

ORIGINAL RESEARCH

Inequalities in immunization coverage in Indonesia: a multilevel analysis

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ABSTRACT:

Introduction: Immunization is one of the most cost-effective methods for reducing mortality and morbidity rates in children. Children being fully vaccinated helps prevent diseases that would have great societal costs otherwise. Incomplete vaccination poses public health risks and challenges. This study examines the issue of incomplete vaccination in Indonesia. The objectives were to quantify the association between child level, parent level and community level determinants and child immunization coverage in Indonesia.

Methods: Data were from the 2017 Indonesian Demographic Health Survey; this study included 4753 children aged 12–24 months. The survey implemented multistage random

sampling. The data were examined using descriptive statistics and multilevel logistic regression analysis.

Results: The survey found that in Indonesia, country-wide, 58.22% of children were fully vaccinated. A multilevel logistic regression model after adjusting for household wealth and proportion of public healthcare centers (PHCs) showed that children of first birth order had significantly lower likelihood of being fully immunized than children of second order and higher. The parent level factors, such as age of mother at delivery, mother's education, father's occupation, antenatal care (ANC) and region, significantly influenced the completeness of child immunization. At the community level, the presence of a PHC significantly improved

immunization coverage.

Conclusion: The findings indicate that there is a wide range of inequality in immunization throughout the region due to socioeconomic and demographic factors. Findings revealed that complete immunization status was significantly associated with

Keywords:

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FULL ARTICLE:

Introduction

Immunization is one of the most cost-effective interventions for reducing mortality and morbidity, as well as disability, in infants^{1,2}. The implementation of routine vaccination in infants has resulted in decreasing vaccine-preventable diseases^{3,4}. WHO has issued a policy on the Expanded Program for Immunization to prevent the population from acquiring six diseases, namely tuberculosis, diphtheria, tetanus, pertussis, measles, and poliomyelitis^{4,5}. WHO has set the goal of vaccination in a global immunization vision and strategy⁶. WHO articulated that every country should achieve the goal of 90% of children aged less than 1 year having immunization coverage nationwide and at least 80% in every district/municipality in the country by the year 2020^{6,7}. However, immunization coverage above 90% has still not been achieved and is a problem in some countries that have very little resources⁸⁻¹⁰. With a population of more than 257 million people, Indonesia has more than 5 million children to be vaccinated every year^{11,12}. Although the vaccination coverage in Indonesia is increasing every year, it is still far from WHO's goal commitment⁷. Indonesia's population and health survey shows that, in 2012, only half (53.6%) of Indonesian children had received complete basic vaccination¹¹; in 2017, the proportion of Indonesian children who had received complete basic vaccination increased slightly to 58.22%¹². Considering the Indonesia Health Profile in 2016, from 34 provinces in Indonesia, only 12 provinces have achieved national vaccination targets set by the government¹³.

Previous literature has demonstrated that the characteristics of children, parents, and households are an important predictor of child immunization¹⁴⁻¹⁶. As to some characteristics, there is conflicting evidence of the gender gap in immunization, which may reflect specific cultural differences in status. This finding revealed that boys are more fortunate than girls in India¹⁷. Other studies have found the opposite in Nigeria, but this gender difference is not found in Swaziland¹⁸ and Togo¹⁹. Moreover, the variables associated with uptake of immunization are parity, child order^{20,21}, age of baby, and place of birth^{22,23}.

For parental-specific characteristics, educational attainment and literacy^{6,7,20,23}, employment status^{22,24,25}, age and age at birth^{23,26}, marital status^{19,27}, and religion^{19,23} have strong relationships with the vaccination status of children. These characteristics have great relevance to the extent and quality of health care mothers are able to provide to their children²⁶. Household characteristics are influential in their effect on children's health outcomes, which are related to economic and social status

birth order, age of mother at delivery, mother's education, father's occupation, ANC, region, and proportion of PHCs. This study emphasizes the need to increase healthcare centers in each community with the objective to reduce disparities in maternal and child health services.

as measured by wealth or property. The impact of these features on the immunization coverage of children is unclear after studying the reflections of national differences. For example, Bugvi et al²², Olorunsaiye and Degge²³, and Singh and Parasuraman²⁸ reported inequality in the vaccination of children in the absence of parents in the family and for children living in households with lower socioeconomic status. In contrast, Babirye et al²⁹ found that the vaccination rate decreased in children of high socioeconomic status. However, the overall results of these studies indicate that there is a variety of factors related to costs and time for mothers to be able to access health facilities to vaccinate their children^{28,30}.

Moreover, a number of studies report disparities in immunization levels based on residential areas in developing countries. Previous studies reported inequality of rural children in receiving vaccines in Ethiopia³¹, Nigeria²¹, and Pakistan²². A study in India showed that vaccination rates have decreased among urban children, especially in slums and informal settlements in this area³². These differences may be due to differences in development strategies on immunization coverage.

The difference in the ability to access health facilities between villages and cities is also an important factor, where access in rural areas is usually lower than in cities. Previous research by Ibnouf et al³³ and Rup et al³⁴ revealed that distance to healthcare providers is an important factor in accessing immunization treatment.

The phenomenon of the incompleteness of immunization in Indonesia still needs to be investigated so that the relevant factors and causes will be known. However, from past literature reviews^{15,18,19,23}, studies are limited because they only consider household-level factors. The characteristics of the residential area play a very important role in the success of the immunization program in Indonesia because the regions of the country have different geographic and economic characteristics²⁴. In addition, most of the previous studies were cross-sectional studies and used only one level of logistic regression analysis²³⁻²⁷, which is not enough to predict behavior affected by hierarchical structures at the community level.

This study implements the theoretical model of healthcare utilization by Andersen. The model consists of three main factors, namely predisposing, enabling and reinforcing characteristics³⁵. Predisposing factors are the personal preference for using services based on demographic, religious, and health-related values and illnesses. This study included predisposing factors, enabling variable and primary health center, while the dependent variable is

the completeness of the basic immunizations recommended by the government. The purpose of this study was to identify a three-level model, including child level, parent level, and community level to analyze determinants of child immunization status in Indonesia based on the Indonesia Demographic and Health Survey 2017 (IDHS 2017).

Methods

This research drew upon data from IDHS 2017, which was accessed through the Demographic and Health Surveys (DHS) Program. The DHS is an important series of surveys that provides important information about health conditions, nutrition, and demographic indicators. The IDHS 2017 successfully interviewed 49250 eligible women aged 15–49 years. Multistage random sampling was used to obtain representative samples from all provinces in Indonesia. In the 2010 population census of Indonesia, there were 1970 census blocks for use as the determination of the first sampling stage, then 34 census blocks representing the number of provinces in Indonesia were selected. In the second stage, eight families were randomly selected for each selected census block. For this study, data were selected pertaining to babies, living with mothers, aged 12–24 months. Accordingly, the sample encompassed 4753 children.

For the purposes of analysis, children under 1 year were not included because they are not old enough to receive all basic vaccination schedules in Indonesia. The dependent variable in this study was the immunization status of children. The immunization status of these children was further grouped into two groups: if a child was completed immunized, it will be coded as 1; otherwise, it was coded 0. Immunization was said to be complete if the baby or child had received basic immunization consisting of the bacille Calmette-Guérin (BCG), diphtheria, tetanus, pertussis (DTP), polio, measles, and hepatitis B vaccines. This routine immunization is scheduled to be received by children up to the age of 12 months¹². The sources of information on the immunization status of children were obtained from the *Buku Kesehatan ibu dan anak* (maternal and child health book) or *Kartu Menuju Sehat* (child health card), owned by the mother and child. This book/card is a record of the health status of mothers and children, including immunizations received by both mother and child. In Indonesia, the ownership of this book/card is higher than 87%. Accordingly, the immunization data based on these records were a reliable reference for a survey. Where there was no maternal health book or child card, and the mother was uncertain about the status of the child, the child's immunization status was categorized as incomplete³⁶.

The independent variable was chosen based on a theoretical study and a literature review that has been published. The conceptual framework used as the basis for developing the model in this study was Andersen's behavioral health model³⁵. The children's sex was grouped into male and female. The age of children was counted in months. The birth order was defined as the list of birth from the order of birth in the child's family. The mother's age when giving birth (15–49 years) was categorized into groups at 5-year intervals. The educational attainment of mother and father was 'no

education', 'primary level', 'secondary level', and 'higher level'. Mother occupation status was 'do not work' and 'working'. Women's wealth status refers to the five quintile groups of household wealth³⁶. The household wealth index was developed by totaling household assets and amenities (radio, television, refrigerator, bicycle, motorcycle or car) and housing characteristics (electricity, flooring, wall/roofing, water source, latrine ownership and bedroom)³⁶. It was categorized into quintiles from lowest to highest. The antenatal care (ANC) was 'received ANC', and 'no ANC'; however, for the frequency distribution, the ANC was described as the number of maternal visits to health facility.

The residential area was grouped into urban and rural areas. The proportion of *puskesmas* (public health centers) was the number of *puskesmas* compared to the population in each province, then categorized into quintiles from lowest to highest^{36,37}.

STATA version 14 (<https://www.stata.com>) application was used to analyze the data. Frequency distribution was applied to describe the respondents' characteristics. Cross-tabulation was employed to demonstrate the proportion of different categories with respect to immunization status. Multilevel logistic regression was implemented to estimate immunization status in a multivariate context. Model fitting using residuals was checked. Three model levels were categorized as child level, parent level, and community level. The child level included child's sex, age, and birth order. The parent's level included mother's age at delivery, mother's education, father's education, father's working status, ANC status, residence, and region. The provincial proportion of *puskesmas* was included as the third level. The data were run using *xtmelogit* in Stata, household wealth was introduced as random factors in the multilevel analysis^{38,39}. The statistical results were expressed as adjusted odds ratio (OR) with *t*-statistic. The hypothesis was rejected at *p*-value greater than 0.05.

Ethics approval

This study has been approved as ethical research by The Institutional Research Board of the Faculty of Public Health, Diponegoro University, Indonesia (25/EA/KEPK-FKM/2020). Approval for the use of IDHS 2017 data was granted by the Measure Demographic and Health Surveys (DHS) Program.

Results

Descriptive statistic

Distribution of the study participants across the sociodemographic variables is presented in Table 1. Gender numbers of children were similar: 51.67% male and 48.33% female. Most (92.7%) were the first-born child. Most (52.09%) of the mothers were aged between 25 and 34 years. Of the mothers, 28.30% had vocation-level education; of the fathers, 31.41% had senior high school-level education. Almost half (49.55%) of mothers did not work outside the house, and the largest occupational group, fathers (26.76%), were agricultural workers. Among the participants, 54.30% were from rural areas and 32.29% were from the Java and Bali region. Of the mothers, 81.46% had completed an ANC visit. Regarding economics, most (51.72%) of the children's families were of the

most impoverished wealth level. Most of the children's families were located near a centralized health center, with an integrated healthcare center (43.32%), village health service center (40.31%), policlinic (private clinic run by medical practitioner) (42.94%) and public health center (42.94%) at the impoverished levels.

Immunization coverage rate among study participants

The immunization coverage across the sociodemographic variables is presented in Table 1. The IDHS dataset contained information for 4753 children whose mothers completed the questionnaire for married women. The proportion of full immunization was 58.22% (2767 out of 4753 children). Full immunization coverage was similar across sex (57.49% for male and 58.99% for female). In this study, first-born babies were less likely to have full immunization (57.19%) than second-born babies (70.97%). Concerning maternal age at delivery, the completed vaccination coverage rate was 51.12% for 15–24 years, 59.53% for 25–34 years and 61.46% for 35 years or older. Regarding education level, full immunization was highest among children whose mother graduated from vocational education (63.35%) and whose father graduated from vocational education (63.16%). Mother's occupation seems to be important. Mothers who had no occupation were less likely to have full immunization (45.99%) than mothers who have an occupation. Furthermore, full immunization was highest when fathers worked as managers and in administration (70.41%) followed by professional/technical occupation (66.50%). Moreover, complete immunization was higher among those who completed ANC (59.74%) than those who did not complete ANC (51.53%). The rate of complete immunization coverage was 55.33% in rural area settings, which was lower than in urban settings (61.65%). In terms of household wealth, incomplete immunization coverage was found to increase with the declining economic status of children's families (34.83% for the highest quintile to 47.98% for the lowest quintile). Importantly, for complete immunization there were disparities among regions.

Considering health facilities coverage as presented at Table 1. It was found that there was no clear relationship between immunization coverage and the proportion of *posyandu* (integrated health centers), *poskesdes* (village health services), and policlinics. Children living in areas with the lowest number of public health centers tend to receive less complete vaccination coverage than children in areas with those health services in the highest proportion.

However, in the multilevel analysis, the model did not include the proportion of *posyandu*, *poskesdes* and private policlinic (policlinic) due to they have multicollinearity problem. Accordingly, for the community level variable, the multilevel analysis only applied the proportion of *puskesmas*.

Multilevel logistic regression analysis

The child level included sex of child and birth order. After adjusting for wealth in Table 2, it was found that children of second birth order (OR=1.934) had a 93.4% higher likelihood of receiving complete immunization than the first child.

The parent level included sex of child, birth order, age of mother at delivery, mother and father's education, mother and father's occupation, antenatal care visit, residence and region. The education of the father and the mother's occupation were removed from the model due to collinearity problems. After adjusting for household wealth, children of mothers who were older at delivery had a 3.4% (OR=1.034) higher likelihood of receiving full immunization than children of mothers who were younger at delivery. Regarding birth order, first borns were less likely to be vaccinated than second order or higher births. Children of mothers with university (OR=3.347), vocation (OR=3.731), senior high school (OR=3.419), junior high school (OR=2.131) and primary (1.809) education level had an increased likelihood of receiving full immunization compared to children of mothers with no education.

After taking household wealth level into account, the likelihood of receiving full immunization among mothers who had completed ANC (OR=1.199) was 19.9% higher than among mothers who did not complete ANC. Regarding the region, children of mothers from Java and Bali (OR=2.080), Nusa Tenggara (OR=3.298), Kalimantan (OR=1.584), Sulawesi (OR=1.879), and Maluku (OR=1.680) regions had increased likelihood of receiving full immunization compared with children of mothers from the Sumatra region.

In the community level model, the proportion of PHCs (highest, high, medium, low, lowest) was added into the model. The result showed that children whose mothers were resident in communities with highest (OR=1.290), medium (OR=1.316) and low (OR=1.440) proportion of PHCs had a higher likelihood of receiving full immunization compared to children of mothers residing in communities with the proportion of PHCs at the lowest level but the 'high' proportion of PHCs did not significantly influence full immunization.

Table 1: Immunization coverage across the sociodemographic variables

Variable	Immunization coverage	
	No f (%)	Yes f (%)
Sex of child		
Male	1044 (42.51)	1412 (57.49)
Female	942 (41.01)	1355 (58.99)
Birth order		
1	1886 (42.81)	2520 (57.19)
2	99 (29.03)	242 (70.97)
≥3	1 (16.67)	5 (83.33)
Age of mother at delivery (years)		
15–24	503 (48.88)	526 (51.12)
25–34	1002 (40.47)	1474 (59.53)
≥35	481 (38.54)	767 (61.46)
Meant±SD	29.88 (6.48)	30.11 (6.48)
Mother's education		
No education	65 (66.33)	33 (33.67)
Primary	181 (52.31)	165 (47.69)
Junior high school	402 (48.73)	423 (51.27)
Senior high school	488 (41.60)	685 (58.40)
Vocation	493 (36.65)	852 (63.35)
Bachelor or higher	357 (36.96)	609 (63.04)
Father's education		
No education	65 (66.33)	33 (33.67)
Primary	583 (49.79)	588 (50.21)
Junior high school	425 (41.46)	600 (58.54)
Senior high school	556 (37.24)	937 (62.76)
Vocation	98 (36.84)	168 (63.16)
Bachelor or higher	259 (37.00)	441 (63.00)
Mother's occupation		
Not working	1083 (45.99)	1272 (54.01)
Professional/technical	152 (34.00)	295 (66.00)
Clerical	72 (33.96)	140 (66.04)
Sales	265 (36.50)	461 (63.50)
Agricultural worker	225 (44.47)	281 (55.53)
Industrial worker	87 (36.25)	153 (63.75)
Services	102 (38.20)	165 (61.80)
Father's occupation		
Not working	116 (44.44)	145 (55.56)
Professional/technical	131 (33.50)	260 (66.50)
Manager and administration	29 (29.59)	69 (70.41)
Clerical	115 (33.63)	227 (66.37)
Sales	237 (42.70)	318 (57.30)
Services	357 (43.48)	464 (56.52)
Agricultural worker	599 (47.09)	673 (52.91)
Industrial worker	402 (39.68)	611 (60.32)
ANC visit		
Not complete	427 (48.47)	454 (51.53)
Complete	1559 (40.26)	2313 (59.74)
Residence		
Urban	833 (38.35)	1339 (61.65)
Rural	1153 (44.67)	1428 (55.33)
Region		
Sumatra	762 (51.24)	725 (48.76)
Java and Bali	363 (33.86)	709 (66.14)
Nusa Tenggara	129 (29.12)	314 (70.88)
Kalimantan	148 (42.65)	199 (57.35)
Sulawesi	291 (39.43)	447 (60.57)
Maluku	196 (41.97)	271 (58.03)
Papua	97 (48.74)	102 (51.26)
Household wealth		
Lowest	748 (47.98)	811 (52.02)
Low	404 (44.94)	495 (55.06)
Medium	310 (40.21)	461 (59.79)
High	261 (33.94)	508 (66.06)
Highest	263 (34.83)	492 (65.17)
Proportion of integrated healthcare centers (<i>posyandu</i>)		
Lowest	465 (43.54)	603 (56.46)
Low	438 (44.20)	553 (55.80)
Medium	378 (36.63)	654 (63.37)
High	274 (38.32)	441 (61.68)

Highest	431 (45.51)	516 (54.49)
Proportion of village health service centers (<i>poskesdes</i>)		
Lowest	409 (42.08)	563 (57.92)
Low	478 (50.64)	466 (49.36)
Medium	446 (40.33)	660 (59.67)
High	385 (43.26)	505 (56.74)
Highest	268 (31.87)	573 (68.13)
Proportion of policlinics		
Lowest	404 (39.38)	622 (60.62)
Low	497 (51.93)	460 (48.07)
Medium	417 (40.68)	608 (59.32)
High	377 (44.35)	473 (55.65)
Highest	291 (32.51)	604 (67.49)
Proportion of public health centers (<i>puskesmas</i>)		
Lowest	495 (48.77)	520 (51.23)
Low	419 (40.84)	607 (59.16)
Medium	389 (36.39)	680 (63.61)
High	364 (43.54)	472 (56.46)
Highest	319 (39.53)	488 (60.47)

ANC, antenatal care center. SD, standard deviation.

Table 2: Multilevel logistic regression analysis of immunization coverage among children aged 12–24 months

Independent variable	Odds ratio (t-statistic)		
	Children level	Parent level	Community level
Sex of child			
Male (ref.)	–	–	–
Female	1.047 (0.932–1.177)	1.056 (0.937–1.190)	1.059 (0.939–1.194)
Birth order			
First (ref.)	–	–	–
Second	1.934*** (1.516–2.468)	1.972*** (1.531–2.540)	1.957*** (1.519–2.522)
Third	4.058 (0.469–35.13)	4.547 (0.521–39.68)	4.562 (0.520–40.02)
Age at delivery		1.034*** (1.024–1.044)	1.034*** (1.024–1.044)
Mother's education			
No education (ref.)		–	–
Primary		1.809* (1.112–2.943)	1.801* (1.106–2.932)
Junior high school		2.131** (1.343–3.379)	2.158** (1.359–3.426)
Senior high school		3.419*** (1.960–5.964)	3.459*** (1.980–6.042)
Vocation		3.731*** (2.346–5.934)	3.751*** (2.356–5.972)
University		3.347*** (2.066–5.422)	3.383*** (2.085–5.487)
Father's education		(omitted)	(omitted)
Mother's occupation		(omitted)	(omitted)
Father's occupation			
Do not work (ref.)		–	–
Work		1.217 (0.912–1.623)	1.236 (0.926–1.650)
ANC visit			
Do not complete (ref.)		–	–
Complete		1.199* (1.026–1.402)	1.198* (1.025–1.400)
Residence			
Rural (ref.)		–	–
Urban		1.024 (0.885–1.185)	1.047 (0.903–1.214)
Region			
Sumatra (ref.)		–	–
Java and Bali		2.080*** (1.748–2.476)	1.993*** (1.665–2.385)
Nusa Tenggara		3.298*** (2.582–4.213)	3.115*** (2.380–4.078)
Kalimantan		1.584*** (1.242–2.021)	1.571*** (1.222–2.019)
Sulawesi		1.879*** (1.558–2.266)	2.094*** (1.697–2.582)
Maluku		1.680*** (1.338–2.108)	2.011*** (1.544–2.618)
Papua		1.345 (0.982–1.842)	1.446* (1.049–1.995)
Proportion of PHC			
Lowest (ref.)			–
Low			1.440*** (1.188–1.745)
Medium			1.316** (1.070–1.620)
High			1.053 (0.853–1.302)
Highest			1.290* (1.039–1.601)
_cons	0.326*** (1.1144–1.7227)	0.07370 (0.03726–0.1457)	–2.881*** (0.0277–0.1132)
Wald χ^2 (df)	30.47 (3)	250.74 (20)	264.42 (24)
Prob> χ^2	0.0001	0.0001	0.0001
Likelihood ratio test vs logistic regression (Prob> χ^2)	0.0001	0.0112	0.0103

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

ANC, antenatal care center. _cons, constant. df, degree of freedom. PHC, public healthcare center. Ref., reference value.

that 58.22% of children aged 12–24 months were fully vaccinated. However, the percentages found in this study are far from the WHO and UNICEF's global immunization goals, vision and strategies, which outline a goal of 80% coverage⁷. Therefore, finding out how socioeconomic factors and community characteristics affect the status of child immunization is crucial to improving vaccination coverage in Indonesia.

Vaccination coverage in Indonesia appears weakly associated with region after accounting for all confounders. Although birth order, age of mother at delivery, mother's education, father's occupation, ANC and proportion of PHC were strongly associated with vaccination coverage, the marginally significant result obtained for the region does not mean that the influence of location on vaccine uptake should be excluded. On a regional basis, it was found that geographical differences and the size of the population were significantly related to achieving complete immunization coverage^{40,41}. The highest coverage of complete immunization was found in the Java and Bali region, whereas the lowest complete immunization coverage was in the Sumatra region. In Indonesia, geographical conditions make some areas isolated or remote, and other areas are difficult to reach because of the limited availability of roads and public transport^{40,41}. Low immunization coverage is often found in distant, rural areas, and where there are religious restrictions and fear of side effects from vaccines⁴¹. Some research has found that certain regions have their own beliefs about health and that it is a challenge for health professionals to try to look after mothers' health^{42,43}. This is also caused by a lack of knowledge and awareness about child immunization^{44,45}. For this reason, in this difficult area, an innovative approach is needed to achieve immunization targets. The needs of supply and demand must be met. For example, outreach programs with small mobile units have great potential to reach remote areas in the mountains. The use of local transportation to reach remote areas in Bangladesh has been highly recommended⁴⁴. This approach is very appropriate for reaching children far from health facilities⁴⁴⁻⁴⁸ so that the overall, low coverage of immunization in children can be addressed and the numbers improved⁴⁹.

As birth order increased, the likelihood of the child being vaccinated increased^{50,51}. This finding contradicts other findings that an experience of immunization side effects in vaccinated babies might have triggered parents' negative perceptions about vaccination⁵². If a first child experiences side effects from vaccination, parents may be less likely to vaccinate their second child. Therefore, the chances of a second child being vaccinated are reduced⁵³. Moreover, it was found that older mothers are more likely to complete the vaccination of children^{51,52}; children of older mothers are more likely to be fully immunized than children of younger mothers, who are often unable to make their own decisions. Younger mothers have to discuss the decision with family members. Older mothers are more likely to have parenting experience and are more likely to have knowledge of the child's health in general⁵⁴. The importance of maternal education in child health is internationally recognized. Children with highly educated mothers are more likely to be fully vaccinated^{51,54}. Older mothers

have possibly been exposed to more immunization information, and have experience in terms of access to information and better health services^{15,18,27}. Knowledge and experience of access to health services is what drives the completeness of child immunization^{41,49}. Also, highly educated mothers tend to have better knowledge and understanding of general health and the benefits of immunization⁵⁰. As previous studies have shown, level of education is significantly related to the level of public health awareness^{51,52}. This can be explained by those having better education having a better understanding of immunization recommendations⁴⁶. The studies also found that children of mothers who routinely do health checks tend to have complete immunization compared to those who do not do health checks during pregnancy and postpartum; this is because mothers who do the checks receive more complete information or health education. Danchin et al's research revealed that information about immunization was received by mothers while pregnant⁵³. It was also found that maternal education affects whether mothers remember whether their children have been vaccinated, and whether the vaccination card is kept for the child⁵⁰. This means that education improves mothers' understanding of the importance of vaccination and child health care. Therefore, ensuring access to education for women in remote areas should reduce the disparity in vaccination^{54,55}.

The completeness of immunization was confirmed as significantly correlated with ANC^{45,56}; mothers who received more information about the benefits of vaccines tended to increase their access to vaccination services for their babies. So, it can be concluded that the ANC visit is not only beneficial to the health of the mother, but it encourages the mother to have a broad insight about health; for example, the benefits of vaccination⁵⁷. A mother's visit during a pregnancy check will increase her interaction with health workers, and this communication can increase the flow of information about health, in this case, the benefits of vaccination, reducing the fear of side effects⁵⁸.

The findings provide very good input for public health worldwide. Public health status is determined not only by modern treatments, but also by effective, widespread public education. In addition, government stakeholders can be encouraged by the findings to increase community education and further increase the dissemination of health information to the wider community^{40,41}. Furthermore, it is suggested that one way the Indonesian government could increase the coverage of universal child immunization would be by long-term investment in increasing parental education⁵⁴.

The results of the study also show the importance of the quality of service received by mothers during their ANC and postpartum delivery. If the quality of service is good, health workers will provide the necessary health education and information about immunization^{51,54}.

Considering the community level determinants, an increase in the number of public health centers was associated with higher vaccination coverage. Children whose mothers reside in the close vicinity of healthcare centers were strongly positively associated

with immunization coverage. Previous research has shown that increasing the number of health centers in a village to 1 per 1000 people increases the likelihood of children being fully vaccinated 54%⁵⁹. Similarly, several studies⁶⁰⁻⁶² have found that complete immunization of children is related to the use and effectiveness of maternal health services. However, immunization coverage is still incomplete, particularly among children born at home^{63,64}.

The findings, consistent with regional analyses and their relationship to vaccination coverage, underscore the need to bridge the gap in vaccination inequality in Indonesia. The public healthcare center (*puskesmas*) is a community health service facility in Indonesia under the Ministry of Health. Postpartum midwifery visits are important to the integrity of the immunization status. Indonesia's midwifery recruitment program in villages across the country is relevant in this context, aiming to bring maternal and child health services to remote areas and disadvantaged communities^{63,64} even when those communities are hard to reach⁶⁵.

Regulation of the Minister of Health of the Republic of Indonesia No. 43 of 2019 states that *puskesmas* play a role in fostering health cadres in running *posyandu* (integrated health centers)^{65,66}. If a *posyandu* has active cadres, promotional and preventive health activities are also expected to run well. One of the important activities in *posyandu* is the immunization program⁶⁷. *Posyandu* cadres have a role in encouraging mothers and parents to bring their children to the *posyandu* to get immunization⁶⁷. Therefore, cooperation and *posyandu* guidance carried out by the *puskesmas* is very important. Moreover, the role of the village midwives may also be related to *posyandu* activity. Vaccination in a *posyandu* is mostly introduced and performed by village midwives^{67,68}. Village midwives also have a role in outreach programs such as special vaccinations during home visits for maternal health. This outreach program may have accelerated the immunization coverage⁶⁹.

This study also reveals that the number of healthcare facilities managed by the community is very meaningful in achieving complete immunization. Accordingly, it is recommended that the Indonesian government increase the availability and the number of health facilities⁷⁰. Moreover, the ease of access to immunization in various health service facilities should also be prioritized.

From the results of this research and discussion, it is recommended that the government increase the number of health facilities, especially in areas that have low immunization coverage.

Likewise, mothers' knowledge about immunization needs to be improved so that they pay more attention to health during pregnancy and to immunization for their children. In addition, it is hoped that the government can design priority programs to improve the quality of health services and health education, especially for people with low education.

Conclusion

This study's findings indicated that there is a wide range of inequality in immunization throughout Indonesia due to socioeconomic and demographic factors. Complete immunization status was significantly associated with birth order, age of mother at delivery, mother's education, father's occupation, ANC, region and proportion of public healthcare centers. This study emphasizes the need to increase the number of health centers in each community with the objective to narrow disparities in maternal and child health services. It is recommended that the Indonesian government provide guidelines for immunization and implement relevant policies, including monitoring and evaluation of immunization, especially for regions with low vaccination coverage levels. This conclusion is made in the context of strengthening the role of the community in the fight against diseases preventable by vaccines in developing countries, which is critical to the success of immunization and the general health of society.

Limitations

Although this study has articulated an important finding, it has some limitations. This study did not cover the time of giving vaccination, in which the time of giving vaccination is related to immunization effectiveness. In terms of data collection, this study ranges to 2 years before data collection, which can result in a bias recall on this study. Furthermore, due to the large area of Indonesia, the results of this study could not be directly implemented in developing health policy for particular areas.

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