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Priority of vaccine-preventable diseases (VPDs) based on routine VPD surveillance using a PAHO-adapted Hanlon method based on Depok City, 2024

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Abstract

Purpose: This situational analysis aimed to identify priority vaccine-preventable diseases (VPDs) in Depok City based on local epidemiological conditions. **Methods:** Secondary routine data from the Depok City Health Office for 2023–2024 were analyzed, including surveillance reports, immunization coverage data, and outbreak records. Priority setting was conducted using a PAHO-adapted Hanlon based on disease magnitude, seriousness, effectiveness of interventions, inequity, and institutional capacity. Scoring was carried out through discussions with surveillance staff and heads of primary health centers (the five highest and five lowest reported cases among the primary health centers), as well as five representatives from the Depok City Health Office. **Results:** Diphtheria was identified as the highest-priority VPD with a basic priority rating (BPR) score of 15.49, followed by pertussis (13.61) and rubella (10.37). During 2023-2024, pertussis incidence increased from 7.26 to 14.92 per 1,000,000 population, while rubella incidence rose from 4.15 to 5.97 per 1,000,000 population. Although immunization coverage was relatively high (95.5% in 2023 and 104.91% in 2024), 28.60% of villages did not achieve UCI status in 2023. VPD surveillance system performance in Depok City during 2023–2024 showed mixed results, with improvements in several indicators but persistent gaps in adequate measles–rubella investigation and acute flaccid paralysis (AFP) specimen adequacy. Discussions identified challenges, including staff turnover, health service capacity, workload constraints, training, delayed case follow-up, and delayed recognition of early pertussis symptoms at the primary health care level. **Conclusion:** Diphtheria, pertussis, and rubella were identified as the highest-priority VPDs in Depok. Context-specific strategies are needed to strengthen surveillance sensitivity, improve immunization equity, and enhance outbreak prevention.

Keywords: health priorities; immunization; vaccination coverage; vaccine-preventable diseases

INTRODUCTION

Globally, vaccine-preventable diseases (VPDs) such as polio, measles, rubella, tetanus, diphtheria, and pertussis continue to pose challenges. Immunization is the prevention and control of infectious diseases [1]. In 2023, global immunization coverage remained suboptimal, with measles second-dose coverage at 74%, rubella coverage at 71%, and poliovirus vaccination coverage at 89% in Europe and only 6% in the WHO

South-East Asia Region [2]. Given the presence of epidemiologically linked and laboratory-confirmed cases, Depok city continues to report VPD cases. The burden is concentrated among children aged 0–18 years, who account for the majority of cases, highlighting their vulnerability. Although basic immunization coverage in Depok reached 95.5% in 2023 and 104.91% in 2024, Universal Child Immunization (UCI) coverage remained uneven, with 18 of 63 villages (28.60%) failing to meet the target [3,4]. These conditions suggest that VPDs continue to pose a substantial public health burden at the local level.

Surveillance plays a critical role in the prevention and control of communicable diseases by enabling early case detection and supporting timely public health action [5]. Acute Flaccid Paralysis (AFP) surveillance is a critical component of polio eradication efforts. In Indonesia, adequate AFP surveillance is defined as a non-polio AFP (NPAFP) rate of ≥2 cases per 100,000 children under 15 years [6]. During outbreak settings, a higher benchmark of ≥3 cases per 100,000 children under 15 years is applied to ensure sufficient surveillance sensitivity [7]. In Depok City, the NPAFP rate had exceeded the target, reaching 4.76 per 100,000 children in 2023 [3]. However, despite achieving surveillance performance indicators, a circulating vaccine-derived poliovirus (VDPV) case was reported in West Java Province and classified as a polio outbreak [8]. Similarly, measles and rubella remain persistent despite elimination targets. In Depok, measles incidence declined from 102.70 per 1,000,000 population in 2023 to 4.97 per 1,000,000 population in 2024, while rubella incidence increased from 4.15 to 5.97 per 1,000,000 population [3,4]. Diphtheria cases also persisted, with ongoing outbreak status since 2022, while pertussis incidence doubled from 7.26 to 14.92 per 1,000,000 population between 2023 and 2024 [3,4].

Additionally, an estimated 14.5 million infants worldwide did not receive any dose of the diphtheria–tetanus–pertussis vaccine in 2023, while 6.5 million were only partially vaccinated, with nearly 59% of these cases concentrated in 10 countries, including Indonesia [9]. Tetanus neonatorum cases were reported in Bogor regency, Bogor City, Majalengka, Garut, and Bekasi in 2023 [10]. Previous studies have shown that transmission may persist even in settings with high immunization coverage, particularly when local pockets of low vaccination coverage remain, thereby still triggering outbreaks [11]. Pertussis resurgence has been associated with vaccination, pathogens, and surveillance [12]. In line with this, the WHO, through the Immunization Agenda 2030, emphasizes strengthening national immunization systems integrated with primary health care to support disease elimination, including improvements in surveillance, data quality, outbreak preparedness, workforce capacity, governance, and sustainable financing [13].

However, despite the availability of surveillance and immunization data, existing analyses are often descriptive and program-specific, with limited integration of multiple indicators to systematically identify priority VPDs. In Depok City, discrepancies between high reported immunization coverage and ongoing VPD transmission, including persistent diphtheria cases and increasing pertussis incidence, suggest gaps in program effectiveness [3,4]. Most existing reports do not simultaneously consider epidemiological trends, surveillance performance, and health system capacity, nor do they incorporate stakeholder perspectives to explain operational challenges such as delayed follow-up, workforce constraints, and uneven service delivery. This lack of a structured, comprehensive approach may limit local health authorities' ability to prioritize interventions effectively and address the underlying determinants of VPD transmission.

Given Indonesia's commitments to eliminate measles and rubella by 2026, eradicate polio by 2026, and control diphtheria and pertussis [14–17], establishing sensitive case-based surveillance systems and conducting a comprehensive situation analysis are essential for identifying priority VPD problems and contributing factors. This study addresses this gap by applying a comprehensive PAHO-adapted Hanlon priority-setting approach that considers seriousness, effectiveness, inequity, and institutional factors. Institutional factors allow for the inclusion of various political and strategic considerations in the priority-setting process. The assessment was based on routine surveillance data and immunization coverage, and stakeholders then identified priority VPDs at the city level. This approach integrates routine data with stakeholder insights to capture operational realities such as workload and staff turnover. This is also the first study to conduct a situational analysis of VPDs in Depok using this approach. Therefore, this study aimed to systematically identify and prioritize VPD in Depok City based on epidemiological data, immunization coverage, and surveillance performance to support evidence-based public health planning and decision-making.

METHODS

Study design, setting, and subjects

This study was a descriptive situational analysis of VPDs in Depok City, 2024. The analysis was conducted

in Depok City, West Java, Indonesia. Participants in the priority-setting process included surveillance staff, heads of community health centers, and representatives from the Depok City Health Office. Inclusion criteria included having formal responsibility and decision-making authority in disease surveillance and immunization programs and being knowledgeable about VPD surveillance activities. A total of 15 participants were included, comprising representatives from 10 community health centers (5 with the highest and 5 with the lowest reported VPD case counts) and 5 representatives from the Depok City Health Office (Figure 1).

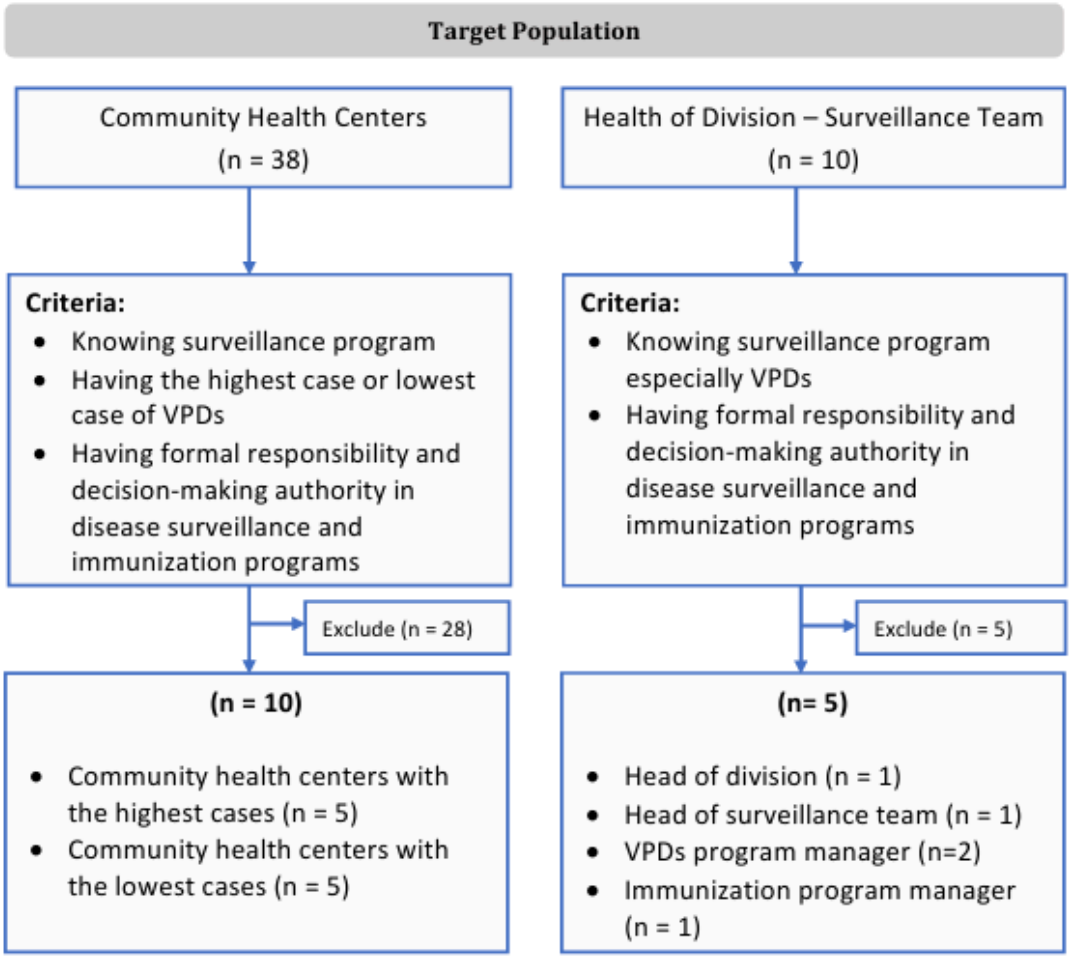

Figure 1. Research samples flow

Data sources

Data scoring was conducted during the group discussion sessions to establish disease priorities based on routine data from 2023–2024. This period was chosen to capture the most recent epidemiological situation and program performance prior to priority setting. Secondary data sources included routine VPD surveillance data, disease outbreak reports, immunization coverage records, and mortality data. Diseases included in the analysis comprised polio (AFP surveillance), measles, rubella, diphtheria, pertussis, and neonatal tetanus.

Data collection

Priority VPD problems were determined using a priority-setting approach adapted from the PAHO-adapted Hanlon method, which considers disease magnitude, seriousness, effectiveness of interventions, inequality, and institutional factors. Participants assigned scores based on routine surveillance data, taking into account gaps in surveillance performance indicators that had not yet met established targets. The gaps were considered key factors in determining the priority of VPD problems.

During the discussion sessions, participants reviewed and summarized secondary data and assigned scores based on the number of reported VPD cases, immunization coverage, mortality, elimination targets, and immunization targets. Following the scoring process, discussions were conducted to provide contextual clarification and support the interpretation of the priority-setting results.

Data analysis

The priority-setting analysis was conducted using the Basic Priority Rating (BPR) formula. Scores were obtained from 15 respondents. The individual scores from the 15 respondents were first averaged for each criterion and disease. The mean scores were then entered into the BPR calculation to generate a BPR value for each VPD. The BPR was calculated using the PAHO-adapted Hanlon formula, in which A represents the magnitude of the problem, where B reflects the overall seriousness of the disease. To ensure proper weighting within the BPR formula, B is calculated as the mean score of its four sub-criteria (B = [B1 + B2 + B3 + B4] / 4), which include urgency (B1), severity (B2), economic loss (B3), and negative effects (B4). E indicates the impact of health inequities (Table 1). The sum of these components was multiplied by C, representing the effectiveness of available interventions, divided by a constant (5.25), and then multiplied by F, which accounts for feasibility and institutional capacity. The range score will be chosen depending on the condition.

Table 1. Score range

Criteria	Score range
A (Magnitude)	0-10
B1 (Urgency)	0-5
B2 (Severity)	0-5
B3 (Economic loss)	0-5
B4 (Negative effect)	0-5
C (Effectiveness of interventions)	0-10
E (Inequity)	0-5
F (Institutional factor)	0.67-1.5

The resulting BPR values were subsequently ranked from highest to lowest to identify the first, second, and third priority VPDs. Formula for calculating BPR:

$$BPR = \frac{(A+B+E)\,C}{5.25} \times F$$

RESULTS

This situational analysis describes the epidemiological profile of VPDs/VPD, surveillance performance, immunization coverage, and contextual determinants in Depok City during 2023–2024. The analysis integrates routine surveillance performance, secondary health indicators, and a structured priority-setting exercise using a PAHO-adapted Hanlon method.

Burden of VPD cases

Table 2 shows the cases and incidence trends of six VPDs among the pediatric and adolescent population

Table 2. Incidence of VPD aged 0-18 years old

Vaccine-preventable diseases (VPD)	Case (incidence)	
	2023	2024
Measles	198 (102.70[a])	10 (4.97[a])
Rubella	8 (4.15[a])	12 (5.97[a])
Diphtheria	8 (4.15[a])	4 (1.99[a])
Pertussis	**14 (7.26[a])**	**30 (14.92[a])**
Tetanus neonatorum	0	0
Acute flaccid paralysis	28 (5.98[b])	29 (6.43[b])

Notes: [a]Incidence per 1,000,000 population; [b]Incidence per 100,000 population for acute flaccid paralysis (AFP)

(aged 0–18 years) in Depok City. Overall, VPD cases remained present despite relatively high immunization coverage. Measles, rubella, diphtheria, and pertussis continued to be reported, while no cases of neonatal tetanus and polio were identified during the study period. Children and adolescents aged 0–18 years accounted for the majority of reported VPD cases, indicating that younger age groups remain the most affected population. Diphtheria and pertussis demonstrated increasing concern due to continued case detection across consecutive years, including confirmed cases and at least one reported death related to diphtheria in 2024 (Table 2).

This trend of diphtheria indicates that while the incidence rate has decreased, active transmission persists, maintaining the city's emergency outbreak status. Pertussis cases increased in 2024 compared to the previous year, reflecting either improved detection or a true rise in transmission. Rubella transmission exhibited an upward trend. These figures are highly significant as they substantially exceed the national elimination target of <1 per 1,000,000 population. This increase indicates ongoing community transmission despite elimination efforts, posing a continuous risk for Congenital Rubella Syndrome (CRS).

Surveillance performance

Overall, the VPD surveillance system in Depok City during 2023-2024 showed mixed performance (Table 3). While several indicators met national targets, notable weaknesses persisted in certain surveillance components, indicating the need for further strengthening. Measles and rubella surveillance indicators showed improvement in 2024, particularly through a higher discard rate, indicating greater sensitivity of the surveillance system in identifying and ruling out suspected cases. However, measles and rubella transmission continued. In addition, the proportion of adequate investigations conducted within 48 hours remained below the recommended target and declined compared with the previous year. This sharp decline to 45.40% highlights critical operational gaps, likely due to delayed reporting by private hospitals to primary health centers, thereby

hindering timely community-based epidemiological investigations. Surveillance performance for diphtheria and pertussis met most national targets. Indicators related to adequate investigation and specimen examination were consistently high in both years. Nevertheless, diphtheria cases, including severe outcomes, and the increase in pertussis incidence in 2024 suggest that strong surveillance performance alone was insufficient to prevent ongoing transmission fully. Polio surveillance, assessed through the non-polio AFP rate and specimen adequacy, showed mixed performance. The non-polio AFP rate consistently met the recommended target in both years, indicating adequate sensitivity of AFP case detection. However, specimen adequacy remained below the ≥80% target and declined in 2024, suggesting challenges in collecting adequate specimens for laboratory confirmation. In contrast, SKDR performance remained strong, with full alert response and improved timeliness and completeness in 2024. These findings indicate that while routine alert-based surveillance functioned well, targeted improvements are still needed to strengthen VPD control efforts. SKDR is a national early-warning surveillance system in Indonesia that monitors priority communicable diseases weekly to enable early outbreak detection and rapid response.

Table 3. Indicator of VPD in Depok 2023 to 2024

Indicator	Target	2023	2024
Indicator of measles and rubella			
Incidence of measles	<1/1,000,000 population	102.70	4.97
Incidence of rubella	<1/1,000,000 population	4.15	5.97
Discarded rate	≥ 2/100,000 population	1.55	6.09
Adequate investigation	<48 hours (≥80%)	71.90	45.40
Indicator of diphtheria			
Incidence of diphtheria	-	4.15	1.99
Adequate investigation	<48 hours (≥80%)	85.11	100
Specimen examination	≥80%	97.87	100
Indicator of pertussis			
Incidence of pertussis	-	7.26	14.92
Adequate investigation	<48 hours (≥80%)	94.12	98.25
Specimen examination	≥80%	94.12	98.25
Indicator of acute flaccid paralysis (AFP)			
Non-polio AFP rate	≥3 per 100,000 population	4.76	5.10
Adequate specimen	(≥80%)	82.1	73.30

Note: Pertussis and diphtheria do not have clearly defined incidence targets

Immunization coverage

Routine immunization coverage in Depok City was assessed using the Complete Basic Immunization (CBI) indicator. In 2023, CBI coverage, based on the routine reporting system, did not reach the national target of 100%, at 95.5%. On the other hand, CBI coverage exceeded the target in 2024, reaching 104.91%. This improvement indicates progress in immunization service delivery and reporting at the city level. Despite high overall coverage, immunization distribution was not uniform across areas. Village-level analysis using Universal Child Immunization (UCI) status showed that 18 out of 63 villages (28.60%) had not achieved UCI in 2023, defined as UCI coverage below 95%. Several villages consistently reported lower coverage than others, with Bhaktijaya identified as having the lowest coverage. In 2024, only one village (1.59%) had not achieved UCI status: Kukusan village. These findings highlight persistent subdistrict-level inequities, suggesting that high city-wide immunization coverage may mask pockets of under-immunized populations that remain vulnerable to VPDs.

Priority-setting of VPD using PAHO score

VPD priority setting in Depok City was conducted using the PAHO-adapted Hanlon method, which generated a BPR for each disease based on disease magnitude, seriousness, effectiveness of interventions, inequity, and institutional factors [18]. The results identified diphtheria as the highest-priority VPD, followed by pertussis and rubella (Table 4). The diphtheria control strategy prioritizes rapid 24-hour reporting via the SKDR system, alongside strengthened laboratory networks, contact tracing, and specialized workforce training to support effective epidemiological investigations.

Table 4. Basic priority rating (BPR) of VPD

VPD	BPR	Ranking
Diphtheria	15.49	1
Pertussis	13.61	2
Rubella	10.37	3
Measles	8.31	4
Polio	7.78	5
Tetanus neonatorum	5.70	6

Additionally, it focuses on standardized clinical management and achieving high coverage targets 90% for Outbreak Response Immunization (ORI) to interrupt persistent transmission. Overall, the PAHO priority-setting results indicate that diphtheria, pertussis, and rubella represent the most pressing VPD challenges in Depok City and require focused public health attention.

DISCUSSION

This study demonstrates that diphtheria remains the most critical VPD challenge in Depok City, followed by pertussis and rubella, as identified through a structured priority-setting process. Basic immunization coverage was reported at 95.5% in 2023 and 104.91% in 2024. However, these administrative coverage figures were based on service utilization at health facilities in Depok City and may include children from outside the city. Consequently, the reported coverage may overestimate true population coverage and may not fully reflect the closure of immunity gaps in non-UCI areas, which could contribute to ongoing VPD transmission. This finding aligns with the evidence that, despite high overall coverage and vaccine effectiveness, local pockets of low vaccination can sustain transmission and trigger outbreaks. A study showed that lower sub-district DTaP (Diphtheria, Tetanus, and acellular Pertussis) coverage and sociodemographic factors were associated with increased case counts, highlighting that uneven coverage can undermine VPD control.

The application of the PAHO-adapted Hanlon method enabled systematic comparison across VPD by integrating disease magnitude, seriousness, effectiveness of available interventions, inequity, and institutional capacity. Routine secondary data from the district health office were used as a standardized, consistent baseline to inform scoring conducted by the district health office and primary health centers. These quantitative inputs were complemented by group discussion with program officers, heads of primary health centers, and health authority representatives to explore the operational and contextual reasons underlying the emergence of priority problems. This mixed approach allowed the analysis to move beyond descriptive epidemiology and capture programmatic realities that influence VPD control at the local level.

The prioritization of diphtheria reflects the interaction of multiple determinants across health system, community, and environmental domains rather than a single dominant factor. Group discussion and determinant mapping highlighted challenges in health service capacity, workload constraints, staff turnover, and variability in training related to VPD surveillance and response. A previous study conducted in Bogor city similarly highlighted staff turnover as a challenge [19]. High staff turnover can decrease service reliability and continuity [20]. Previous surveillance evaluation studies reported that staff turnover may affect surveillance system stability, while surveillance sensitivity declined during periods of reduced system performance [21]. Therefore, WHO's support will help ensure equitable access to quality health services during security crises, thereby strengthening outbreak response efforts [22]. Although surveillance systems were in place, challenges such as delayed follow-up of cases and contacts, incomplete acceptance of prophylactic measures, and competing program responsibilities reduced their effectiveness. Limited awareness among close contacts regarding disease transmission and prevention, refusal of prophylactic treatment and immunization in specific groups, and inconsistent acceptance of preventive measures weakened outbreak containment efforts. This prophylaxis is necessary to prevent transmission, such as for household contacts of pertussis [23]. In addition, high population movement into and within Depok City, together with differences in local living and sanitation conditions, was perceived as a challenge for sustaining effective disease control. Similar patterns of vulnerability were observed for pertussis and rubella, with ongoing transmission and uneven immunization coverage. Delayed recognition of pertussis symptoms contributed to delayed early control. Participants said that pertussis is often mistaken for a common cough, so doctors sometimes fail to recognize its early symptoms. Previously vaccinated individuals with pertussis may present with milder or atypical symptoms, often without the characteristic inspiratory whoop [24]. Delayed diagnosis in the index case was associated with a 5.1 increase in the odds of secondary household transmission compared with cases without diagnostic delay [25]. Although the definition of suspect pertussis is clearly defined in the technical guideline, we need to provide recommendations to the health office to evaluate case-detection practices and to regularly remind them of the criteria for suspect pertussis.

These findings suggest that VPD programs in Depok City should move beyond disease-specific responses and adopt more integrated and context-sensitive strategies. Strengthening workforce capacity through targeted training, improving coordination between surveillance and immunization services, and enhancing the role of community health volunteers are essential to address the interconnected drivers of VPD transmission in Depok. Initial training for surveillance personnel, followed by regular refresher sessions, is necessary to maintain system sensitivity and ensure

data accuracy [5]. The government must prioritize risk communication and community engagement (RCCE), as poor communication fosters rumors and hesitancy that trigger outbreaks. Engaging the community is essential for understanding local perspectives and co-developing higher-quality immunization services and policies [26]. This study has several limitations that should be considered. Although routine surveillance data from the district health office provided a standardized and consistent basis for PAHO priority scoring, the analysis relied on routinely reported indicators, which may not fully capture all contextual or operational factors influencing VPD control, potentially affecting the accuracy of priority scoring. In addition, input obtained through group discussions primarily reflects the perspectives of health system stakeholders and may not fully represent community views. The selection of participants was limited to the criteria; not all health centers were included, which may introduce selection bias and limit the diversity of viewpoints included in the prioritization process. In some health centers, not all staff familiar with surveillance were present for the discussion, so the assessment was limited to the participants knowledge without consideration of other staff. Nevertheless, combining secondary data with stakeholder discussions strengthens the interpretation of priority-setting results and provides practical insights for program planning. This integrated approach supports the development of targeted, context-specific strategies to improve VPD surveillance, immunization coverage, and outbreak prevention in Depok City.

CONCLUSION

This situational analysis identified diphtheria, pertussis, and rubella as the top-priority VPDs in Depok City. Although overall immunization coverage and surveillance systems were in place, persistent VPD transmission persisted. Persistent operational challenges include high staff turnover, workload constraints, delayed follow-up of cases and contacts, delayed diagnosis of pertussis, gaps in community awareness and acceptance of preventive measures, and the fact that some villages have not achieved UCI.

Based on these findings, several targeted actions are recommended. First, routine weekly reviews of cases of persistent cough and pharyngitis at primary health care facilities should be implemented to detect pertussis and diphtheria. Second, villages that have not achieved UCI status should be prioritized for evaluation. Third, thematic refresher training should be conducted for health workers, particularly on early clinical recognition of pertussis, strengthening acute flaccid paralysis (AFP) surveillance, and evaluating human resources. Strengthening coordination between hospitals and public health authorities is also needed to improve the timeliness of case reporting and follow-up investigations. Moreover, strengthening community engagement at the village level is essential to improve acceptance of prophylaxis and immunization during case and contact follow-up. In addition, future research related to vaccination is needed to evaluate implementation, as cases continue to occur despite relatively high vaccination coverage.

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Authors' contribution
Y.K.: conceptualized the study, conducted data analysis, and drafted the manuscript. A.C.A.: supervised the study and critically reviewed the manuscript. H.N.: supported data collection coordination and provided input on the manuscript. All authors approved the final version.

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Data availability
The data that support the findings of this study are available from the Depok City Health Office. Some data are not publicly available. However, available from the author upon reasonable request and with permission of the institution.

Ethics statement
This study was approved by the Ethics Committee of Universitas Indonesia (Number: Ket-265/UN2.F10.ETK/PPM. 00.02/2026).

Conflicts of interest
The authors declare no conflict of interest

Use of artificial intelligence (AI)
The authors used ChatGPT to correct English grammar, and references were managed with Mendeley. NotebookLM was used to assist with literature searching. The authors remained responsible for the interpretation, analysis, and final content of the manuscript.

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