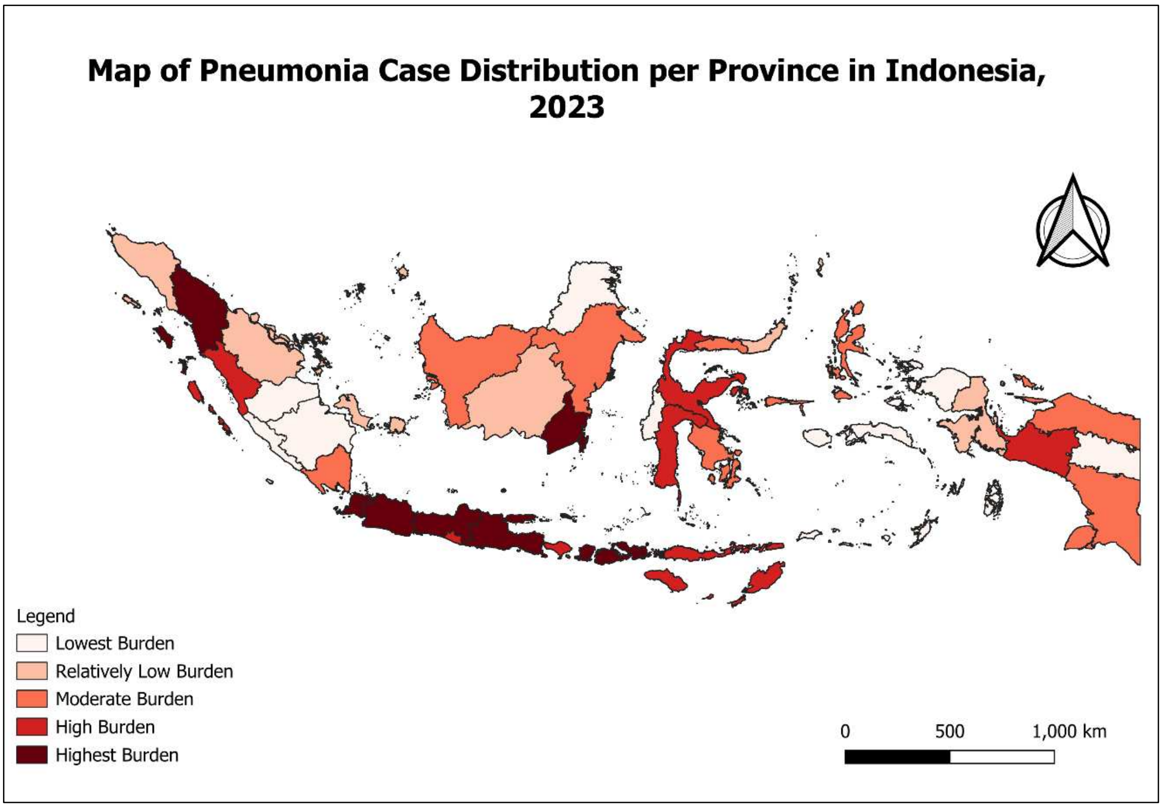

Figure 2. Spatial Distribution of Pneumonia Cases by Province, Indonesia, 2023

In 2024 (Figure 3), the distribution pattern showed persistent dominance in Java and western Indonesia, while eastern provinces such as Maluku, Papua, and North Kalimantan continued to report low to moderately low burdens. High-risk clusters outside Java, including North Sumatra, South Sulawesi, South Kalimantan, East Kalimantan, Bali, West Nusa Tenggara, and East Nusa Tenggara, remained prominent. These consistent spatial gradients underscore enduring geographic disparities throughout the study period.

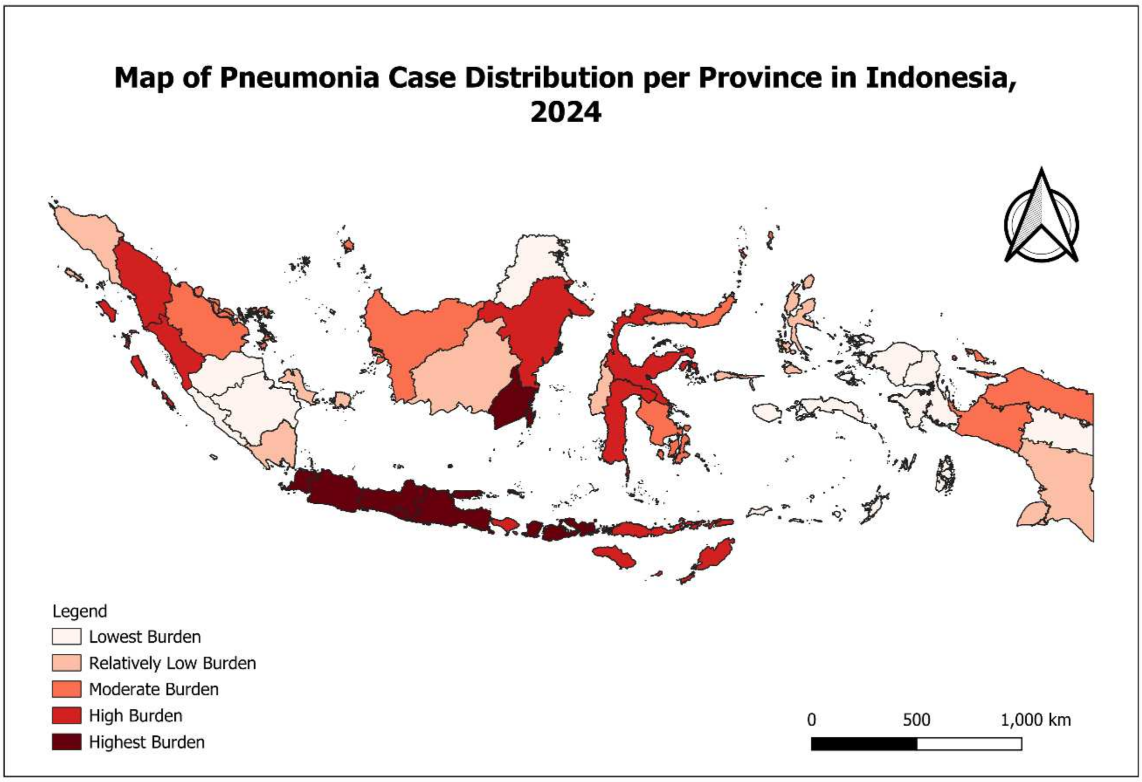

Figure 3. Spatial Distribution of Pneumonia Cases by Province, Indonesia, 2024

Taken together, the three annual maps demonstrate a relatively stable yet gradient spatial pattern, with the highest burdens concentrated in densely populated and economically active regions, while eastern Indonesia exhibited relatively lower risks. This pattern indicates the influence of demographic, urbanization, and healthcare accessibility factors on disease distribution.

National Temporal Trend of Pneumonia Cases

The national temporal trend of pneumonia cases during 2022–2024, illustrated in Figure 4, reveals consistent annual increases along with clear seasonal variation. In general, pneumonia cases rose steadily each year, peaking in Quarter IV of 2022 and 2023, before shifting to Quarter III in 2024. This shift suggests temporal variability in disease incidence, potentially influenced by environmental factors and seasonal changes.

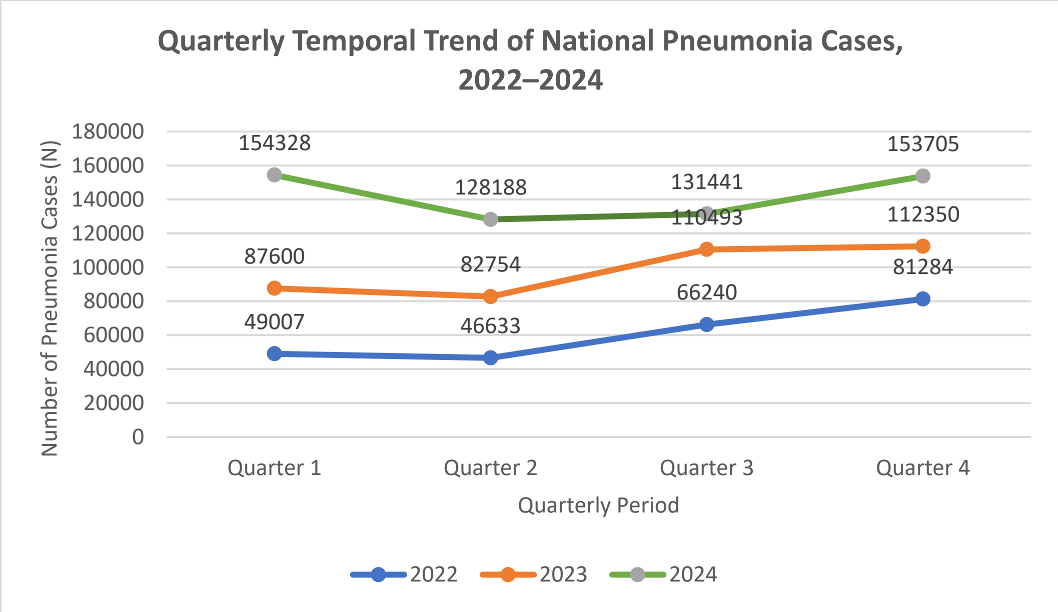

Figure 4. Quarterly Temporal Trend of National Pneumonia Cases, 2022–2024

Beyond the annual increases, the quarterly analysis revealed a consistent decline in cases during Quarter II of each observation year. This recurring seasonal dip may reflect the influence of tropical climatic conditions on the transmission of pneumonia-causing pathogens in Indonesia. Consequently, the temporal analysis provides an important basis for early warning strategies and the optimal timing of public health interventions.

DISCUSSION

This study delineated the epidemiological characteristics of pneumonia in Indonesia from 2022 to 2024 using a comprehensive descriptive approach. The overall increase in pneumonia cases over the three years reflects a broader post-pandemic resurgence of respiratory infections globally, particularly in tropical-climate countries where environmental and behavioral determinants strongly influence transmission [12]. The consistent decline in cases observed in Quarter 2 each year aligns with seasonal epidemiological patterns described in Southeast Asia, where lower rainfall, reduced humidity, and shifts in population mobility contribute to a temporary reduction in respiratory pathogen circulation [13]. Understanding these predictable seasonal windows is essential for implementing early-warning systems and scheduling preventive interventions, consistent with WHO recommendations for respiratory disease preparedness [14]. A clear understanding of this seasonal pattern creates a strategic window of opportunity for pneumonia control programs. This proactive approach, supported by the identification of a clear seasonal pattern, aligns with broader global health strategies outlined by the WHO to reduce morbidity and prepare for annual respiratory epidemics [15].

Multiple factors may drive the sustained year-to-year increase in pneumonia cases. The concept of immunity debt, a global phenomenon characterized by heightened susceptibility to respiratory infections following prolonged periods of reduced exposure during the COVID-19 pandemic, has been widely reported in Asia and Europe and may partially explain the upward trend observed in Indonesia[16]. At the same time, improvements in the SKDR surveillance system, including expanded reporting coverage, better diagnostic availability, and strengthened digital reporting platforms, may have enhanced case detection, producing a more complete picture of the national pneumonia burden [17]. The shift in peak incidence from Quarter 4 to Quarter 3 in 2024 also suggests dynamic interplays between climatic variation and circulating respiratory viruses, such as RSV, Influenza, and adenoviruses, patterns similarly documented in studies from Thailand, Malaysia, and the Philippines [18,19]. Therefore, this shift highlights the need for real-time monitoring to manage the temporal uncertainty of outbreaks from year to year, while also providing a foundation for further analytical investigations to specifically confirm the relative contributions of climatic and virological factors.

Beyond temporal patterns, this study revealed pronounced spatial disparities in pneumonia burden across Indonesia. The concentration of high-burden clusters in Java is consistent with prior studies linking population density, urban crowding, and industrial air pollution to elevated risks of respiratory infections in Southeast Asia [20,21]. Java's extremely high population density increases person-to-person contact rates, accelerating pathogen transmission. In contrast, its high levels of PM2.5 pollution have been repeatedly linked to increased pneumonia mortality and hospitalization in regional meta-analyses [22,23]. Nevertheless, the emergence of West Nusa Tenggara, East Nusa Tenggara, North Sumatra, and South Kalimantan as secondary high-risk clusters highlights that context-specific determinants beyond Java, particularly socio-economic disparities and limited healthcare access, play a critical role in shaping pneumonia risk. [24–26]. Furthermore, studies in rural settings in Indonesia and Bangladesh similarly show that delayed care-seeking, malnutrition, indoor biomass fuel exposure, and low-quality primary care contribute significantly to pneumonia incidence in non-urban settings [24,27,28].

In contrast, provinces categorized as coldspots, such as Southwest Papua, Maluku, and West Sulawesi, require careful interpretation. The low number of reported cases is unlikely to indicate a genuinely low disease burden, but rather reflects persistent gaps in surveillance sensitivity, health system reach, and service accessibility. These regions face structural challenges, including geographic isolation, limited transportation networks, understaffed health facilities, and logistical constraints in laboratory confirmation factors repeatedly highlighted in national assessments of surveillance performance in Eastern Indonesia [29]. This condition indicates that the recorded pneumonia burden is likely far lower than the actual incidence in the community [30]. In addition, lower health-seeking behavior, reliance on traditional healers, and incomplete reporting from remote Puskesmas contribute to under-detection of pneumonia cases [31].

Similar challenges related to the under-detection of respiratory infections in remote and underserved areas have been reported across several countries in Southeast Asia and the Pacific. Studies from Papua New Guinea and the Philippines, for example, show that geographical isolation, limited diagnostic capacity, and weak routine surveillance contribute to substantial underreporting of pneumonia and other acute respiratory infections [32,33]. Thus, the coldspot classification likely reflects underreporting rather than lower incidence, and these provinces should be considered priority areas for surveillance strengthening.

Taken together, these temporal and spatial findings offer critical insights for pneumonia control in Indonesia. The predictable seasonal patterns provide clear opportunities for targeted interventions such as vaccination drives, reinforcement of primary care readiness, and resource pre-positioning before peak months [14]. Spatial mapping allows the Ministry of Health to allocate resources in a differentiated manner: high-burden urban clusters such as Java require intensive transmission control, air quality interventions, and hospital surge preparedness, while underserved regions in Eastern Indonesia require investments in surveillance sensitivity, diagnostic capacity, and accessibility of essential health services. Strengthening the integration between routine SKDR reporting and community-level case detection, especially through active surveillance and digital reporting innovations, could substantially reduce reporting gaps.

Finally, although this study is descriptive and cannot establish causal inferences, its findings are consistent with global evidence on pneumonia epidemiology and highlight key structural determinants that warrant policy attention. The observed disparities reinforce WHO's call for targeted, equity-driven strategies for respiratory disease control, especially in geographically diverse lower-middle-income countries. Future studies using individual-level data or spatial-temporal modeling are needed to deepen the understanding of the underlying drivers and to support more precise risk stratification.

CONCLUSION

Based on the analysis of Early Warning and Response System (EWARS/SKDR) data from 2022–2024, it is concluded that pneumonia in Indonesia exhibits distinct epidemiological characteristics, marked by a yearly increasing temporal trend and a consistent seasonal pattern (a predictable decline in Quarter II). Extreme spatial disparities establish Java Island as the national epicenter (hotspot), driven primarily by demographic and environmental factors such as urbanization and air pollution. Conversely, the low number of reported cases in Eastern Indonesia (e.g., Southwest Papua, Maluku) more likely reflects limitations in surveillance systems and healthcare access, indicating the existence of hidden high-risk areas.

These findings underscore the necessity of a differentiated, highly specific control strategy. Temporally, proactive interventions such as the mobilization of vaccination campaigns

(PCV/Influenza) and logistics preparation (e.g., ensuring medical supply stock) must be strategically scheduled during Quarter II to maximize preparedness before the peak transmission period. Spatially, resource allocation must be tailored:

1. For Hotspots (Java): Focus on intensive transmission control and mitigating modifiable environmental risk factors, including enforcing policies to address non-infectious triggers like air pollution (PM2.5).
2. For Coldspots (Eastern Indonesia): The priority is strengthening the detection system. This requires specific actions, including detailed training for surveillance personnel on national case definitions and real-time SKDR reporting, as well as the mobilization of diagnostic logistics and improved service access to uncover the true burden of disease.

This study thus provides a robust, actionable evidence base to improve pneumonia control resource allocation in Indonesia.

DECLARATIONS

Ethics approval

This study was approved by the Ethical approval obtained from the Research and Community Service Ethics Committee, Faculty of Public Health, Universitas Indonesia (No. Ket-592/UN2.F10. D11/PPM. 00.02/2025).

Conflict of interest.

The authors declare no conflict of interest.

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