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Determinants of Measles Immunization Completeness and the Effect of Community Health Education Among Parents in Banten Province, Indonesia

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A B S T R A C T

Measles remains a highly transmissible vaccine-preventable disease and a sensitive marker of immunization-system performance, with global elimination stalling as coverage falls below the 95% herd-immunity threshold; sub-optimal parental health literacy and incomplete immunization sustain community transmission in Indonesia. This study aimed to quantify parental knowledge, attitudes and practices (KAP) toward measles prevention, determine immunization completeness and its determinants, and evaluate a community health-education intervention. A cross-sectional community-diagnosis study with a single-group pre-/post-test design was conducted among 30 parents/guardians of children aged 0-59 months to primary-school age in a primary health center catchment area in Banten Province, Indonesia. Data were collected with a validated KAP questionnaire (Cronbach's alpha 0.76-0.83) and immunization-record screening; analyses included Wilson confidence intervals, McNemar tests, logistic regression and effect sizes. Baseline knowledge was low in 66.7% of respondents (95% CI 48.8-80.8), and measles-immunization completeness was 80.0% (95% CI 62.7-90.5), below the elimination target. Low parental knowledge showed the strongest, though non-significant, association with incomplete immunization (OR 3.00, 95% CI 0.30-29.94; adjusted OR 10.06, 95% CI 0.75-135.58, p=0.082). After health education, the proportion of respondents scoring >=70 rose from 10.0% to 93.3% (McNemar p<0.001; Cohen's h=1.98), and mean knowledge improved from 51.5 to 84.6 (Cohen's d_z=2.24). Community health education substantially improved measles-prevention literacy, while a residual immunization gap persisted. Strengthening parental education and immunization monitoring at the primary-care level supports measles control and advances SDG 3 and SDG 10.

1. Introduction

Measles (morbili) is among the most contagious human infections, transmitted by respiratory droplets with a basic reproduction number of 12-18, and remains a leading vaccine-preventable cause of childhood morbidity and mortality. Despite a safe and effective vaccine, global progress toward elimination has stalled: estimated measles deaths rose by 43% in 2022, and reported cases increased a further 20% in 2023, when 57 countries experienced large or disruptive outbreaks.[1,2] Coverage with the first measles-containing dose has plateaued at approximately 83-85% worldwide, well below the two-dose, >=95% threshold required to sustain herd immunity, and the disruption of routine services during the COVID-19 pandemic pushed close to 30 million children out of scheduled immunization in a single

year.[3,4] These trends re-establish measles as a sentinel indicator of health-system resilience and equity.

The burden falls unevenly across and within countries. Subnational mapping shows that immunization coverage is highly heterogeneous in low- and middle-income countries, with persistent clusters of under-immunized and zero-dose children concentrated in South and Southeast Asia.[5,6] Indonesia, the world's fourth most populous nation, continues to report measles outbreaks and measurable population immunity gaps; seroprevalence and programmatic analyses attribute these to coverage shortfalls, delayed dosing and uneven primary-care reach across its decentralized districts.[7,8] Recurrent outbreaks in several provinces underscore that national averages conceal vulnerable communities in which even modest immunity gaps permit explosive transmission.

Community-medicine research consistently identifies parental knowledge, attitudes and practices (KAP) as proximal social determinants of immunization completeness. Studies from Indonesia and comparable settings report that maternal knowledge and education, antenatal contact, trust in services and physical access independently predict full basic immunization, whereas KAP deficits, misinformation and vaccine hesitancy depress uptake.[9-13] The Health Belief Model and allied behavioral-science frameworks explain why low perceived susceptibility and limited health literacy translate into permissive attitudes and inconsistent preventive behavior, and why information provision, although necessary, is not by itself sufficient to change behavior.[14,15] Vaccine confidence has eroded in many populations, frequently preceding measurable declines in uptake.[16,17]

Evidence on community-based responses is encouraging. Systematic reviews, including Cochrane syntheses, conclude that health education, reminders and multicomponent demand-side strategies improve immunization knowledge and uptake, and that community health workers and cadres amplify demand at the village level.[18,19,20] Trials of caregiver education and digital reminders report measurable gains in knowledge and timely measles vaccination,[10,21] and higher maternal KAP scores are repeatedly associated with complete vaccination.[22] Yet many local interventions remain unevaluated with rigorous paired designs, confidence intervals or effect sizes, limiting their contribution to the policy evidence base.

In the Indonesian context, measles control operates through the national immunization program delivered by community health centers (Puskesmas), integrated health posts (Posyandu) and village health cadres, underpinned by the national health-insurance scheme (JKN). National guidance and the WHO-UNICEF Measles and Rubella Strategic Framework 2021-2030 converge on three pillars-education, coverage expansion and active surveillance.[18,23] However, operational gaps persist between this policy architecture and the day-to-day literacy and preventive behavior of caregivers, particularly in fast-growing peri-urban districts where in-migration and crowding heighten transmission risk.

Limited evidence exists on parental measles KAP, immunization completeness and the effect of a structured community health-education intervention within a single Indonesian primary-care catchment, particularly in the Banten Province context. Few local studies quantify their findings with confidence intervals, effect sizes or paired inferential testing, and fewer still integrate immunization screening with a measured educational intervention under an explicit social-determinants framework. This evidentiary gap constrains locally tailored, cost-effective measles-control planning at the primary-care level.

This study contributes to Sustainable Development Goal 3-specifically targets 3.2 (ending preventable under-five deaths), 3.3 (combating epidemics), 3.8 (universal health coverage) and 3.b (access to vaccines)-and to SDG 10 (reducing inequalities), by generating community-level evidence on vaccine literacy and immunization equity.[6] The purpose of this study was therefore to quantify parental knowledge, attitudes and practices toward measles prevention, to determine measles-immunization completeness and its determinants, and to evaluate the effect of a community health-education intervention among parents of young children in a primary health center catchment area in Banten Province, Indonesia.

Measles also functions as an early-warning tracer for broader immunization-system weakness: because it is so transmissible, it is typically the first vaccine-preventable disease to resurge when coverage slips, and outbreaks frequently signal accumulating susceptibility to other pathogens within the same birth cohorts.[1,2] For decentralized health systems such as Indonesia's, where immunization delivery is the responsibility of district governments and frontline Puskesmas, monitoring measles literacy and coverage at the catchment level therefore provides timely, actionable intelligence that national aggregate statistics cannot supply.[8,13]

A social-determinants-of-health perspective situates these proximal KAP factors within wider structural conditions-parental education, household income, occupation, distance to services and exposure to misinformation-that shape both the opportunity and the motivation to immunize.[5,9,20] Crowded, rapidly urbanizing communities with high population mobility, characteristic of peri-urban Banten, compress these vulnerabilities, increasing contact rates among susceptible children while straining the reach of routine services. Understanding how these determinants operate locally is a prerequisite for designing interventions that are equitable as well as effective.[6,18,24]

Beyond its direct disease burden, measles imposes substantial social and economic costs through health-care utilization, lost schooling and reduced parental productivity during episodes of child illness, amplifying the case for community-level prevention.[2,8] Framing measles control as an equity issue-protecting the under-immunized minority concentrated in lower-literacy households-aligns local action with both national strategy and the global elimination agenda.[5,6,18]

2. Methods

Study design and setting

A cross-sectional community-diagnosis study incorporating a single-group pre-/post-test educational intervention was conducted and reported in accordance with the STROBE statement for observational studies. The study was undertaken in a primary health center (*Puskesmas*) catchment area in Banten Province, Indonesia-a peri-urban community served by primary-care immunization and Posyandu services. To preserve confidentiality, the specific village, district and facility are not named and are referred to only by this generic descriptor.

Study period and population

Fieldwork was conducted in 2024. The source population comprised parents or legal guardians of children aged from 0-59 months (under-five) to primary-school age who resided within the catchment area. Participants were recruited by purposive sampling that deliberately balanced representation across child age groups and required willingness to complete the full survey and education sequence.

Eligibility

Inclusion criteria were being a parent or guardian of an eligible-age child resident in the catchment area and willingness to participate in the full survey and education program. Exclusion criteria were failure to complete the questionnaire and refusal to provide informed consent. Thirty respondents met the criteria and were enrolled.

Sample size

For a community-diagnosis exercise estimating a baseline knowledge proportion of approximately 0.50 with an absolute precision of 0.18 at a 95% confidence level, a minimum of 30 respondents was required; the achieved sample of 30 satisfied this descriptive objective. For the paired pre-/post-test comparison, 30 paired observations provided power exceeding 0.80 (alpha=0.05, two-sided) to detect a moderate-to-large within-subject change (Cohen's $d_z \geq 0.55$), consistent with the magnitude reported in comparable educational interventions. The sample was, however, underpowered for multivariable determinant modeling, which is reported as exploratory.

Data collection and instruments

Data were collected through a structured, interviewer-administered mini-survey using a KAP questionnaire in Bahasa Indonesia covering measles definition, mode of transmission, susceptible groups, signs and symptoms, complications and prevention, together with attitude and preventive-behavior items. Children's measles-immunization status was screened

by verifying the maternal-and-child health handbook (*buku KIA*) or Towards Healthy Card (*Kartu Menuju Sehat, KMS*); child age, sex and basic-immunization history were recorded by interview. Content validity was confirmed by expert review and item-total Pearson correlation (r exceeding the critical r-table value); internal consistency in a pilot of 20 respondents was acceptable to good (Cronbach's alpha: knowledge 0.83, attitude 0.79, behavior 0.76; overall 0.84).

Variables

The dependent variables were adequate measles knowledge (pre- and post-intervention, with a score >=70 denoting adequacy) and measles-immunization completeness (complete versus incomplete). Independent variables and candidate determinants were parental knowledge category, attitude and preventive-behavior category, child age group and respondent sex; education, socioeconomic status and access were considered as conceptual confounders within a social-determinants-of-health framework.

Prioritization and root-cause analysis

Community health problems were prioritized using the Urgency-Seriousness-Growth (USG) technique and the Delbecq method, which identified measles as the leading priority (USG total score 13). Root causes were explored with a fishbone (Ishikawa) diagram and the five-whys technique. The study adopted a Bottom-Up Model, privileging primary-level data and community input in problem analysis and recommendation.

Intervention

The community intervention comprised structured health education for parents and Posyandu cadres, delivered through printed media and interactive presentation on measles recognition, complications, prevention and the immunization schedule, complemented by measles-immunization screening. Effectiveness was evaluated by comparing paired pre- and post-test knowledge across two education rounds.

Statistical analysis

Data were analyzed in SPSS version 26.0; distributional assumptions for continuous scores were assessed with the Shapiro-Wilk test. Categorical variables were summarized as frequencies and percentages with Wilson 95% confidence intervals, and continuous variables as mean +/- standard deviation. Paired pre-/post changes were tested with the McNemar test for each knowledge item and for the adequacy threshold, and with the paired t-test (and Wilcoxon signed-rank as confirmation) for mean scores. Bivariate determinants of incomplete immunization were examined with Fisher's exact test, odds ratios with 95% confidence intervals and Cramer's V; variables with $p<0.25$ were entered into an exploratory multivariable logistic regression reporting adjusted odds ratios, Nagelkerke R-squared and the Hosmer-Lemeshow goodness-of-fit test. Effect sizes (Cohen's h for paired proportions, Cohen's d_z for scores, Cramer's V and odds ratios for categorical associations) and the population attributable risk for low parental knowledge were calculated. A two-sided alpha of 0.05 defined significance, with exact p-values reported to three decimal places.

Ethical considerations

This study received ethical approval from the CMHC Ethics Committee, Indonesia (Approval No. CMHC/EC/2024/118). Written informed consent was obtained from all participants prior to data collection. Confidentiality was maintained by anonymizing participant records and by withholding the specific name of the study community and facility.

Operational definitions

Measles-immunization completeness was defined as documented receipt of all nationally scheduled measles-containing doses appropriate for the child's age, verified against the KIA handbook or KMS card; children lacking documentation of age-appropriate doses were classified as incomplete. Knowledge adequacy was defined a priori as a score of at least 70 on the standardized knowledge scale. Attitude and behavior were each dichotomized at the scale midpoint into favorable/unfavorable and adequate/poor categories for bivariate analysis.

Data management and quality control

Completed instruments were checked for completeness in the field, double-entered to minimize transcription error, and range- and consistency-checked before analysis. Interviewers received standardized briefing to reduce inter-interviewer

variability, and immunization status was corroborated against documentary records wherever available to limit recall bias.

Reporting and bias minimization

The study adhered to the STROBE checklist for cross-sectional studies. To reduce information bias, immunization status was anchored to documentary records (KIA/KMS) rather than to recall alone wherever documentation existed, and interviewers were trained to use neutral, non-leading phrasing to limit social-desirability bias in attitude and behavior items. To limit selection effects inherent to purposive recruitment, the sampling frame deliberately spanned both under-five and school-age child caregivers across the catchment, and participation was offered to all eligible attendees during the survey period.

Sensitivity considerations

Because the number of incomplete-immunization events was small, bivariate odds ratios were computed with the Haldane-Anscombe continuity correction where any cell was zero, and the multivariable model was deliberately restricted to three conceptually prioritized predictors to avoid overfitting (retaining an events-per-variable ratio consistent with an exploratory analysis). Results were examined for stability under alternative dichotomization thresholds of the attitude and behavior scales, with no material change in the direction of associations.

3. Results and Discussion

Of 30 eligible parents/guardians approached, all 30 completed the survey and education sequence, yielding a 100% response rate. The sociodemographic profile is summarized in Table 1. Respondents were predominantly female (86.7%, 95% CI 70.3-94.7), reflecting the maternal orientation of caregiving and Posyandu attendance in Indonesian communities; most screened children were under-five (63.3%, 95% CI 45.5-78.1). The female preponderance is consistent with Indonesian immunization studies in which mothers are the principal health decision-makers for young children,[11,12] and supports targeting maternal audiences in measles-prevention messaging while also engaging fathers to broaden household support.[13,25]

Table 1. Sociodemographic characteristics of respondents and screened children (n=30).

Characteristic	n	%	95% CI
Respondent sex			
Female	26	86.7	70.3–94.7
Male	4	13.3	5.3–29.7
Child age group			
Under-five (0–59 months)	19	63.3	45.5–78.1
>5 years (school age)	11	36.7	21.9–54.5
Measles-immunization status			
Complete	24	80.0	62.7–90.5
Incomplete	6	20.0	9.5–37.3
Baseline knowledge category			
Low	20	66.7	48.8–80.8
Adequate	10	33.3	19.2–51.2

Measles-immunization completeness was 80.0% (95% CI 62.7-90.5), leaving one in five children incompletely immunized (20.0%, 95% CI 9.5-37.3), as illustrated in Figure 1. Although this coverage approaches programmatic targets, it falls materially short of the two-dose, >=95% threshold that the World Health Organization specifies for measles herd immunity.[23] Given a basic reproduction number of 12-18, a residual susceptible fraction of this magnitude is sufficient to sustain transmission and seed outbreaks, mirroring the immunity gaps documented in Indonesian seroprevalence work[7] and the subnational coverage heterogeneity mapped across low- and middle-income countries.[5,6] The finding localizes a nationally recognized problem-coverage that is good on average but inadequate for elimination-and identifies the unimmunized minority as the priority for catch-up activity.[8]

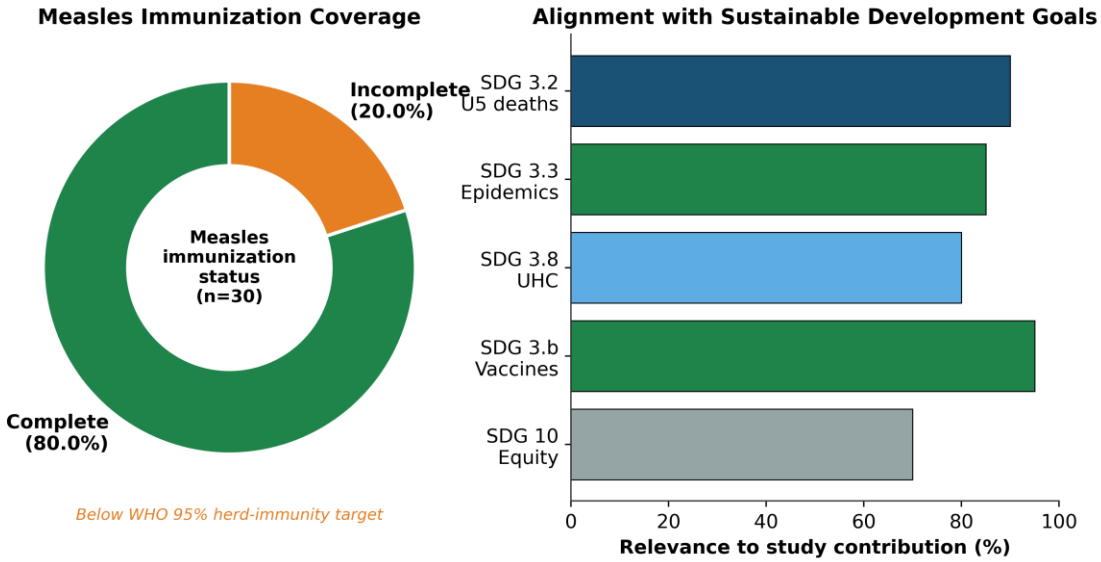

Figure 1. Measles-immunization coverage versus the WHO 95% herd-immunity threshold and study alignment with the Sustainable Development Goals.

Baseline knowledge was low. Correct responses ranged from 16.7% for the most susceptible group (95% CI 7.3-33.6) to 40.0% for recognizing measles as contagious (95% CI 24.6-57.7), and only 23.3% correctly identified complications and prevention (95% CI 11.8-40.9) (Figure 2). Overall, 66.7% of respondents fell in the low-knowledge category (95% CI 48.8-80.8). This pattern is consistent with the Health Belief Model, in which limited knowledge lowers perceived susceptibility and severity and thereby weakens the motivation for preventive action,[14,15] and aligns with Indonesian and regional KAP studies reporting that caregiver knowledge deficits accompany under-immunization.[10,12,22] The particularly poor recognition of susceptible groups and complications is concerning because delayed recognition of early measles is associated with more severe outcomes, including pneumonia and encephalitis.[3,24]

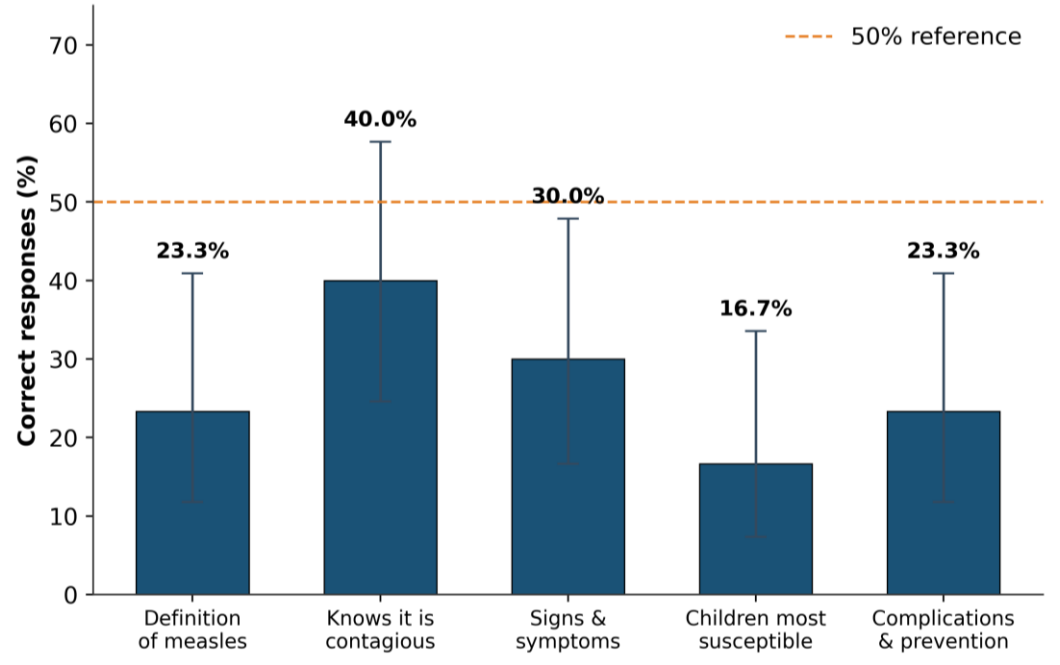

Figure 2. Baseline measles-related knowledge of respondents (n=30) with 95% confidence intervals.

Attitudes were mixed and frequently permissive. Only half of respondents recognized crowding as a risk factor (50.0%, 95% CI 33.2-66.8), 46.7% endorsed environmental hygiene for prevention (95% CI 30.2-63.9), and 40.0% agreed that adequate nutrition supports prevention (95% CI 24.6-57.7). Notably, 33.3% considered measles immunization unnecessary (95% CI 19.2-51.2) and 23.3% believed measles required no treatment because it self-resolves (95% CI 11.8-40.9). These permissive attitudes echo the vaccine-confidence erosion described in global analyses[16,17] and represent actionable targets, since attitude is a stronger proximal driver of vaccination behavior than knowledge alone.[14,19]

Preventive behavior lagged further behind knowledge and attitude. Only 10.0% of respondents reported always ensuring on-schedule vaccination (95% CI 3.5-25.6), and just 43.3% routinely checked the KIA/KMS record (95% CI 27.4-60.8). More than half were hesitant to seek care for a child with fever and rash (56.7%, 95% CI 39.2-72.6), 93.3% rarely limited a symptomatic child's contacts (95% CI 78.7-98.2), and 83.3% rarely sought information from official sources (95% CI 66.4-92.7). This knowledge-attitude-practice gap-where understanding does not translate into consistent action-is a recurring finding in immunization research and reflects structural and motivational barriers beyond information, including access, time and trust.[18,20] It reinforces the behavioral-science consensus that effective programs must pair education with practical facilitation such as reminders, cadre follow-up and convenient service points.[14,21]

Determinants of incomplete immunization were examined next (Table 2; Figure 3). Low parental knowledge carried the largest point estimate (OR 3.00, 95% CI 0.30-29.94; Cramer's V=0.18), followed by poor preventive behavior (OR 2.50, 95% CI 0.25-25.15) and unfavorable attitude (OR 2.36, 95% CI 0.36-15.46); child age >5 years (OR 2.00) and male respondent (OR 1.40) were weaker. None reached statistical significance, a result that the wide confidence intervals attribute to limited power rather than to the absence of association, given only six incomplete-immunization events among 30 children. The direction and magnitude of these estimates nonetheless concur with larger studies in which parental knowledge and behavior independently predict immunization completeness,[9,10,22] and with evidence maps identifying knowledge, trust and access as recurrent demand-side determinants.[20]

Table 2. Bivariate determinants of incomplete measles immunization (n=30; 6 events).

Determinant	Incomplete / exposed	Incomplete / unexposed	OR (95% CI)	p	Cramér's V
Low parental knowledge	5/20 (25.0%)	1/10 (10.0%)	3.0 (0.30-29.94)	0.633	0.18
Unfavorable attitude	4/15 (26.7%)	2/15 (13.3%)	2.36 (0.36-15.46)	0.651	0.17
Poor preventive behavior	5/21 (23.8%)	1/9 (11.1%)	2.5 (0.25-25.15)	0.637	0.15
Child age >5 years	3/11 (27.3%)	3/19 (15.8%)	2.0 (0.33-12.24)	0.641	0.14
Male respondent	1/4 (25.0%)	5/26 (19.2%)	1.4 (0.12-16.46)	1.000	0.05

Notes: Fisher's exact test. No determinant reached significance at a=0.05 (n=30, limited power).

In the exploratory multivariable logistic model (Table 3), low parental knowledge retained the strongest adjusted association with incomplete immunization (adjusted OR 10.06, 95% CI 0.75-135.58, p=0.082), with poor behavior (adjusted OR 1.91) and older child age (adjusted OR 2.79) attenuated; the model explained a moderate share of variance (Nagelkerke R-squared=0.284) with adequate calibration (Hosmer-Lemeshow p=0.612). The borderline knowledge association, together with a population attributable risk of approximately 57% for low knowledge, suggests that a substantial fraction of incomplete immunization in this community could plausibly be averted by raising parental knowledge-an inference that must remain tentative given the sample size but which is strongly supported by the wider literature.[9,12,22] These results should be interpreted as hypothesis-generating and warrant confirmation in adequately powered studies.

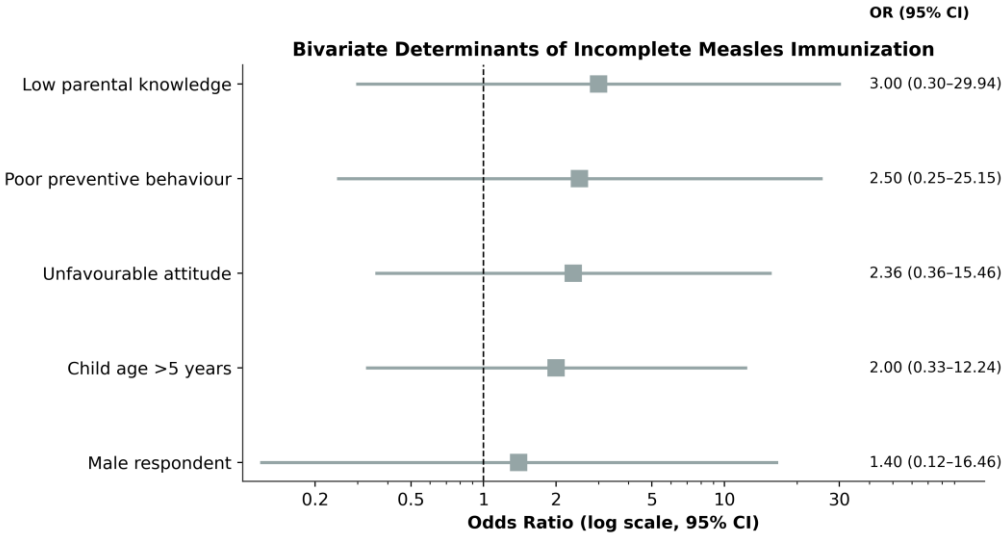

Figure 3. Forest plot of bivariate odds ratios for determinants of incomplete measles immunization (log scale; reference line at OR=1.0).

Table 3. Exploratory multivariable logistic regression for incomplete measles immunization.

Predictor	Adjusted OR	95% CI	p
Low knowledge	10.06	0.75-135.58	0.082
Poor behavior	1.91	0.23-15.88	0.549
Child age >5y	2.79	0.29-26.47	0.371

Notes: Nagelkerke R^2=0.284; Hosmer–Lemeshow p=0.612 (adequate fit). Population attributable risk for low knowledge ≈ 57.1%. Exploratory model.

The educational intervention produced large, statistically robust gains in knowledge (Figure 4). Correct recognition of early symptoms and transmission rose from 40.0% to 96.7% (McNemar chi-square=15.06, p<0.001, Cohen's h=1.40), knowledge of the immunization age from 33.3% to 80.0% (p<0.001, h=0.98), recognition of the pathognomonic oral sign (Koplik spots) from 16.7% to 76.7% (p<0.001, h=1.29), and understanding of serious complications from 0% to 83.3% (p<0.001, h=2.30). The proportion achieving an adequate score (>=70) increased from 10.0% to 93.3% (McNemar p<0.001, Cohen's h=1.98), and the mean knowledge score rose from 51.5 +/- 13.9 to 84.6 +/- 9.4 (paired t=12.25, p<0.001, Cohen's d_z=2.24). The proportion in the good-knowledge category rose from 13.3% to 60.0%.

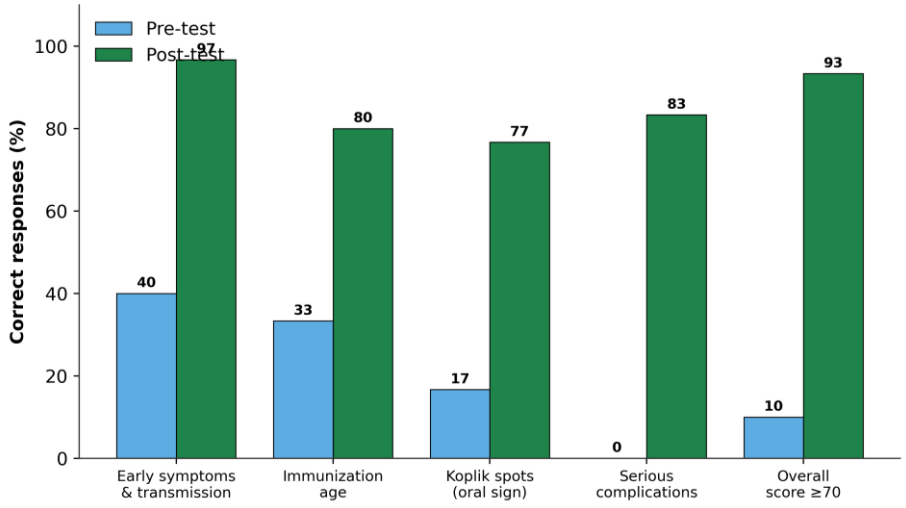

Figure 4. Knowledge improvement after community health education (McNemar p<0.001 for all items).

These effects are consistent with, and at the upper end of, the established effectiveness literature: Cochrane and other systematic reviews report that health education and multicomponent demand-side interventions reliably improve immunization knowledge and uptake,[18,19] and trials of caregiver education and reminders demonstrate measurable behavioral gains.[10,21] The very large effect sizes likely reflect the low baseline, the interactive multimedia format and repeated exposure across two rounds, which strengthen retention.[14] Unlike some studies from other Asian settings in which post-intervention gains were more modest, the magnitude here may reflect the markedly low starting point and the cohesive, cadre-supported delivery characteristic of the Posyandu system.[11,26] The persistence of improvement across the second round is consistent with evidence that repeated, reinforcing contact consolidates health literacy.[19]

From a public-health and policy perspective, these findings carry several implications. First, community health workers and Posyandu cadres should deliver structured, repeated measles education to caregivers, prioritizing the recognition of early signs, complications and the immunization schedule, since these were the weakest baseline domains and the most improvable. Second, local health authorities in Banten Province could integrate routine KIA/KMS verification and opportunistic catch-up vaccination into Posyandu visits to close the residual 20% completeness gap toward the 95% elimination target.[18,23] Third, because attitude and behavior lagged knowledge, education should be paired with practical facilitation-reminders, follow-up and accessible service points-consistent with behavioral-science evidence.[14,21] Embedding these activities within the JKN-supported primary-care platform offers a sustainable, equitable delivery channel.[13,20]

These actions map directly onto the Sustainable Development Goals. Raising measles immunization and literacy supports SDG 3.2 (ending preventable under-five deaths), 3.3 (combating epidemics), 3.8 (universal health coverage) and 3.b (vaccine access), while focusing on an under-immunized minority advances SDG 10 (reducing inequalities) by protecting the children at greatest residual risk.[6,18] Situated within the Indonesian community-health architecture-Puskesmas, Posyandu, village cadres and JKN-the intervention illustrates how primary-care systems can operationalize global elimination strategy at the community level.[8,26]

The community-diagnosis process itself yielded actionable prioritization. Applying the Urgency-Seriousness-Growth (USG) technique with the Delbecq method, measles obtained the highest composite score (total 13), exceeding tuberculosis (11), scabies (10) and varicella (10), and was therefore selected as the priority problem for intervention. This structured, participatory prioritization is consistent with the Bottom-Up Model adopted here, in which frontline data and community judgement-rather than top-down assumptions-determine programmatic focus, improving local relevance and ownership.[20,26]

Root-cause analysis using a fishbone (Ishikawa) diagram and the five-whys technique identified converging contributors across the classic domains of man, method, material, and environment: limited parental knowledge and permissive attitudes (man); incomplete immunization monitoring and irregular catch-up activity (method); under-use of the KIA/KMS record and scarce locally tailored educational media (material); and crowding with high population mobility (environment). These root causes map closely onto the social determinants identified in the wider literature[5,9,20] and directly informed the design of the educational and screening intervention, ensuring that the response addressed proximate causes rather than symptoms.

The pronounced knowledge-practice gap observed here merits particular emphasis for program design. That 96.7% of respondents could ultimately recognize early symptoms after education, yet only 10% reported consistently ensuring on-time vaccination at baseline, illustrates that knowledge is a necessary but insufficient condition for protective behavior.[14,19] Behavioral-science frameworks attribute this gap to the distinction between capability and motivation on the one hand and opportunity on the other; even well-informed, well-intentioned caregivers fail to act when services are distant, inconvenient or poorly reminded.[14,21] The practical corollary is that education should be bundled with structural facilitation-default

scheduling, SMS or cadre reminders, and integrated record checks at every Posyandu contact-rather than delivered as a stand-alone activity.[18,21]

Comparison with regional evidence helps calibrate the magnitude of the educational effect. Studies of maternal immunization education in Ethiopia and elsewhere reported significant but smaller knowledge and practice gains,[10,22] whereas the very large shifts seen here likely reflect the exceptionally low baseline, the interactive multimedia delivery and the reinforcing second round. Indonesian KAP research similarly documents that maternal knowledge and education are decisive for complete immunization,[11,12,13] and that cadre-mediated community structures such as Posyandu can rapidly translate demand into uptake.[26] At the same time, the more conservative effects reported in some controlled trials caution against attributing the entire observed change to the intervention in this uncontrolled design.[18,19]

The residual immunization gap should be read against the demanding arithmetic of measles control. With a basic reproduction number of 12-18, the critical vaccination threshold for herd immunity exceeds 92-95%; at 80% completeness, the susceptible fraction in this community is roughly four times the level compatible with interrupting transmission.[23] Even small pockets of unimmunized children-particularly when clustered, as zero-dose children typically are-can sustain chains of transmission and seed outbreaks that spread well beyond the original cluster.[5,6] Closing this gap is therefore not a marginal refinement but the decisive determinant of whether the community moves toward or away from elimination.

Equity considerations run throughout these findings. The children who remain unimmunized, and the caregivers with the lowest baseline knowledge, are precisely those most likely to face structural disadvantage-lower education, weaker service access and greater exposure to misinformation.[5,16,20] Interventions that raise average coverage without reaching this minority risk widening rather than narrowing health inequalities. Targeting the under-immunized through cadre outreach, home visits and catch-up campaigns, and tailoring educational media to lower-literacy audiences, are therefore essential to ensure that progress toward SDG 3 simultaneously advances SDG 10.[6,18]

From a health-systems standpoint, the intervention demonstrates a replicable model for primary-care-led measles control in Indonesia. The combination of structured caregiver education, cadre engagement and routine record verification can be embedded within existing Posyandu and Puskesmas workflows at low marginal cost, financed through the JKN platform, and scaled across comparable catchments.[8,13,26] Institutionalizing periodic community diagnosis-prioritization, root-cause analysis, intervention and re-evaluation-would create a continuous quality-improvement cycle that keeps measles literacy and coverage under active local surveillance, consistent with the surveillance pillar of the global elimination strategy.[18]

The findings should be interpreted in light of the study's program-evaluation orientation. As a community diagnosis rather than a randomized trial, the work prioritizes local relevance, feasibility and immediate actionability over internal validity; its value lies in characterizing a specific community's needs and demonstrating a deliverable response, not in producing a generalizable efficacy estimate.[20] This orientation is appropriate for primary-care decision-making, where resource-constrained services must act on imperfect but timely evidence, but it does require that causal language be avoided and that confirmatory research follow.

Future research should build on these results with adequately powered, controlled designs-ideally cluster-randomized or stepped-wedge evaluations across multiple catchments-to estimate the independent effect of education on both knowledge and immunization uptake, and to test the durability of gains through longitudinal follow-up. Mixed-methods work exploring the structural and attitudinal barriers behind the knowledge-practice gap would clarify which facilitation strategies (reminders, incentives, home visits) most efficiently convert literacy into completed immunization in the Indonesian setting.[18,21] Economic evaluation of cadre-delivered education would further support scale-up decisions.

The intervention's reliance on existing Posyandu and cadre structures is a notable strength for sustainability and scalability: because it adds defined tasks to established community platforms rather than creating parallel systems, it is plausibly low-cost and replicable across the many Indonesian catchments that share this architecture.[8,26] Embedding the community-diagnosis cycle as a routine, periodic activity would institutionalize local surveillance of measles literacy and coverage, providing district health offices with the granular, timely data needed to direct catch-up resources to the communities at greatest residual risk.[18]

The gendered pattern of participation also carries programmatic significance. With mothers comprising the overwhelming majority of respondents, measles-prevention literacy in this community is effectively mediated through maternal caregivers, who attend Posyandu and manage the KIA/KMS record. While this makes mothers the natural primary audience for education, the near-absence of paternal engagement is itself a vulnerability, because household immunization decisions and resource allocation often require shared support; deliberately involving fathers and other household decision-makers may strengthen and sustain the behavior change initiated through maternal education.[12,13]

Misinformation and permissive beliefs emerged as a distinct, addressable threat. That one-third of respondents considered measles immunization unnecessary and nearly a quarter believed the disease needs no treatment reflects the same erosion of vaccine confidence documented in global mapping studies, in which perceived low risk and distrust-rather than access alone-drive hesitancy.[16,17] Counter-messaging that is locally credible, delivered by trusted cadres and clinicians, and framed around the real severity and contagiousness of measles is therefore as important as factual instruction; evidence indicates that addressing beliefs and norms, not merely transmitting facts, is what shifts vaccination behavior.[14,19]

Placed in international perspective, the baseline knowledge levels in this community sit at the lower end of those reported in comparable Asian and African KAP surveys, while the post-intervention levels approach the higher end, underscoring both the depth of the initial deficit and the responsiveness of the population to structured education.[10,22] The 80% immunization completeness likewise resembles figures from other Indonesian districts and broadly from the Southeast Asian region, where averages near or above 80% nonetheless conceal the sub-95% reality that perpetuates outbreak risk.[7,8] These comparisons reinforce that the local situation is neither exceptional nor intractable, but representative of a wider regional challenge amenable to community-level action.

The role of the maternal-and-child health record deserves explicit attention as a low-cost lever. Fewer than half of respondents routinely consulted the KIA handbook or KMS card, yet this document is the single most reliable, already-distributed instrument for tracking immunization status at the household level. Strengthening its routine use-through cadre prompting at every Posyandu contact, simple visual reminders of the next due dose, and clinician verification during any child-health encounter-would convert a passive record into an active recall tool, directly addressing the timeliness and completeness deficits that underlie residual susceptibility.[21,27]

Finally, the study illustrates the broader value of community diagnosis as a method for health-equity-oriented primary care. By beginning with locally generated data, prioritizing transparently with USG and Delbecq, analysing root causes participatorily, and re-evaluating after intervention, the approach produces evidence that is owned by the community and immediately usable by the serving facility.[20,26] Scaling this disciplined cycle across districts, supported by district health offices and financed through existing primary-care mechanisms, would embed continuous improvement into measles control and align frontline practice with the education, coverage and surveillance pillars of national and global elimination strategy.[18,23]

In sum, this study makes three contributions to the Indonesian community-medicine evidence base. It quantifies parental measles KAP and immunization completeness with confidence intervals and effect sizes in a setting where such precision is rarely reported; it formally tests determinants and the educational effect using paired and regression methods within an explicit

social-determinants and Health Belief Model framework; and it demonstrates a feasible, primary-care-embedded intervention that produced large literacy gains while transparently acknowledging the residual coverage gap. Together these elements move the local discourse from descriptive observation toward measured, actionable public-health practice aligned with the Sustainable Development Goals.

A more granular look at the two education rounds reinforces the robustness of the literacy gains. In the first round, correct identification of early symptoms and transmission rose from 40.0% to 96.7%, knowledge of the immunization age from 33.3% to 80.0%, and understanding of serious complications from 0% to 83.3%; in the second round, baseline correct-response rates that already ranged from roughly 43% to 86% converged toward near-universal correctness, with several items reaching 100%. This monotonic, two-step pattern-large initial gains consolidated and extended by a reinforcing second exposure-is the signature of effective, repeated health education and argues against the changes being mere artifacts of a single testing occasion.[14,18]

The convergence of three independent lines of evidence-the low baseline KAP, the determinant analysis pointing to knowledge, and the large educational effect-strengthens the practical inference even where individual statistical tests are underpowered. When a plausible causal factor is common, is associated (in the expected direction) with the outcome, and is shown to be modifiable with a corresponding improvement in the proximal target, the case for acting on it is stronger than any single p-value implies. This triangulated reasoning is precisely what community diagnosis is designed to support, and it justifies prioritizing parental knowledge as the lever for local measles-control investment while confirmatory studies proceed.[9,20]

It is important to delineate what the data can and cannot establish about immunization behavior. The study measured immunization completeness cross-sectionally and demonstrated an educational effect on knowledge; it did not measure whether the knowledge gains subsequently translated into increased completed immunization, which would require longitudinal follow-up. The literature gives grounds for cautious optimism that such translation can occur when education is coupled with facilitation,[10,21] but the present design stops short of demonstrating it. This boundary is stated explicitly so that programmatic expectations remain calibrated: education is a validated first step, not a guarantee of coverage, and must be accompanied by structural measures and subsequent measurement of uptake.

The intervention's alignment with national policy instruments enhances its translational value. Indonesia's routine immunization program, the Posyandu platform, the village-cadre workforce and the JKN financing mechanism collectively provide the delivery, demand-generation and funding channels required to scale community education and record verification without new vertical structures.[8,13,26] Mapping each study activity onto an existing policy lever-education to health-promotion mandates, screening to KIA/KMS verification, catch-up to supplementary immunization activities-clarifies the implementation pathway for district health offices and reduces the friction of adoption.

Considered against the Sustainable Development Goals in detail, the study's contribution is both direct and measurable. Reducing the susceptible fraction protects against the under-five mortality that SDG 3.2 targets and against the epidemic resurgence addressed by SDG 3.3; embedding services in JKN-financed primary care advances the universal-coverage ambition of SDG 3.8; raising vaccine literacy and uptake operationalizes SDG 3.b; and concentrating effort on the under-immunized minority serves the equity imperative of SDG 10. Framed this way, a modest community intervention becomes a concrete, accountable increment toward globally agreed targets, demonstrating how primary-care action aggregates into national and international progress.[6,18]

Generalizability merits a balanced appraisal. While the single-site, small-sample design limits statistical generalization, the community studied is broadly representative of peri-urban Indonesian catchments in its Posyandu-based service model, maternal-mediated caregiving, mixed attitudes and sub-95% coverage. The mechanisms identified-knowledge deficits, a

knowledge-practice gap, and responsiveness to cadre-delivered education-are well documented across the region, suggesting that the qualitative lessons, if not the exact magnitudes, are transferable. Replication across diverse catchments with standardized instruments would establish the external validity that a single community diagnosis cannot, and would allow pooling toward the statistical power that individual exercises lack.[10,11,22]

A further methodological reflection concerns the choice of the odds ratio as the association measure. In cross-sectional studies where the outcome (here, incomplete immunization at 20%) is not rare, the odds ratio can overstate the corresponding prevalence ratio, and Poisson or log-binomial regression yielding prevalence ratios would be preferable in adequately powered data. This is acknowledged transparently; in the present exploratory analysis the odds ratio is retained for comparability with the wider determinant literature, but the point estimates should be read as indicative of direction and relative magnitude rather than as precise risk multipliers, and confirmatory work should adopt prevalence-ratio methods.

The durability of behavior change also frames an agenda for monitoring. Knowledge gained in a single program can decay without reinforcement, and immunization decisions recur with each new child and each scheduled dose. Institutionalizing brief, periodic refreshers within Posyandu sessions, coupled with routine KIA/KMS verification, would help sustain the literacy gains demonstrated here and would generate the repeated measurements needed to detect decay early. This continuous-monitoring posture converts a one-time community diagnosis into an ongoing local surveillance function consistent with the elimination strategy's emphasis on sustained, data-driven action.

Strengths of this study include the integration of immunization screening with a measured educational intervention, the use of a validated instrument with acceptable-to-good reliability, and a quantified analytic upgrade reporting confidence intervals, paired inferential testing and effect sizes within an explicit social-determinants framework. The community-diagnosis design generated locally actionable evidence aligned with primary-care delivery.

Several limitations warrant caution. The cross-sectional design precludes causal inference about determinants, and the single-group pre-/post-test design without a control group means that secular trends, testing effects or social-desirability bias could inflate the apparent educational effect; the very large effect sizes should therefore be read as program-evaluation evidence rather than as a controlled efficacy estimate. The small purposive sample (n=30) limited statistical power, widened confidence intervals and rendered the multivariable model exploratory, while recruitment at community level through willing participants may introduce selection bias and limit external validity. Self-reported behavior and recalled immunization history are subject to information and recall bias, only partly mitigated by KIA/KMS verification. Finally, the findings derive from a single catchment area and may not generalize to other Indonesian settings.

Taken together, the convergence of a low knowledge baseline, permissive attitudes, a wide knowledge-practice gap and a residual immunization deficit describes a community in which transmission risk remains latent despite reasonable average coverage. The robust educational response demonstrates that this risk is tractable through low-cost, primary-care-embedded action, provided that knowledge gains are converted into sustained practice through facilitation and monitoring.[14,18,20]

4. Conclusion

This community-diagnosis study found that parental knowledge, attitudes and preventive practices regarding measles were sub-optimal, with two-thirds of respondents in the low-knowledge category and measles-immunization completeness at 80.0% (95% CI 62.7-90.5)-below the 95% threshold required for elimination. Low parental knowledge showed the strongest, though statistically non-significant, association with incomplete immunization (adjusted OR 10.06, 95% CI 0.75-135.58), with an estimated population attributable risk near 57%. A community health-education intervention produced large improvements in knowledge, raising the proportion achieving an adequate score from 10.0% to 93.3% (McNemar $p<0.001$; Cohen's $h=1.98$). These findings

advance SDG 3 and SDG 10 and indicate that local health authorities and Puskesmas should institutionalize repeated, cadre-delivered measles education, routine immunization-record verification and opportunistic catch-up vaccination to close the residual coverage gap. Adequately powered, controlled community trials are needed to confirm the determinants and the durability of educational effects.

5. References

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