

Video-Based Education on Complete Basic Immunization Improves Parents' Knowledge, Attitudes, and Practices Regarding Immunization

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Abstract

Complete basic immunization aims to establish an effective protection system and achieve herd immunity. Key factors influencing immunization programs include parents' knowledge, perceptions, and attitudes. One method to enhance parental understanding is through accessible educational media, such as videos. This study aims to assess the impact of video-based education on parents' knowledge, attitudes, and practices regarding complete basic immunization. A quasi-experimental one-group pretest-posttest design was employed. Data collection was conducted in April 2024. The calculation of the minimum sample size used a proportion formula, with a total of 361 participants, parents of children aged up to 1.5 years who lived in the working area of the Community Health Center in Yogyakarta City and met the inclusion criteria. Knowledge, attitudes, and practices were assessed before (day 1) and after (day 7) the intervention. The educational video was distributed via WhatsApp using a YouTube link. The study employed a validated and reliable instrument of the Knowledge, Attitude, and Practice (KAP) questionnaire. KAP content was reviewed and approved by health experts. The questionnaire comprised 10 sociodemographic questions, 7 questions on knowledge, 6 questions on attitude, and 6 questions on practice. Data were analyzed using the Wilcoxon test. The proportion of respondents with good knowledge increased from 80.1% to 97.2%, good attitudes from 83.1% to 97.0%, and good practices from 92.8% to 96.7%. Wilcoxon test results showed a significant improvement in knowledge and attitudes ($p < 0.05$), while practices showed no statistically significant differences ($p > 0.05$). This study shows that video-based education supports immunization programs by increasing parental understanding and acceptance.

Keywords: Attitudes, immunization, knowledge and practices, video-based education

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Introduction

Complete Basic Immunization (CBI) is a series of vaccination processes administered to infants from birth until the age of 18 months. CBI aims to establish a protective immune system and provide herd immunity [1]. The CBI coverage rate at Kasihan II Community Health Center is 94.7%, while the target coverage for the Special Region of Yogyakarta Province is 98% [2]. The factors influencing the success of immunization programs can be analytically categorized into main factors and significant contributing factors. The main factors consist of parents' knowledge, perceptions, and attitudes, which directly affect their decision-making regarding vaccination. In contrast, parents' understanding of vaccines serves as a significant contributing factor that may indirectly influence immunization outcomes by fostering vaccine hesitancy and distrust [3]. Fear of side effects or adverse events following immunization (AEFI), limited access to information, and the quality of healthcare services also affect public

acceptance of vaccines [4]. Parents with good knowledge and positive attitudes are more likely to comply with and participate in complete basic immunization programs [5].

Previous studies have shown that parental knowledge and attitudes significantly influence immunization decisions. For instance, educational interventions not only improved parents' understanding of immunization schedules but also strengthened their trust and confidence in vaccines, leading to greater vaccine acceptance [5]. However, despite some existing evidence on knowledge and attitudes, limited research has examined their direct link with actual immunization practices [6].

Video-based education has the potential to enhance knowledge retention, as information delivered through audiovisual media is often retained longer than information provided through text-based or verbal explanations [7]. By focusing on the effectiveness of video-based education in influencing knowledge, attitudes, and practices, this study offers a more comprehensive perspective and aims to examine the impact of video-based education on parents' knowledge, attitudes, and practices regarding complete basic immunization.

Materials and Methods

Materials

The population in this study consisted of parents (fathers or mothers) of children aged up to 1.5 years living in the areas of Banguntapan 2, Kasihan 2, Berbah, Umbulharjo 2, and Kalasan Community Health Centers in the Special Region of Yogyakarta (SRY). The total population of 1,200 was obtained from the total number of children immunized across five community health centers located in the SRY including Kasihan II Health Center (240 children), Banguntapan Health Center (150 children), Kalasan Health Center (315 children), Berbah Health Center (207 children), and Umbulharjo Health Center (328 children). The study was conducted in the working area of the Yogyakarta City Health Center and received ethical clearance from the Ahmad Dahlan University Research Ethics Committee (No. 012310260).

Methods

This study employed a quasi-experimental design using a one-group pretest-posttest approach. Data collection was conducted during April 2024. The minimum sample size was calculated using the proportion formula by Sullivan [8]. The required sample size n was calculated using the formula below:

$$n = [\text{DEFF} \times N \times p(1 - p)] / \{[(d^2 / Z_{1-\alpha/2}^2)(N - 1)] + p(1 - p)\} \quad (1)$$

where:

n : required sample size

DEFF: design effect = 1

N : population size = 1,200

d : desired precision = 5%

$Z_{1-\alpha/2}$: standard normal deviation = 2.575 (for 99% confidence level)

p : estimated immunization coverage = 97.7% [9].

The total population of 1,200 was obtained from the total number of children immunized across five community health centers located in the SRY. The final sample included 361 respondents, selected using purposive sampling, based on the following inclusion criteria: (1) parents of children aged ≤ 1.5 years, (2) residing within the working area of the Yogyakarta City Health Center and participating in immunization programs, (3) having access to WhatsApp on a smartphone, as both the questionnaire and the video intervention were delivered online (4) previous experience with child immunization, specifying whether participants had older children who had been immunized or only a single child and (5) parents who visited the health center to have their children immunized during the study period.

The intervention consisted of video-based education on Complete Basic Immunization (CBI), sent to participants via WhatsApp in the form of a YouTube link. The video content was evaluated by a panel of experts, including pharmacists, physicians, and clinical psychologists. Experts watched the CBI video and completed a 10-item evaluation form using a 5-likert scale assessing clarity, accuracy, and educational relevance. Written suggestions for improvement were also collected and incorporated into the final video before distribution to participant. The outcomes measured were parents' KAP regarding immunization. These were assessed at baseline (day 1) and post-intervention (day 7) using a structured questionnaire. The 7-day interval was chosen because it provided sufficient time for participants to comprehend the educational material, while not being too long, thus minimizing potential influence from external information. The questionnaire consisted of 23 items including 10 demographic questions, 7 items on knowledge, 6 items on attitudes, and 6 items on practices.

The questionnaire assessing knowledge, attitudes, and practices was developed by the researchers based on the study objectives and written in Indonesian for clarity. Prior to the main study, it was pilot-tested with 30 respondents from a different health center with similar inclusion criteria to assess clarity, relevance, and reliability. The sample size

of 30 follows literature recommendations for pilot testing questionnaires [10]. Validity was confirmed using Pearson correlation ($r > 0.3$) and reliability with Cronbach's Alpha ($\alpha > 0.7$). The final instrument used in the main study closely resembled the validated version, with only minor adjustments based on pilot feedback.

Each correct answer in the knowledge section was scored as 1, and incorrect answers as 0. The knowledge questionnaire consisted of 7 dichotomous (yes/no) items, resulting in a total score range of 0–7. The mean score (M) was 3.5, and standard deviation (SD) was 1.17. All knowledge items were considered equally important, with no weighting differences. Using the mean $\pm$ SD to categorize knowledge assumes equal importance of all items and may result in most respondents falling in the moderate category, which is consistent with pilot study findings. Based on this, knowledge was categorized as follows: poor if $X < 2.33$, moderate if $2.33 \leq X < 4.67$, and good if $X \geq 4.67$. Attitudes and practices were measured using a 5-point Likert scale. For attitude, the questionnaire included 6 items with options from “strongly disagree” (1) to “strongly agree” (5), giving a possible score range of 6–30. The calculated mean (M) was 18 and SD was 4. Therefore, attitude levels were categorized as: poor if $X < 14$, moderate if $14 \leq X < 22$, and good if $X \geq 22$. For practice, the instrument also included 6 items with likert-scale responses ranging from “never” (1) to “always” (5), resulting in the same total score range of 6–30. The mean (M) was 18 and SD was 4, similar to the attitude section. Thus, categorization followed the same cutoff: poor if $X < 14$, moderate if $14 \leq X < 22$, and good if $X \geq 22$.

Results and Discussion

Demographic characteristics of parent's respondent

Respondent characteristics were analyzed descriptively to obtain an overview of respondents based on age, gender, education, marital status, occupation, monthly income, number of children under 1.5 years of age, sources of information about immunization, religion, and access to health facilities. The results of the questionnaire are shown in Table 1.

Table 1 shows the characteristics of the research subjects or demographics of the respondents. Based on the characteristics, most of the respondents were female, totaling 281 respondents (79.5%). This is in line with the research that women are more involved in immunizing their children, namely 94.5% [11]. Generally, women who take on the role of a mother are more concerned about their children's health due to women's natural characteristics of being gentle, loving, emotional, and attentive to their children's needs and health [11]. This ultimately leads to curiosity, which in turn fosters awareness and develops attitudes and actions, all of which contribute to concern for children's health [12].

In Table 1, the respondents involved in this study were predominantly in the 18-29 age category, with 190 respondents (52.6%). In Table 1, the majority of respondents were aged 18–29 years ($n = 190$; 52.6%), representing the largest age group and participating throughout the study from start to finish. This age category may be attributed to early marriage, which remains prevalent in Indonesia. Nationally, the prevalence of child marriage decreased from 8.06% in 2022 to 5.90% in 2024. This study aligns with research conducted by Sarfaraz et al. (2017), in which most mothers (76.69%) were aged 21–25 years [13]. Additionally, based on statistical data from the Indonesian Demographic and Health Survey, the fertility rate of women giving birth in Indonesia is highest among those aged 15–49 years, with the 20–24 age group being the most dominant [14]. These findings indicate that early marriage is relatively common.

Based on educational level, the results obtained that the majority of respondents participating in this study were high school graduates, totalling 199 respondents (55.1%). Consistent with the findings of the study, the majority of parents had a secondary education level (high school), with 45.2% of fathers and 52.9% of mothers [11]. Educational level is one of the factors influencing an individual's ability to understand the education provided, such that the higher an individual's educational level, the easier it is for them to understand it and continue to seek knowledge [15]. Based on marital status, all respondents were married, consistent with the study population of parents with children aged ≤ 1.5 years.

Based on occupation, the majority of respondents were housewives, whereas civil servants formed the smallest group, which may influence health-related decision-making within the study population. Based on the data, the “other category/housewives” has the most respondents. The study population was predominantly female, with housewives comprising the largest occupational subgroup. Housewives have sufficient time at home, which may facilitate taking their children to health care facilities for immunization [16].

Monthly income is a socioeconomic factor that plays a crucial role in decision-making regarding children's health, including complete basic immunizations. Income levels influence a family's ability to access healthcare services, purchase essential health supplies, and prioritize household spending. Therefore, it is important to understand the income distribution of respondents in this study as a social indicator that can influence child immunization

coverage. There are several categories of monthly income, with the IDR 1,000,000 – 3,500,000 income category dominating the respondents who participated in the study, totaling 184 respondents (51.0%).

Table 1. Characteristics of parent respondents at community health centers in Yogyakarta.

Respondent Characteristics	Frequency (n=361)	Percentage (%)
Gender		
Mother	281	79.5
Father	80	20.5
Age		
<18 year	1	0.3
18-29 year	190	52.6
30-39 year	147	40.7
>39 year	23	6.3
Education		
Elementary school	13	3.6
Junior high school	33	9.2
Senior high school	199	55.1
College (diploma, bachelor's, master's, doctoral)	116	30.1
Marital Status		
Married	361	100
Job Type		
Civil servants	26	7.2
Entrepreneurs	83	22.9
Farmers/laborers	37	10.3
Others (housewife)	215	59.6
Earnings per month (IDR)		
< 1,000,000	113	31.3
1,000,000 – 3,500,000	184	51.0
> 3,500,000	64	17.7
Number of children aged <1.5 years		
1 child	357	98.9
2 children	4	1.1
Source of information		
Neighbors/friends/relatives	90	21.3
Doctor	75	22.7
Counseling by health workers	142	37.6
Social media (facebook, whatsapp, youtube)	54	18.4
Religion		
Islam	342	94.7
Christian	17	4.7
Access to Health facilities		
Difficult	4	1.1
Quite difficult	3	0.8
Easy	281	77.8
Very easy	72	20.3

Based on the data presented in Table 1, income is dominated by respondents with moderate income levels, as the majority of participants in this study are housewives with side jobs such as online shopping, catering, home-based cake production, and others. According to research reported that 84% of mothers with incomes at or above the minimum wage have children with complete basic immunizations. Income level is a strong determinant of behavior. This is related to access to health facilities, including complete basic immunization services [17].

The results based on the number of children show that most of the subjects had one child aged ≤ 1.5 years, with 280 respondents (98.9%). This is in line with the research conducted, which found that the number of respondents with fewer than two children was greater than the number of respondents with two or more children. More parents with fewer than two children had complete immunization status compared to parents with two or more children. This could be due to parents being traumatized or afraid that their children might experience side effects such as fever or swelling at the injection site, which may have occurred in their first child. Additionally, it could be due to exposure to issues regarding fake vaccines and the presence of prohibited or harmful substances in vaccines [18].

Based on the characteristics of the subjects regarding their sources of information about immunization, the majority of respondents (142 respondents, 37.6%) obtained information about immunization through health worker counseling. That information about immunization is more commonly obtained from health workers. Health workers play a role in conducting direct counseling sessions about the benefits of basic immunization by visiting the parents of infants, thereby fostering positive behavior among parents. Parents who are less active in visiting health centers or community health posts receive more accurate information about basic immunization and vaccinate their children [19].

The characteristics of the subjects based on their religion show that the majority are Muslim, with 342 respondents (94.7%). This is because the majority of the population in Kasihan Subdistrict is Muslim [20]. Demographic results of respondents based on statements regarding access to health facilities are dominated by subjects who stated that access to health facilities is easy, with 281 respondents (77.8%). Easy access indicates that parents can easily bring their children to health facilities such as community health centers and hospitals using public transportation, private vehicles, or walking. This is because the study was conducted in the Kasihan subdistrict, where every health facility, such as community health centers, can be reached in accordance with Minister of Health Regulation No. 75 on Community Health Centers [1].

Respondents' knowledge of CBI

Parental knowledge about CBI is one way to reduce the number of morbidity disability and death due to diseases that can be prevented by immunization [21]. In 361 respondents, namely parents, their knowledge about CBI was measured. The questionnaire was given before and after the intervention using educational video media via a Youtube link. The statements in the knowledge section about CBI consisted of 7 items, where each statement item showed different results before and after the intervention was given.

The results of the respondents' answers on the pretest questionnaire showed that, out of the 7 statements on the questionnaire, many respondents still did not know the correct answers. Regarding statement number 2 on the purpose of immunization, 328 respondents answered correctly and 33 answered incorrectly. For statement number 3, 272 answered correctly and 89 answered incorrectly. For statement number 4, 270 respondents answered correctly and 91 answered incorrectly. For statements 6 and 7, 275 and 295 respondents answered correctly, respectively, while 86 and 66 respondents answered incorrectly. Meanwhile, the analysis of the post-test questionnaire responses showed that all questions experienced an increase in correct answers, with no statements showing a decrease in correct answers. This indicates that there was an improvement in respondents' knowledge after receiving educational intervention.

The categorization of criteria used in this study is in accordance with the guidelines, that have been calculated [22]. Overview of parents' knowledge level regarding complete basic immunization with the results of the pre-test by category good 80.1%, and enough 19.9%, while the post-test results good 97.2%, enough 2.8%. The level of knowledge of respondents after being given an intervention using educational videos showed positive results or was said to have increased. The percentage of correct answers increased from 80.1% to 97.2%, indicating that the video intervention successfully improved respondents' knowledge about CBI, consistent with the findings [23]. Maternal knowledge exerts a significant positive influence on decision-making and behaviors related to infant immunization, with higher levels of knowledge being associated with an increased likelihood of complete immunization [18].

Respondents' attitudes on CBI

Attitude is the readiness or willingness to act, not the implementation of a particular motive [24]. Attitudes can be influenced by knowledge, as individuals with greater knowledge are more likely to make informed decisions [25]. The questionnaire on attitudes toward CBI consists of 6 statements with response options ranging from strongly disagree, disagree, undecided, agree, and strongly agree, as shown in Table 3.

Based on Table 3, which presents respondents' answers to the pre-test questionnaire, many participants appeared uncertain in their responses especially for statements 3 and 4. This suggests that many parents were unsure about the appropriate age range for receiving complete basic immunizations and lacked confidence in health workers' ability to manage potential vaccine side effects. To address this, healthcare professionals should strengthen education and outreach efforts by clearly explaining the immunization schedule and how they handle common post-vaccination reactions. This may help reduce parental hesitation and encourage full participation in immunization programs.

The results show that parental respondents' attitudes toward CBI predominantly showed positive results. Each question reflects a positive parental attitude toward CBI. The pre-test results showed a minimal percentage of participants with category bad 1.4%, enough 15.5% and good 83.1%, while post-test results bad 0.8%, enough 2.2% and good 97.0%. This may reflect entrenched beliefs, previous negative experiences, or scepticism that are not easily changed with just one educational exposure. This finding underscores the importance of tailoring health promotion strategies to address individual concerns and incorporating more interactive or repeated educational efforts for groups that are resistant.

Furthermore, the positive attitude criterion reached 83.1%, which changed to 97.0% after the educational intervention using a video on complete basic immunization, as shown in the post-test results. Parents' attitudes toward immunization are already positive, there is an influence on attitudes after receiving an intervention using video [26]. Video is an electronic educational medium that combines audio and visual technology simultaneously, producing an engaging and dynamic presentation that stimulates the senses [27]. Attitudes influence mothers' behavior in fulfilling immunization requirements. Mothers with positive attitudes believe that immunization has many benefits for children's health and are more likely to vaccinate their children [28].

Table 2. Distribution of respondents' responses to the parental knowledge questionnaire on complete basic immunization.

Statement	Respondent's answer (n= 361)			
	Pre		Post	
	Correct	Incorrect	Correct	Incorrect
Immunization is an effort to improve the human immune system (immunity)	356	5	361	0
The goal of immunization is to reduce the number of illnesses, disabilities and deaths due to diseases that can be prevented by immunization.	328	33	359	2
Infectious diseases that can be prevented through immunization include tuberculosis, hepatitis, polio, measles and Diphtheria, Pertussis, Tetanus (DPT)	272	89	336	25
Vaccination is the process of administering vaccines (biological products) as an effort to increase immunity	270	91	344	17
Complete basic immunization is given when infants are 0-18 months old in the form of immunization of hepatitis B, BCG, polio 1, DPT-HB-Hib 1, polio 2, DPT-HB-Hib 2, polio 3, DPT-HB-Hib 3, polio 4, IPV, DPT-HB-Hib 4 and measles.	240	121	337	24
Complete basic immunizations in the form of hepatitis B, BCG, polio 1, DPT-HB-Hib 1, polio 2, DPT-HB-Hib 2, polio 3, DPT-HB-Hib 3, polio 4, IPV, DPT-HB-Hib 4 and measles, should be given according to the schedule to achieve the maximum protective effect against infectious diseases	275	86	344	17
Events after immunization are normal side effects	295	66	347	14

Table 3. Distribution of respondents' responses to the attitude questionnaire on complete basic immunization of parents.

Statement	Respondents (n=361)									
	Pre					Post				
	SD	D	U	A	SA	SD	D	U	A	SA
I believe that children should be immunized to improve their immune system.	3	6	21	208	123	3	1	2	107	248
I believe that children should receive complete basic immunization to prevent infectious diseases (tuberculosis, hepatitis, polio, measles and Diphtheria, Pertussis, Tetanus / DPT)	2	10	50	181	118	2	1	7	115	236
I think that basic immunization should be given to babies aged 0-18 months.	4	43	95	143	76	4	2	17	109	229
I assume that health workers will try their best to minimize the occurrence of side effects from vaccination such as fever, fatigue, muscle pain, swelling at the injection site, shortness of breath and seizures.	3	8	66	202	82	2	1	10	103	245
I am confident that if my children are fully immunized according to schedule, it will provide maximum protection against preventable diseases.	2	16	44	223	76	2	3	7	117	232
I support the government's immunization program for children.	4	5	25	191	136	1	1	5	94	260

Note : SD (strongly disagree); D (disagree); U (undecided); A (agree); SA (strongly agree)

Respondents' practices regarding CBI

There were six statements in the questionnaire to describe respondents' practices regarding immunization. Based on Table 4, most respondents answered "always" and "often" for favorable statements, but there were still some respondents who answered "sometimes" and "rarely." Meanwhile, for unfavorable statements, most respondents answered "never" and "rarely," as shown in Table 4.

Table 4. Distribution of respondents' responses to the parental practice questionnaire on complete basic immunization.

Statement	Respondents (n=361)									
	Pre					Post				
	N	R	S	O	A	N	R	S	O	A
I include my child in the complete basic immunization program	0	0	13	177	171	0	0	4	61	296
I include my child in the immunization program according to the schedule	0	5	44	170	142	0	2	14	82	263
I missed my children's immunization schedule	124	173	53	9	2	244	98	18	0	1
I refuse immunization for my children	217	117	23	3	1	302	51	7	0	1
My child has experienced side effects from vaccination such as fever, lethargy, muscle pain, swelling at the injection site, shortness of breath and seizures	64	84	140	44	29	58	81	141	35	46
I got information from health workers about the vaccinations that were given	2	8	43	164	144	1	2	19	129	210

Note: N (never); R (rarely); S (sometimes); O (often); A (always)

Table 4 shows that respondents' responses regarding immunization practices were better. More respondents responded "always" after receiving the video intervention. The data were then categorized as good, enough and bad. The results of the research on behavior in the pre-test were in the good category 92,8%. and enough 7,2%, while the results of the post-test were in the good category was 96,7%, and enough 3,3%. The results of the study showed an increase in the percentage of respondents in the good category after receiving video education intervention. There are findings in previous studies that state that knowledge and attitudes, which imply that behavioral change requires long-term reinforcement or involvement from health workers. Similar results also show changes in practice after watching educational videos [29].

The influence of video education on parents' knowledge, attitudes and practices regarding basic immunization

Increased knowledge has a positive impact on mothers' compliance with basic immunization for infants/children. Mothers' knowledge is influenced by the amount of information they receive and their ability to understand the information provided. This is influenced by what they hear and see, such as information from the mass media and other media [26].

The Wilcoxon test was chosen because the data were paired and not normally distributed. The Wilcoxon test is suitable for ordinal or nonparametric continuous data, such as likert scale scores. The Wilcoxon test showed negative and positive ranks. Negative ranks, which refer to the negative difference between post-test results, indicate that no respondents showed a decrease in scores from the pre-test. Positive ranks are the positive difference between the post-test and pre-test results, with 62 respondents showing an increase in knowledge of complete basic immunization. The statistical results show a p -value < 0.05 , indicating a significant effect on parents' knowledge after the video education intervention. The use of video as an educational medium makes the content less boring, enabling information to be easily understood [4].

Table 5. Effect of video education on parents' knowledge, attitudes and practices regarding basic immunization.

Variable	P-value	Test results		
		Positive rank	Negative rank	Ties
Knowledge about complete basic immunization	0.001*	62	0	299
Attitudes towards complete basic immunization	0.001*	50	0	311
Practice of complete basic immunization	0.083	3	0	358

Note: *significant

There was an increase of 50 respondents with a positive attitude toward complete basic immunization. Statistical results showed a p -value < 0.05 indicating a significant effect of video-based educational intervention. Video-based educational media as a health education tool for improving parents' or mothers' knowledge and attitudes [26]. The number of respondents practicing complete basic immunization increased by 3. Statistical results showed a

p -value > 0.05 , no significant effect on parents' practices. This is because parents had already administered immunization to their children. In this study, the respondents were those who came to the health center to have their children immunized. The researcher only provided a one-week intervention period, thus it cannot be confirmed that the educational video will influence the respondents' practices. The role of healthcare workers is crucial in improving immunization literacy, promoting the importance of vaccination, and increasing awareness of immunization practices, so that the immunization program can be successful in achieving its coverage targets [30]. Table 5 demonstrates the significant improvements in knowledge and attitudes ($p < 0.05$) which highlight the crucial role of healthcare workers in sustaining immunization literacy and reinforcing positive behavior. However, as practices did not significantly improve ($p > 0.05$), ongoing counseling and behavioral support are needed to strengthen consistent participation in immunization programs.

Conclusion

There was a significant effect of video education on complete basic immunization on parents' knowledge and attitudes with a p -value < 0.05 , but there was no significant effect on practice. This study shows that video-based education supports immunization programs by increasing parental understanding and acceptance.

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Declarations

Author contribution	: WS was responsible for conceptualization, methodology design, and final manuscript review. MAZN contributed to data collection, statistical analysis, and interpretation of results. ACP developed the questionnaire, performed data entry, and drafted the initial version of the manuscript. NRM conducted the literature review, prepared figures and tables, and edited the manuscript. PAR coordinated field activities, managed informed consent, and verified the collected data. RG provided statistical support and contributed to the writing of the results and discussion section. GZS handled data cleaning, formatting, and reference management. NQ was responsible for clinical validation and managed the ethical approval process. SAK contributed to the discussion of policy implications and refinement of the final manuscript.
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