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RURAL-URBAN DISPARITIES IN DETERMINANTS OF BCG IMMUNIZATION COVERAGE FOR CHILDREN AGED 0-3 MONTHS IN INDONESIA

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ABSTRACT

Bacillus Calmette–Guérin (BCG) immunization plays a crucial role in preventing tuberculosis, especially in developing countries like Indonesia. Its coverage is influenced by various factors that differ between urban and rural areas. This study aimed to identify factors associated with BCG immunization among infants aged 0–3 months in urban and rural Indonesia. This study used data from the 2017 Indonesia Demographic and Health Survey (IDHS), including 562 rural and 476 urban respondents. Variables analyzed included maternal age, education, household wealth, contraceptive use, and ANC visits. Chi-square tests and multiple logistic regression were conducted separately for urban and rural areas. The findings showed that 64.2% of urban and 48.7% of rural children received BCG immunization. In rural areas, children from the richest households were more likely to be immunized compared to those from the poorest households (OR = 2.29; 95%CI = 1.1–4.6). Children of mothers with higher education in urban areas were more likely to receive BCG compared to those with lower education (OR = 3.43; 95%CI = 1.3–9.0), as were those with secondary education (OR = 2.28; 95%CI = 1.1–4.4). Mothers who used contraception were also more likely to immunize their children compared to those who did not (OR = 2.71; 95%CI = 1.5–4.8). BCG coverage remains lower in rural communities. Improving coverage requires expanding access to health services in rural areas and strengthening education and contraceptive programs in urban settings.

***Kata Kunci**:*
Imunisasi BCG, anak-anak, kesenjangan, Survei Demografi dan Kesehatan Indonesia, perdesaan-perkotaan

ABSTRAK

Imunisasi Bacillus Calmette–Guérin (BCG) berperan penting dalam mencegah tuberkulosis, terutama di negara berkembang seperti Indonesia. Cakupannya dipengaruhi oleh berbagai faktor yang berbeda antara daerah perkotaan dan perdesaan. Studi ini bertujuan mengidentifikasi faktor yang berhubungan dengan imunisasi BCG pada bayi usia 0–3 bulan di daerah perkotaan dan perdesaan di Indonesia. Studi ini menggunakan data dari Survei Demografi dan Kesehatan Indonesia (SDKI) 2017, dengan 562 responden dari perdesaan dan 476 dari perkotaan. Variabel yang dianalisis meliputi usia ibu, pendidikan, kekayaan rumah tangga, penggunaan kontrasepsi, dan kunjungan ANC. Uji chi-square dan multiple logistic regression dilakukan secara terpisah untuk daerah perkotaan dan perdesaan. Hasil menunjukkan 64,2% anak di perkotaan dan 48,7% anak di perdesaan menerima imunisasi BCG. Di perdesaan, anak dari rumah tangga terkaya lebih mungkin diimunisasi dibandingkan anak dari rumah tangga termiskin (OR = 2,29; 95%CI = 1,1–4,6). Di perkotaan, anak dari ibu dengan pendidikan tinggi lebih mungkin menerima BCG dibandingkan yang berpendidikan rendah (OR = 3,43; 95%CI = 1,3–9,0), demikian juga dengan pendidikan menengah (OR = 2,28; 95%CI = 1,1–4,4). Ibu yang menggunakan kontrasepsi juga lebih mungkin mengimunisasi anaknya dibandingkan yang tidak (OR = 2,71; 95%CI = 1,5–4,8). Cakupan BCG tetap lebih rendah di komunitas perdesaan. Peningkatan cakupan memerlukan perluasan akses layanan kesehatan di perdesaan dan penguatan program pendidikan serta kontrasepsi di perkotaan.

INTRODUCTION

Tuberculosis (TB), caused by various species of Mycobacteria, persists as a major threat to health on a global scale, despite being both preventable and treatable. With a staggering 1.5 million deaths annually, TB continues to be the most lethal infectious illness globally (1).

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Recognizing the urgency, World Health Organization (WHO) and United Nations (UN) member states launched the End TB Strategy alongside the the Sustainable Development Goals (SDGs) in 2014-2015, aiming to combat the epidemic. The plan aims for significant reductions in tuberculosis incidence, targeting a decrease of 4-5% annually by 2020, 10% by 2025, and 17% by 2035 (2).

Approximately 10 million individuals across the globe were affected by tuberculosis during 2020, with 5.6 million men, 3.3 million women, and 1.1 million children. The disease transcends geographic boundaries and affects all age demographics (3). A total of 87% of all estimated global cases came from the 30 countries with the highest TB rates, with eight nations alone contributing to over two-thirds of the worldwide total. Within these countries, Indonesia ranks as the second-largest contributor, responsible for 10% of the global cases (2).

The projected occurrence rate of tuberculosis in Indonesia in 2021 is 969,000 or 354 per 100,000 population, while the death rate from TB is estimated at 144,000 deaths (4). The Indonesian government has launched a comprehensive national program for tuberculosis control that encompasses a series of strategic measures, including health promotion, TB surveillance, risk factor management, case detection and treatment, immunization, and preventive medication (5). Included in these measures, the BCG vaccine is a mandatory immunization that has shown high success rates, especially in children aged 12-23 months (6).

The only approved vaccine for preventing tuberculosis is Bacillus Calmette-Guérin (BCG), which provides protection against various forms of the disease such as pulmonary, meningeal and disseminated tuberculosis (7)(8). Across countries with a high incidence of tuberculosis, the BCG vaccine is strongly recommended for children and serves as a primary strategy in TB prevention. Therefore, BCG immunization is administered to infants as part of the national tuberculosis control program (5). BCG immunization rates among children aged 12–23 months were reported to be high in the 2017 IDHS data—92.9% in urban areas and 89.3% in rural ones (9). However, these aggregate figures may mask inequalities in early coverage, particularly among infants in their first three months of life when BCG should ideally be administered.

Several studies have identified key factors influencing childhood vaccination, including maternal age (10), education (11), household wealth (12), antenatal care utilization (13), contraceptive use (14), and place of residence (15)(10). While research in Indonesia has explored the determinants of BCG immunization (14), few studies in Indonesia have explored how these factors differ between urban and rural areas, especially for infants aged 0–3 months. This gap is particularly concerning given Indonesia's geographic and socioeconomic diversity, which may impact access to timely immunization services.

A study on immunization determinants in Indonesia emphasized that geographic location significantly affects immunization coverage, with place of residence identified as one of the key predictors (16). Regarding the Indonesian context, urban areas often benefit from better infrastructure, shorter distances to health facilities, and more healthcare providers, advantages that may not be available in rural settings.

Building on this understanding of geographic disparities, this study aims to examine the disparities in BCG immunization coverage among infants aged 0–3 months in urban and rural areas of Indonesia, and it also explores the role of maternal factors such as age, education level, household wealth, antenatal care utilization, and contraceptive use as potential contributors to immunization inequalities in both settings. Maternal factors are a central focus because mothers are typically the primary decision-makers in child healthcare. Moreover, previous evidence indicates that maternal characteristics play a significant role in supporting children's access to immunization services (17).

METHODS

Data Sources

This study used secondary data from the 2017 IDHS.

Population and Sample

This research collected data from the 2017 IDHS, which included a total of 17,848 mothers aged 15 to 49 who were successfully surveyed. The sampling process was carried out in two stages: 1) choosing groups from every stratum and creating a directory of households

located in the selected groups, and 2) subsequently selecting households for interviews (18). This study concentrated on children aged 0 to 3 months, leading to a total of 1,073 mothers with children in that age range. Within this group, 580 mothers were from rural areas, while 493 were from urban areas. The analysis was performed after filtering the data to include only complete observations, resulting in 1,038 participants, with 562 residing in rural areas and 476 in urban areas. The population and sample are described as follows:

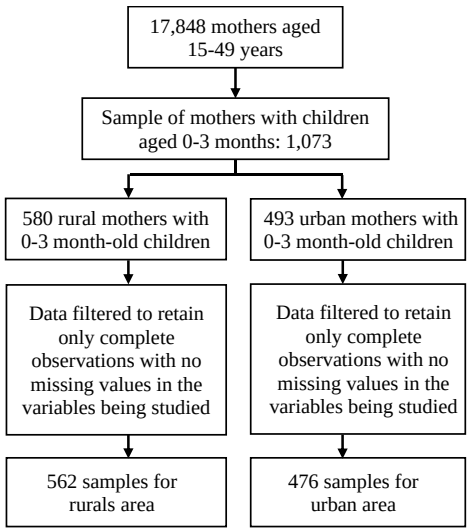

Figure 1. Flowchart of Sample Selection

Research Variables`

This study's dependent variable focused on BCG immunization, categorized into two groups: not received and received. A child was considered vaccinated if the vaccination date was noted on the card and confirmed by the mother. Conversely, if there was no such record, the child was classified as not having received BCG immunization.

The independent variables examined included maternal age, maternal education level, wealth index, contraceptive use, and antenatal care (ANC). Maternal age was categorized into ≤ 24, 25 - 34, and ≥ 35 years. Maternal education was classified into three tiers: low (no formal schooling or completion of only primary education), medium (junior high school), and high (senior high school through college). The wealth index was categorized into poorest, poorer, average, richer, and richest. For contraceptive use, we distinguished between those who used contraceptives and those who did not. ANC visits were classified as incomplete if they were less than three and as complete if they were four or more.

The choice of these variables was based on Andersen's Behavioral Model of Health Services Use (19), a framework frequently used to identify factors affecting healthcare utilization, including immunization (20)(21). Based on this model, the variables were grouped into predisposing, enabling, and environmental components. Maternal age and education were categorized as predisposing characteristics, while wealth index, contraceptive use, and ANC visits represented enabling resources. The place of residence served as an external environmental factor, aligning with the study's focus on rural-urban disparities. Recognizing these contextual drivers is essential to inform policies and design equitable immunization programs that meet the needs of both rural and urban communities in Indonesia.

Data Analysis

The data analysis followed a three-stage approach. Initially, descriptive statistics were employed to outline respondent characteristics. Next, chi-square tests were performed to analyze the association between individual predictors and the dependent variable. Variables demonstrating a p value below 0.25 in the bivariate analysis were subsequently entered into a multivariable logistic regression model to determine the factors significantly associated with the outcome. All statistical procedures incorporated the complex sampling structure of the IDHS and were conducted separately for urban and rural populations.

Research Ethics

The IDHS received ethical approval from both the ICF Institutional Review Board (IRB) and the IRB in the host country (22).

RESULT

The analysis included 1,038 respondents, with 562 residing in rural areas and 476 in urban areas. A marked difference in BCG immunization coverage was observed, with 64.2% of children aged 0–3 months vaccinated in urban areas, compared to 48.7% in rural areas. Conversely, a larger proportion of rural children (51.2%) had not received BCG compared to urban children (35.7%).

Most mothers in both areas were aged 25–34 years, followed by those aged ≤ 24 years. The proportion of mothers aged 35 and older was the smallest in both settings. Urban mothers had high levels of education, with 61.7% having medium education compared to 50.5% in rural areas. Low education was more prevalent in rural areas (32.2%) than in urban (15.3%).

Rural respondents were more likely to fall into the poorest wealth category (30.7%), while the richest category had similar proportions in both areas. Contraceptive use was slightly higher among urban mothers (74.1%) than rural (72.6%). ANC visit completion was generally high, but slightly greater in urban (89.0%) than rural areas (82.5%), while incomplete ANC visits were more common in rural communities (17.4% vs. 10.9%).

Table 2 shows that in rural areas, BCG immunization in children aged 0-3 months was associated with wealth index, contraceptive use, and ANC visits with BCG immunization in children aged 0-3 months. Meanwhile, in urban areas, maternal age, maternal education, wealth index, contraceptive use, and ANC were associated with BCG immunization in children 0-3 months of age.

Table 3 shows that in rural areas, household wealth had a significant influence on BCG vaccination. Children from wealthier families were 2.29 times more likely to receive the vaccine compared to those from the poorest families (OR=2.29; 95% CI: 1.1–4.6). Meanwhile in urban areas, maternal education and contraceptive use were important predictors. Mothers with high education were 3.43 times more likely to vaccinate their children compared to those with low education (OR = 3.43; 95% CI: 1.3–9.0), while mothers with medium education were 2.28 times more likely (OR = 2.28; 95% CI: 1.1–4.4). Additionally, mothers who used contraceptives were 2.71 times more likely to vaccinate their children compared to non-users (OR = 2.71; 95% CI: 1.5–4.8).

DISCUSSION

BCG immunization uptake among children aged 0–3 months was higher in urban than in rural areas. A previous study supports this finding, indicating that immunization coverage, including BCG, tends to be higher in urban areas in Indonesia (23). Access to healthcare services in rural regions is often constrained by a shortage of adequately trained medical personnel and limited transportation infrastructure. Several studies have identified distance to health facilities as a key barrier to completing childhood immunization, particularly in Indonesia, an archipelago comprising more than 17,000 islands (24)(25). Other research conducted in developing nations has similarly indicated that immunization rates are more significant in urban area than in rural regions (10)(26). Prior investigations have demonstrated that geographical proximity significantly influences mothers' ability to access healthcare services (27). The higher immunization rates in urban areas result from improved access to healthcare facilities offering the Essential Immunization Program and variations in vaccination awareness and health-seeking behaviors (26).

Conversely, individuals in rural areas often face significant challenges in accessing immunization services, with limited transportation options and long distances to health facilities being major barriers—particularly in Indonesia, an archipelagic nation consisting of over 17,000 islands (24)(25). The geographical complexity of the country makes it difficult for rural populations to reach health centers, thereby hindering timely vaccination. This finding is reinforced by evidence that distance to health facilities remains one of the key obstacles to completing childhood immunization. However, this contrasts with findings from other studies (28), which revealed that rural communities achieved higher immunization rates than their urban counterparts, although it still remained far below the WHO-recommended target.

Table 1. Description of Study Participants

Variables		Rural (N = 562)	Urban (N = 476)	Total (N=1038)
		N (%)	N (%)	N (%)
BCG immunization status	Not received	288 (51.2)	170 (35.7)	458 (44.1)
	Received	274 (48.7)	306 (64.2)	580 (55.9)
Mother's Age	≤ 24	160 (28.4)	138 (28.9)	398 (28.7)
	25 - 34	300 (53.3)	236 (49.5)	536 (51.6)
	≥ 35	102 (18.1)	102 (21.4)	204 (19.7)
Mother's Education	Low	181 (32.2)	73 (15.3)	254 (24.5)
	Medium	284 (50.5)	294 (61.7)	578 (55.7)
	High	97 (17.2)	109 (22.9)	206 (19.8)
Wealth Index	Poorest	173 (30.7)	132 (27.7)	305 (29.4)
	Poorer	106 (18.8)	91 (19.1)	197 (19.0)
	Average	94 (16.7)	105 (22.0)	199 (19.2)
	Richer	91 (16.1)	74 (15.5)	165 (15.9)
	Richest	98 (17.4)	74 (15.5)	172 (16.6)
Contraceptive Use	No	154 (27.4)	123 (25.8)	277 (26.7)
	Yes	408 (72.6)	353 (74.1)	761 (73.3)
ANC Visits	Incomplete	98 (17.4)	52 (10.9)	150 (14.5)
	Complete	464 (82.5)	424 (89.0)	888 (85.5)

Source: IDHS 2017

Table 2. Distribution of Maternal Socio-Demographics, Contraceptive Use, and ANC Visits Based on The BCG Immunization Status of Children Aged 0-3 Months in Rural and Urban Areas in Indonesia

Variables	Rural BCG Immunization				χ^2	p value	Urban BCG Immunization				χ^2	p value
	No		Yes				No		Yes			
	N	%	N	%			N	%	N	%		
Mother's Age												
≤ 24	87	54.3	73	45.6	2.8	0.42	58	42.0	80	57.9	13.0	<0.001
25 - 34	144	48.0	156	52.0			73	30.9	163	69.0		
≥ 35	57	55.8	45	44.1			39	38.2	63	61.7		
Mother's Education												
Low	100	55.2	81	44.7	2.5	0.40	33	45.2	40	54.7	12.1	0.02
Medium	141	49.6	143	50.3			106	36.0	188	63.9		
High	47	48.4	50	51.5			31	28.4	78	71.5		
Wealth Index												
Poorest	105	60.6	68	39.3	15.2	0.04	57	43.1	75	56.8	8.6	0.21
Poorer	58	54.7	48	45.2			30	32.9	61	67.0		
Average	46	48.9	48	51.6			34	32.3	71	67.6		
Richer	33	36.2	58	63.7			22	29.7	52	70.2		
Richest	46	46.9	52	53.6			27	36.4	47	63.5		
Contraceptive Use												
No	94	61.4	60	38.9	2.8	0.18	59	47.9	64	52.0	16.9	<0.001
Yes	194	47.5	214	52.4			111	31.4	242	68.5		
ANC Visits												
Incomplete	64	65.3	34	34.6	9.0	<0.001	23	44.2	29	55.7	5.6	0.03
Complete	224	48.2	240	51.7			147	34.6	277	65.3		

Source: IDHS 2017

BCG immunization is more likely among children from wealthier families in rural areas. Previous studies have shown that as household wealth rises, the likelihood of children being unimmunized decreases, with children from the poorest households in Indonesia significantly facing a 2.9 times higher risk of not receiving vaccinations (21). This research further supports findings from other studies indicating that children born to families with a higher wealth index are more inclined to get vaccinated (12)(29)(30). Research from Nigeria also highlights persistent health disparities, with children from wealthier households more likely to receive full immunization. These inequalities are considered unfair yet preventable, and call for policies tailored to local socio-cultural contexts to reduce gaps in coverage (31). This study supports their view that household wealth plays a role in immunization, and public health efforts should address economic barriers, especially in rural areas. Families with greater economic means often have improved access to immunization information and resources, which enhances their capacity to fulfill the recommended childhood vaccinations.

Although essential vaccinations are offered at no cost in Indonesia, wealthier families tend to be more proactive in seeking and obtaining vaccinations due to better access to health-related information and services. Other countries, such as Ghana, demonstrate that even when health insurance and services are provided for free, women often still face out-of-pocket expenses for transportation and additional services—costs that tend to favor wealthier mothers (32)(33). As a result, economically disadvantaged women, despite recognizing the importance of immunization, often face financial barriers (29). This study opposes previous findings of no association between wealth and BCG coverage in 0–2-month-old infants (14).

Table 3. Relationship Between Maternal Socio-Demographics, Contraceptive Use, and ANC Visits with BCG Immunization among Children Aged 0-3 Months in Rural and Urban Areas in Indonesia

Variables	Rural		Urban	
	OR	**95% CI**	**OR**	**95% CI**
Mother's Age				
≤ 24	Ref		Ref	
25 - 34	1.26	0.75 – 2.12	1.60	0.91 – 2.79
≥ 35	0.92	0.49 – 1.74	0.87	0.44 – 1.72
Mother's Education				
Low	Ref		Ref	
Medium	1.05	0.62 – 1.76	2.28**	1.17 – 4.44
High	1.22	0.58 – 2.53	3.43**	1.30 – 9.03
Wealth Index				
Poorest	Ref		Ref	
Poorer	1.04	0.55 – 1.95	1.15	0.59 – 2.23
Average	1.27	0.68 – 2.36	1.41	0.71 – 2.77
Richer	2.29**	1.14 – 4.61	1.34	0.61 – 2.94
Richest	1.52	0.76 – 3.04	0.83	0.34 – 2.04
Contraceptive Use				
No	Ref		Ref	
Yes	1.34	0.81 – 2.20	2.71*	1.51 – 4.85
ANC Visits				
Incomplete	Ref		Ref	
Complete	1.64	0.93 – 2.86	1.41	0.65 – 3.02

Source : IDHS 2017
Note : * = p < 0.01; ** = p < 0.05

Maternal education and contraceptive use are key factors influencing BCG immunization in urban areas, unlike rural regions. This research indicates that more educated mothers are more likely to vaccinate their children with BCG. The category of 'high education' referred to in this study encompasses high school to university levels. These results are in line with a study conducted in urban India (34)

and are further supported by research in various developing countries, including Afghanistan (35), Spain (36), Laos (37), Pakistan (38), and several others such as Nepal, Senegal, and Zambia (39). A systematic review and meta-analysis also revealed regional variations, with the impact of maternal education on immunization uptake being stronger in Asia and Africa compared to Europe, likely because education in low-income countries is more closely linked to access to healthcare services (40). Additionally, mothers with higher education tend to have better awareness and capability to access immunization services (41)(42)(43). They are also more effective in reducing missed opportunities for vaccination (MOV) (44). In general, educated mothers are expected to have greater access to health information, which promotes positive health-seeking behaviors and contributes to higher childhood vaccination rates (45).

This research also revealed that urban mothers who utilized contraceptives were more likely to vaccinate their children aged 0-3 months with BCG. A prior study in Indonesia reported similar findings, associating contraception with BCG immunization in infants under 3 months. An increase in the number of children in a household is associated with divided parental attention, making it more challenging to meet each child's needs and decreasing the likelihood of timely vaccination (14). Parents who use contraception tend to have fewer children, allowing them to provide more attention to each child. Conversely, families with a larger number of children frequently face financial challenges, which diminishes the likelihood of vaccinating the youngest child (46)(47). Additionally, phenomenological research examining barriers to basic immunization coverage in children suggests that having closely spaced siblings may hinder mothers from accessing immunization services for their children (48). The adoption of contraceptive methods may facilitate improved family planning, enabling parents to focus more on the health and immunization of each child.

The disparities in factors influencing BCG immunization between rural and urban areas highlight the need for context-specific strategies in immunization program design. Rural areas face economic constraints as a dominant barrier, particularly among low-income families who often struggle with indirect costs such as transportation and opportunity costs. Addressing this requires policies that reduce financial burdens through targeted economic empowerment programs, such as conditional cash transfers or transportation subsidies, while simultaneously strengthening community-based education on the importance of immunization. These combined efforts can help increase both awareness and access, ultimately improving immunization coverage in underserved rural populations. In contrast, urban areas face different challenges. While physical access to health services is generally better, gaps persist in maternal knowledge and engagement with immunization services. Therefore, improving maternal education through health literacy programs is crucial. Such programs should emphasize not only the benefits of immunization but also promote contraceptive use as part of a broader child health strategy. As maternal education levels increase, so does contraceptive use (49), which can lead to better family planning and more focused attention on each child's health needs. Integrating immunization education into family planning and maternal health services can serve as a synergistic approach, equipping mothers with the knowledge and resources to ensure their children receive timely and complete vaccinations. Tailoring interventions to the unique barriers of each setting is essential to close the rural–urban gap in immunization coverage.

Limitations of the Study

This study is subject to several limitations that should be acknowledged when interpreting the findings. First, the analysis relies on secondary data derived from the 2017 IDHS, which, although methodologically rigorous, may be considered outdated. Second, the scope of the study is confined to a limited set of variables, with a primary focus on maternal characteristics. This constraint precludes the examination of other potentially influential determinants, such as the availability and quality of healthcare infrastructure, cultural and religious beliefs surrounding immunization, paternal involvement, and broader household or community-level factors.

Nonetheless, a key strength of this research is its use of the IDHS dataset, which is nationally representative and follows

standardized sampling and data collection methods. These features enhance the generalizability of the findings and support broader conclusions about immunization disparities across rural and urban populations.

CONCLUSION AND SUGGESTION

Conclusions

A disparity in BCG immunization coverage was observed, with infants aged 0–3 months in urban areas showing higher coverage than those in rural areas. The observed urban–rural disparity is associated with maternal characteristics, as identified within the scope of this research. In rural settings, higher household wealth increases the likelihood of immunization. Meanwhile, in urban areas, mothers with higher education levels and those who use contraceptives are more likely to have their children vaccinated.

Suggestions

Targeted policies and context-specific intervention programs are needed to improve BCG immunization coverage. Economic empowerment programs in rural areas have the potential to enhance access to health services. Meanwhile, in urban settings, strengthening health literacy and maternal education—particularly through counseling on immunization and contraception—plays a crucial role. Collaboration between government and civil society organizations will be key to addressing access gaps. Further research on socioeconomic factors and health policies is also important to formulate more effective strategies.

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AUTHOR CONTRIBUTIONS

NMHH was responsible for study design, data collection, analysis, and manuscript drafting. EA and AH supervised the research process and provided critical input on data interpretation.

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