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## Determinants of immunisation coverage of children aged 12-59 months in Indonesia: a cross-sectional study.

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3 **Determinants of immunisation coverage of children aged 12-59 months in**  
4 **Indonesia: a cross-sectional study.**  
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## 1. Abstract

Objectives: Immunisation is considered to be the most cost-effective intervention with the highest impact against infectious diseases. Despite the adaption of WHO's Expanded Programme on Immunisation in Indonesia since 1977, a large proportion of children are still unimmunised or only partly immunised. This study aimed to assess factors associated with low immunisation coverage of children in Indonesia.

Setting: Children aged 12-59 months in Indonesia.

Participants: The socioeconomic characteristics and immunisation status of the children were obtained from the most recent Demographic and Health Survey, the 2012 IDHS. Data from 14,401 children aged 12-59 months nested within 1,832 census blocks were included in the analysis. Participants were randomly selected through a two-stage stratified sampling design. Multilevel logistic regression models were constructed to account for hierarchical structure of the data.

Results: The children were 2.5 years old on average and equally divided by sex. Only 32% of the children were fully immunised in 2012. Coverage was significantly lower amongst children who lived in Maluku and Papua region (Adjusted Odds Ratio: 1.94; 95% Confidence Interval [1.42 to 2.64]), were 36-47 months old (1.39 [1.20 to 1.60]), had higher birth order (1.68 [1.28 to 2.19]), had greater family size (1.47 [1.11 to 1.93]), whose mother had no education (2.13 [1.22 to 3.72]), and from the poorest households (1.58 [1.26 to 1.99]). The likelihood of being unimmunised was also higher amongst children without health insurance (1.16 [1.04 to 1.30]) and those who received no antenatal (3.28 [2.09 to 5.15]) and postnatal care (1.50 [1.34 to 1.69]).

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3 Conclusions: Socioeconomic factors were strongly associated with the likelihood of  
4 being unimmunised in Indonesia. Unimmunised children were geographically  
5 clustered and lived amongst the most deprived population. To achieve WHO target of  
6 immunity level, public health interventions must be designed to meet the needs of  
7 these high risk groups.  
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## 13 14 15 **2. Keywords**

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18 Immunisation coverage; routine immunisation; determinants; Indonesia; Indonesia  
19 Demographic and Health Survey; multilevel analysis.  
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## 24 25 **3. Strengths and Limitations of This Study**

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27 • Our study investigated, for the first time, the factors associated with routine  
28 immunisation coverage of children in Indonesia using data from the most  
29 recent Demographic and Health Survey.  
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- 31 • The large sample size allowed us to analyse many potential predictors  
32 simultaneously and produce better estimates.  
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- 34 • We used multilevel modelling to account for the hierarchical structure of the  
35 data.  
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- 37 • However, we could only build a two-level model (i.e. children nested within  
38 census blocks) because there was no household identifier in the dataset, as it  
39 may compromise the participants' anonymity.  
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- 41 • The selection of variables included in this study also relied on the information  
42 available from the dataset.  
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## 49 50 **4. Main Text**

### 51 52 **BACKGROUND**

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55 Immunisation is one of the most cost-effective and greatest-impact health intervention  
56 against infectious diseases.[1] Immunisation from vaccination protects individuals as  
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3 well as communities through herd immunity, a state where ‘the presence of immune  
4 individuals could provide indirect protection to others’.[2:p.265] Childhood  
5 immunisation is particularly important because infants and young children are at an  
6 increased risk of infectious diseases.[3] Furthermore, the human immune system  
7 undergoes changes as age increases, which would reduce the protective effect of  
8 vaccination.[3] Therefore, many believe that childhood immunisation is the key to the  
9 successful control of infectious diseases.  
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20 In 1974, the World Health Organisation initiated the Expanded Programme on  
21 Immunisation (EPI) with the goal of providing universal immunisation for all  
22 children.[1] The first diseases targeted were diphtheria, tetanus, pertussis, polio,  
23 measles, and tuberculosis.[1] New and increasingly sophisticated vaccines have  
24 become available, and more children than ever before are being vaccinated today.[4,  
25 5] Global coverage increased from 74% in 2000 to 86% in 2014.[6] As a result, the  
26 annual number of child deaths fell from 9.6 million in 2000 to 5.9 million in 2015.[1,  
27 6] Immunisation drives this reduction in child mortality and the collective recognition  
28 has led to the development of the Global Vaccine Action Plan (GVAP), a framework  
29 to help countries achieve universal child immunisation by 2020.[5] The target, as  
30 stated in the United Nations Sustainable Development Goals, is to end preventable  
31 child deaths by 2030.[7]  
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47 Despite this progress, vaccine-preventable diseases are still responsible for 1.5 million  
48 child deaths each year.[8] Almost 18.7 million children were not given routine  
49 immunisation in 2014 and 75% of them live in only ten countries in Africa and  
50 Asia.[6] Although some regions have successfully maintained a high level of  
51 immunisation coverage, there are pockets of unimmunised children which induce the  
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3 continuous spread of diseases and outbreaks.[4] This highlights the fact that global  
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5 coverage may hide variability between countries. It also suggests that the  
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7 achievements are still fragile. Should this trend continue, the goals of providing  
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9 universal immunisation for all children by 2020 and ending vaccine-preventable  
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11 deaths by 2030 could not be achieved, and the cost of such failure would be close to  
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13 26 million child deaths.[5]  
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17 One of the ten countries that are home to the highest number of unimmunised children  
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19 is Indonesia.[6] Indonesia is a lower middle income country located in Southeast  
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21 Asia.[9] It has an estimated population of over 255 million in 2015, 10% of whom are  
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23 children under the age of five.[10] Child mortality rate in Indonesia currently stands at  
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25 27 deaths per 1,000 births and ranks 101st out of 175 countries.[11] Approximately  
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27 36% of child deaths were caused by infectious diseases.[12] For most of these  
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29 diseases, vaccines are available to prevent child deaths.  
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33 The Indonesian Ministry of Health (MOH), which organises public health matters  
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35 within the Indonesian government, has adopted and implemented the EPI guidelines  
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37 since 1977 through a routine immunisation programme that is compulsory for all  
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39 children.[13] Even so, a large number of young children in Indonesia are still either  
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41 unimmunised or only partly immunised. In 2013, the MOH has reported that only  
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43 59.2% of children were fully immunised.[13] There were also striking gaps within the  
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45 country as coverage was as low as 29.2% at a certain area in Indonesia.[13] These  
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47 figures were well below the 90% advised threshold that is required to maintain herd  
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49 immunity and prevent the spread of diseases.[5] As the fourth most-populous country  
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51 in the world with a great proportion of young children, the risk of large and  
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53 uncontrollable outbreaks in Indonesia is more likely than ever.  
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3 In order to significantly increase coverage in Indonesia, a strategy proposed by GVAP  
4 is to identify and engage the unimmunised children.[5] These children are often the  
5 ones carrying a heavier burden of diseases.[5] There is particular concern that diseases  
6 may thrive when unimmunised children are residentially segregated from immunised  
7 children.[4] It is therefore critical to know who they are, where they live, and what  
8 factors might have contributed to their unimmunised status, in order to ascertain  
9 where greater efforts are needed.  
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19 While administrative and geographic barriers may contribute to low coverage in a  
20 country with such a large population,[14] GVAP explicitly highlights the importance  
21 of socioeconomic factors in determining coverage.[5] Theory suggests that factors  
22 such as income level, employment status, and education are major determinants of  
23 healthcare utilisation[15] and a growing body of empirical evidence advances such  
24 association. The socioeconomic characteristics attached to routine immunisation  
25 coverage, and the extent these factors may play a role, vary by country.[14, 16-26]  
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35 However, no such research has been done in Indonesia.  
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39 In this study, we used data from the 2012 Indonesia Demographic and Health Survey  
40 (IDHS) which collected information on both the immunisation status and the  
41 socioeconomic characteristics of Indonesian children under five years of age. Our aim  
42 was to identify the socioeconomic factors associated with routine immunisation  
43 coverage of children in Indonesia. The results should help in identifying susceptible  
44 subgroups of the population that require additional resources and focused attention.  
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## 51 52 53 **METHODS**

### 54 55 56 **Data Source**



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3 This study is a cross-sectional study of the most recent DHS in Indonesia. The IDHS  
4 is conducted routinely by the national statistics authority Statistics Indonesia, in  
5 collaboration with the National Population and Family Planning Board, the Indonesian  
6 MOH, and ICF International. Studies on its quality suggest that DHS is nationally  
7 representative, with little evidence of systematic bias.[27]  
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15 Data was collected from May 7 to July 31, 2012. Participants were selected through a  
16 two-stage stratified sampling design. The primary sampling unit was the census block  
17 (CB) and the complete list of households in each CB became the basis for second-  
18 stage sampling. A total of 46,024 households were chosen as the sample. From 44,302  
19 occupied households, 45,607 women aged 15-49 were successfully interviewed,  
20 yielding a response rate of 96%.  
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30 The Women's Questionnaire included questions about the woman's background  
31 characteristics and her children aged under five, for whom immunisation and health  
32 data were collected. The dataset had one record for every child of each interviewed  
33 woman, born in the five years preceding the survey. Data were obtained for 18,021  
34 children.  
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#### 40 41 42 **Outcome Variable**

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45 The outcome variable in the analysis was the child's immunisation status. Information  
46 on immunisation status was collected from two sources, the health card or health book  
47 shown to the interviewer, or if unavailable, from the mother's report. It was  
48 categorised as 'fully immunised' if they had received the full schedule of routine  
49 immunisation and otherwise 'unimmunised', regardless of the source of the  
50 information. Routine immunisation referred to three doses of DTP vaccines, four  
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3 doses of polio vaccine, one dose of measles vaccine, one dose of BCG vaccine, and  
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5 four doses of hepatitis B vaccine.[13] The proportion of children who had been fully  
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7 immunised defined immunisation coverage.[28]  
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11 In a small number of cases, where health cards were unavailable and mothers  
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13 indicated that they did not know about the immunisation status (1.51%), the child was  
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15 considered as not fully immunised. The fact that mothers responded 'don't know' is  
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17 likely to reflect that the child was not fully immunised[14, 29] and fits better in the  
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19 'unimmunised' category.  
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### 22 23 **Independent variables**

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26 Selection of independent variables was based on the literature review and variables  
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28 available in the dataset. Twenty-two independent variables were identified as potential  
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30 factors and Andersen's Behavioural Health Model[15] was used as a framework to  
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32 group the factors into three main groups: external environment, predisposing, and  
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34 enabling factors (Figure 1). The model has been commonly used to examine factors  
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36 associated with health service utilisation, including immunisation uptake.[23, 30]  
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41 Categorisation of continuous variables and description of categorical variables were  
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43 undertaken according to the literature. The child's age (12-59 months) was categorised  
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45 into groups at one-year intervals. Similarly, the mother's age (15-49 years) was  
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47 categorised into groups at five-year intervals. The child's birth order and family size  
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49 were also categorised into groups based on previously published literatures.  
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53 The 33 provinces in Indonesia were categorised into six island-based regions.  
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55 Following IDHS protocol, household wealth was categorised into quintiles from  
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57 poorest to richest based on household amenities and assets. In the absence of direct  
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3 information on household income or expenditures, wealth index is considered a robust  
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5 measure of household income level.[31] A child's place of birth was classified into  
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7 three categories: home, public health institution, and private health institution. Public  
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9 health institution included public hospitals, public clinics, health centres, village  
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11 health posts, and delivery posts. Private health institution included private hospitals,  
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13 private clinics, maternity hospitals, maternity home, and also private practices of  
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15 obstetrician, general practitioner, nurse, midwife, and village midwife. Finally,  
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17 antenatal care represented any care received during the pregnancy, while postnatal  
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19 care represented any examination within two months of the child's birth.  
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### 24 **Statistical Analysis**

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27 The original dataset comprised of 18,021 children aged 0-59 months distributed  
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29 among 1,840 CBs. For the purpose of the analysis, we excluded 3,620 children who  
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31 were under one year old because they were not old enough to have received the full  
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33 schedule of routine immunisation in Indonesia. The final sample, therefore, contained  
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35 14,401 children from 1,832 CBs. From this, we had 656 children (4.6%) with missing  
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37 immunisation status because they were no longer alive at the time of the survey,  
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39 leaving complete observations of 13,745 children (95.4%). Given the small number of  
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41 missing values, we used complete-case analysis and no sensitivity analysis was  
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43 required.  
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49 Data analysis was conducted using STATA 14 software. Frequency and percentage  
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51 were used to report baseline characteristics of the children. Cross tabulation was  
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53 undertaken to demonstrate the proportion of different categories with respect to  
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55 immunisation status.  
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Univariate analysis was used to separately evaluate of the effect of each independent variable on the outcome variable. Test of trends across ordered groups were evaluated. Variables with a univariate P-value of less than 0.2 were then selected as candidates for the multivariate analysis.

Multilevel logistic regression was used to estimate immunisation status in multivariate context while accounting for clustering. Model fitting using residuals were checked. A two-level model was used for the multivariate analysis (i.e. children nested within CBs). Associations between independent variables and the likelihood of children being unimmunised were assessed simultaneously. The results were expressed as adjusted odds ratio (AOR) with 95% CI.

## RESULTS

### Descriptive Statistics

A total of 14,401 children from 1,832 CBs were included in the analysis. Our result showed that only 31.5% (95% CI 30.7% to 32.3%) of the children aged 12-59 months had been fully immunised at the time of the survey. The baseline characteristics of sample were presented in Table 1.

Table 1: Baseline characteristics of sample (n=14,401).

Characteristics		Frequency <sup>†</sup>	Percentage (%)
Immunisation status	Fully immunised	4331	31.5
	Unimmunised	9414	68.5
<b>External Environment</b>			
Geographic region	Sumatera	4061	29.5
	Java	3079	22.4
	Bali and Nusa Tenggara	1220	9.0
	Kalimantan	1447	10.5
	Sulawesi	2381	17.3
	Maluku and Papua	1557	11.3
Place of residence	Urban	6307	45.9
	Rural	7438	54.1
<b>Predisposing Characteristics</b>			
Child's sex	Male	7092	51.6
	Female	6653	48.4

Child's age (months)	12-23	3501	25.5
	24-35	3413	24.8
	36-47	3378	24.6
	48-59	3453	25.1
Child's birth order	1 <sup>st</sup>	5929	35.9
	2 <sup>nd</sup> - 4 <sup>th</sup>	7533	54.8
	≥ 5 <sup>th</sup>	1283	9.3
Mother's age (years)	15-19	262	1.9
	20-24	2381	17.3
	25-29	3928	28.6
	30-34	3454	25.2
	35-39	2410	17.5
	40-44	1104	8.0
	45-49	206	1.5
Mother's marital status	Married	13168	95.8
	Living with partner	176	1.3
	Widowed	118	0.8
	Divorced	231	1.7
	No longer living together	43	0.3
	Never in union	9	0.1
Family size (number of household members)	≤ 4	5314	38.6
	5-9	7637	55.6
	≥ 10	794	5.8
Mother's educational level	Higher	1819	13.2
	Secondary	7221	52.6
	Primary	4291	31.2
	No education	414	3.0
Father's educational level	Higher	1740	12.7
	Secondary	7438	54.2
	Primary	4204	30.6
	No education	311	2.3
	Don't know	24	0.2
Mother's occupation	Professional	1018	7.4
	Agricultural	1855	13.5
	Industrial	1571	11.4
	Clerical, services, and sales	3236	23.6
	Did not work	6052	44.1
	Don't know	2	0.0
Father's occupation	Professional	1336	9.8
	Agricultural	3550	25.9
	Industrial	4884	35.6
	Clerical, services, and sales	3709	27.0
	Did not work	225	1.6
	Don't know	12	0.1
Mother's exposure to media (newspaper, magazine, radio, or television)	At least once a week	11528	83.9
	Less than once a week	1527	11.1
	Not at all	686	5.0
Mother's tobacco use history	Smokes nothing	13317	96.9
	Uses tobacco	424	3.1
<b>Enabling Resources</b>			
Household wealth index	Richest	2108	15.3
	Richer	2276	16.6
	Middle	2504	18.2
	Poorer	2722	19.8
	Poorest	4135	30.1
Covered by health insurance	Yes	5580	40.6
	No	8156	59.4
Antenatal care	Received some care	10861	96.2
	Received no care	640	3.8
Postnatal care	Received some care	7395	65.7
	Received no care	3813	33.8
	Don't know	53	0.5
Child's place of delivery	Home	6325	46.2
	Public health institution	2527	18.4

	Private health institution	4823	35.2
	Other	28	0.2
Distance to health facilities	Not a big problem	11915	86.9
	Big problem	1792	13.1
Maternal healthcare decision making	By herself	4758	35.7
	Jointly with husband	6567	49.3
	Husband alone	1972	14.7
	By others	34	0.3
Child healthcare decision making	By herself	4497	36.3
	Jointly with husband	1407	50.5
	Husband alone	6255	11.4
	By others	225	1.8

† Total number varies between categories because of missing values.

The children in this study were 2.5 years old on average and equally divided by sex. More than half of them were second- to fourth-born. The mothers were 25 to 29 years old on average and almost all were married at the time of the survey. Most of the families had five to nine household members.

Majority of the mothers were secondary school graduates. Although educational attainment was approximately equal for both parents, nearly half of the mothers did not work. A large proportion of the mothers were exposed to media at least once a week and almost all reported that they did not smoke around the time of the survey.

In terms of enabling resources, half of the children lived in the poorer and poorest households. Additionally, almost two-thirds of the children were not covered by health insurance. While only a small proportion were born without antenatal care, much more children were born without postnatal care. Nearly half of the children were delivered at home although most mothers reported that distance to health facilities were not a big problem. Lastly, the majority of mothers reported that they were involved in the decision making process of their own healthcare as well as their children's.

### Univariate Analysis

The association between each independent variable and the likelihood of being unimmunised was investigated one by one. The result were shown in Table 2.

Table 2: Univariate analysis results for factors associated with immunisation coverage.

Characteristics		Status (%)				Unadjusted OR (95% CI)		P-value
		Fully immunised		Unimmunised				
<b>External Environment</b>								
Geographic region	Sumatera	1135	(26.2%)	2926	(31.8%)	1.68	(1.52 to 1.86)	0.000
	Java	1215	(28.1%)	1864	(19.8%)	1		
	Bali and Nusa Tenggara	525	(12.1%)	695	(7.4%)	0.86	(0.75 to 0.99)	0.032
	Kalimantan	490	(11.3%)	957	(10.2%)	1.27	(1.12 to 1.45)	0.000
	Sulawesi	672	(15.5%)	1709	(18.2%)	1.66	(1.48 to 1.86)	0.000
	Maluku and Papua	294	(6.8%)	1263	(13.4%)	2.80	(2.42 to 3.24)	0.000
Place of residence	Urban	2232	(51.5%)	4075	(43.3%)	1		
	Rural	2099	(48.5%)	5339	(56.7%)	1.39	(1.30 to 1.50)	0.000
<b>Predisposing Characteristics</b>								
Child's sex	Male	2255	(52.1%)	4837	(51.4%)	1		
	Female	2076	(47.9%)	4577	(48.6%)	1.03	(0.96 to 1.10)	0.455
Child's age (months)	12-23	1246	(28.8%)	2255	(24.0%)	1		
	24-35	1066	(24.6%)	2347	(24.9%)	1.22	(1.10 to 1.34)	0.000
	36-47	1011	(23.3%)	2367	(25.1%)	1.30	(1.17 to 1.43)	0.000
	48-59	1008	(23.3%)	2445	(26.0%)	1.34	(1.21 to 1.48)	0.000
Child's birth order	1 <sup>st</sup>	1675	(38.7%)	3254	(34.6%)	1		
	2 <sup>nd</sup> – 4 <sup>th</sup>	2413	(55.7%)	5120	(54.4%)	1.29	(1.21 to 1.37)	0.000
	≥ 5 <sup>th</sup>	243	(5.6%)	1040	(11.0%)	1.41	(1.27 to 1.57)	0.000
Mother's age (years)	15-19	67	(1.5%)	195	(2.1%)	1		
	20-24	704	(16.2%)	1677	(17.8%)	0.82	(0.61 to 1.10)	0.178
	25-29	1219	(28.2%)	2709	(28.8%)	0.76	(0.57 to 1.02)	0.064
	30-34	1166	(26.9%)	2288	(24.3%)	0.67	(0.51 to 0.90)	0.007
	35-39	815	(18.8%)	1595	(16.9%)	0.67	(0.50 to 0.90)	0.007
	40-44	301	(7.0%)	803	(8.5%)	0.92	(0.67 to 1.25)	0.579
	45-49	59	(1.4%)	147	(1.6%)	0.86	(0.57 to 1.29)	0.458
Mother's marital status	Married	4159	(96.0%)	9009	(95.7%)	1		
	Living with partner	50	(1.2%)	126	(1.3%)	1.16	(0.84 to 1.62)	0.368
	Widowed	37	(0.9%)	81	(0.9%)	1.01	(0.68 to 1.49)	0.958
	Divorced	70	(1.6%)	161	(1.7%)	1.06	(0.80 to 1.41)	0.678
	No longer living	11	(0.3%)	32	(0.3%)	1.34	(0.68 to 2.64)	0.400

	together					2.67)			
	Never in union	4	(0.0%)	5	(0.1%)	0.58	(0.15	to	0.413
						2.15)			
Family size	≤ 4	1746	(40.3%)	3568	(37.9%)	1			
(number of	5-9	2381	(55.0%)	5256	(55.8%)	1.08	(1.00	to	0.044
household						1.16)			
members)	≥ 10	204	(4.7%)	590	(6.3%)	1.42	(1.20	to	0.000
						1.68)			
Mother's	Higher	756	(17.5%)	1063	(11.3%)	1			
educational level	Secondary	2451	(56.6%)	4770	(50.7%)	1.38	(1.25	to	0.000
						1.54)			
	Primary	1081	(25.0%)	3210	(34.1%)	2.11	(1.88	to	0.000
						2.37)			
	No education	43	(0.9%)	371	(3.9%)	6.14	(4.41	to	0.000
						8.53)			
Father's	Higher	717	(16.6%)	1023	(10.9%)	1			
educational level	Secondary	2508	(58.0%)	4930	(52.5%)	1.38	(1.24	to	0.000
						1.53)			
	Primary	1054	(24.4%)	3150	(33.5%)	2.09	(1.86	to	0.000
						2.36)			
	No education	42	(1.0%)	269	(2.9%)	4.49	(3.20	to	0.000
						6.30)			
	Don't know	3	(0.0%)	21	(0.2%)	4.91	(1.46	to	0.010
						16.5)			
Mother's	Professional	428	(9.9%)	590	(6.3%)	1			
occupation	Agricultural	405	(9.4%)	1450	(15.4%)	2.60	(2.20	to	0.000
						3.07)			
	Industrial	480	(11.1%)	1091	(11.6%)	1.65	(1.40	to	0.000
						1.94)			
	Clerical, services, and sales	1069	(24.7%)	2167	(23.0%)	1.47	(1.27	to	0.000
						1.70)			
	Did not work	1944	(44.9%)	4108	(43.7%)	1.53	(1.34	to	0.000
						1.76)			
Father's	Professional	520	(12.0%)	816	(8.7%)	1			
occupation	Agricultural	809	(18.7%)	2741	(29.2%)	2.16	(1.89	to	0.000
						2.47)			
	Industrial	1584	(36.7%)	3300	(35.1%)	1.33	(1.17	to	0.000
						1.50)			
	Clerical, services, and sales	1350	(31.2%)	2359	(25.1%)	1.11	(0.98	to	0.102
						1.27)			
	Did not work	58	(1.4%)	167	(1.8%)	1.83	(1.33	to	0.000
						2.52)			
	Don't know	2	(0.0%)	10	(0.1%)	3.19	(0.70	to	0.136
						14.6)			
Mother's	At least once a week	3814	(88.1%)	7714	(82.0%)	1			
exposure to media (newspaper, magazine, radio, or television)	Less than once a week	373	(8.6%)	1154	(12.2%)	1.53	(1.35	to	0.000
						1.73)			
	Not at all	142	(3.3%)	544	(5.8%)	1.89	(1.57	to	0.000
						2.29)			
Mother's tobacco use history	Smokes nothing	4246	(98.0%)	9071	(96.4%)	1			
	Uses tobacco	85	(2.0%)	339	(3.6%)	1.87	(1.47	to	0.000
						2.37)			
<b>Enabling Resources</b>									
Household wealth index	Richest	914	(21.1%)	1194	(12.7%)	1			
	Richer	834	(19.2%)	1442	(15.3%)	1.32	(1.17	to	0.000
						1.49)			
	Middle	883	(20.4%)	1621	(17.2%)	1.41	(1.25	to	0.000
						1.58)			
	Poorer	848	(19.6%)	1874	(19.9%)	1.69	(1.50	to	0.000
						1.90)			
	Poorest	852	(19.7%)	3283	(34.9%)	2.95	(2.63	to	0.000
						3.31)			
Covered by	Yes	1993	(46.0%)	3587	(38.1%)	1			



health insurance	No	2336	(54.0%)	5820	(61.9%)	1.38 (1.29 to 1.49)	0.000
Antenatal care	Received some care	3668	(99.0%)	7193	(94.8%)	1	
	Received no care	38	(1.0%)	394	(5.2%)	5.29 (3.78 to 7.39)	0.000
Postnatal care	Received some care	2732	(73.8%)	4663	(61.7%)	1	
	Received no care	958	(25.9%)	2855	(37.8%)	1.75 (1.60 to 1.90)	0.000
	Don't know	14	(0.3%)	39	(0.5%)	1.63 (0.88 to 3.01)	0.117
Child's place of delivery	Home	1376	(31.8%)	4949	(52.8%)	1	
	Public health institution	1041	(24.1%)	1486	(15.9%)	0.40 (0.36 to 0.44)	0.000
	Private health institution	1905	(44.0%)	2918	(31.1%)	0.43 (0.40 to 0.46)	0.000
	Other	6	(0.1%)	22	(0.2%)	1.02 (0.41 to 2.52)	0.967
Distance to health facilities	Not a big problem	3885	(89.9%)	8030	(85.6%)	1	
	Big problem	438	(10.1%)	1354	(14.4%)	1.50 (1.33 to 1.68)	0.000
Maternal healthcare decision making	By mother herself	1461	(34.7%)	3297	(36.1%)	1	
	Jointly with husband	2193	(52.1%)	4374	(47.9%)	0.88 (0.82 to 0.96)	0.003
	Husband alone	543	(12.9%)	1429	(15.7%)	1.17 (1.04 to 1.31)	0.010
	By others	10	(0.3%)	24	(0.3%)	1.06 (0.51 to 2.23)	0.870
Child healthcare decision making	By mother herself	1469	(37.0%)	3028	(36.0%)	1	
	Jointly with husband	2015	(50.8%)	4240	(50.4%)	1.12 (0.99 to 1.28)	0.076
	Husband alone	424	(10.7%)	983	(11.7%)	1.02 (0.94 to 1.11)	0.621
	By others	59	(1.5%)	166	(1.9%)	1.36 (1.01 to 1.85)	0.045

Geographic region came out as a significant predictor of immunisation coverage in our univariate analysis. The majority, one third, of children who were fully immunised lived in Java, while the lowest coverage was reported in Maluku and Papua. The odds of being unimmunised were almost threefold amongst children who lived in Maluku and Papua (OR 2.80; 95% CI 2.42 to 3.24). On the contrary, we found that children from Bali and Nusa Tenggara had the least likelihood of being unimmunised (OR 0.86; 95% CI 0.75 to 0.99). Our univariate analysis also showed that children from rural areas were significantly more likely to be unimmunised compared to their urban counterparts (OR 1.39; 95% CI 1.30 to 1.50).

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3 Although coverage was approximately equal for both sexes, the child's age and birth  
4 order were significantly associated with coverage. Older children were more likely to  
5 be unimmunised compared to the youngest ones. The odds of being unimmunised  
6 amongst the older children ranged from 1.22 to 1.34. Similarly, children who were not  
7 first-born had significantly higher chance of being unimmunised. The odds of being  
8 unimmunised increased as the child's age and birth order increased ( $p < 0.000$ ).  
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17 We found that children whose mothers were 30-39 years old at the time of the survey  
18 were less likely to be unimmunised (OR 0.67; 95% CI 0.50 to 0.90). However, there  
19 was no clear trend across the age groups. We also found that children who came from  
20 bigger families were significantly more likely to be unimmunised. The likelihood  
21 increased by 8% up to 42%. As the number of household members increased, the  
22 likelihood of a child to be unimmunised increased ( $p < 0.000$ ).  
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31 Although their marital status was not a significant predictor of coverage, each parent  
32 educational attainment was significantly associated with coverage. As parents'  
33 educational attainment increased, the likelihood of being unimmunised decreased  
34 ( $p < 0.000$ ). Hence, children from uneducated parents had the highest odds of being  
35 unimmunised. Those whose mothers had no education were at least six times more  
36 likely to be unimmunised (OR 6.14; CI 95% 4.41 to 8.53). Likewise, children whose  
37 fathers were uneducated had greater than fourfold chance of being unimmunised (OR  
38 4.49; 95% CI 3.20 to 6.30).  
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50 Additionally, parents' occupation, mother's exposure to media, and mother's tobacco  
51 use history were significantly associated with coverage. Across the occupational  
52 groups, children whose parents worked in agriculture had the highest odds of being  
53 unimmunised. Children whose mothers worked in agriculture were 2.6 times more  
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3 likely to be unimmunised (OR 2.60; 95% CI 2.20 to 3.07), while children whose  
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5 fathers worked in agriculture were 2.16 times more likely to be unimmunised (OR  
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7 2.16; 95% CI 1.89 to 2.47). Regarding mother's exposure to media, the child's  
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9 likelihood of being unimmunised increased as the frequency of media exposure  
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11 decreased ( $p < 0.000$ ). Finally, children whose mothers smoked tobacco around the  
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13 time of the survey had 87% higher chance of being unimmunised (OR 1.87; 95% CI  
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15 1.47 to 2.37).  
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19 We found that as the household wealth index increased, the likelihood of being  
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21 unimmunised decreased ( $p < 0.000$ ). Hence, children from poorest households had the  
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23 highest odds of being unimmunised (OR 2.95; 95% CI 2.63 to 3.31). We also found  
24  
25 that children who had no health insurance were significantly more likely to be  
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27 unimmunised compared to those who had insurance (OR 1.38; 95% CI 1.29 to 1.49).  
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31 Our univariate analysis indicated that antenatal and postnatal care visits were  
32  
33 significant predictors of coverage in Indonesia. Our results showed that children who  
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35 were born without antenatal care were at least five times more likely to be  
36  
37 unimmunised (OR 5.29; 95% CI 3.78 to 7.39). Likewise, those who were born without  
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39 postnatal care were 75% more likely to be unimmunised (OR 1.75; 95% CI 1.60 to  
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41 1.90).  
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47 In terms of access to health services, we found that children who were born in health  
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49 institution were significantly less likely to be unimmunised compared to those who  
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51 were born at home. Specifically, children who were born at public health institution  
52  
53 had the least likelihood of being unimmunised (OR 0.40; 95% CI 0.36 to 0.44). In  
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55 addition, children whose mothers think that distance to health facilities was a big  
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problem had 50% higher chance of being unimmunised (OR 1.50; 95% CI 1.33 to 1.68).

### Multivariate Analysis

Out of the 22 independent variables, child's sex and mother's marital status were excluded. Table 3 summarised the significant results of our multilevel logistic regression analysis between the remaining 20 independent variables and the likelihood of being unimmunised.

Table 3: Multivariate analysis results for factors significantly associated with immunisation coverage of children in Indonesia.

Characteristics		AOR (95% CI)	P- value
<b>External Environment</b>			
Geographic region	Sumatera	1.51 (1.24 to 1.83)	0.000
	Java	1	
	Bali and Nusa Tenggara	0.71 (0.54 to 0.94)	0.016
	Maluku and Papua	1.94 (1.42 to 2.64)	0.000
Place of residence	Urban	1	
	Rural	0.82 (0.69 to 0.96)	0.013
<b>Predisposing Characteristics</b>			
Child's age (months)	12-23	1	
	24-35	1.24 (1.08 to 1.42)	0.002
	36-47	1.39 (1.20 to 1.60)	0.000
	48-59	1.36 (1.17 to 1.58)	0.000
Child's birth order	1 <sup>st</sup>	1	
	2 <sup>nd</sup> - 4 <sup>th</sup>	1.18 (1.03 to 1.35)	0.016
	≥ 5 <sup>th</sup>	1.68 (1.28 to 2.19)	0.000
Family size (number of household members)	≤ 4	1	
	≥ 10	1.47 (1.11 to 1.93)	0.006
Mother's educational level	Higher	1	
	No education	2.13 (1.22 to 3.72)	0.008
Father's occupation	Professional	1	
	Clerical, services, and sales	0.82 (0.67 to 1.00)	0.047
<b>Enabling Resources</b>			
Household wealth index	Richest	1	
	Poorer	1.30 (1.06 to 1.59)	0.011
	Poorest	1.58 (1.26 to 1.99)	0.000
Covered by health insurance	Yes	1	
	No	1.16 (1.04 to 1.30)	0.010
Antenatal care	Received some care	1	
	Received no care	3.28 (2.09 to 5.15)	0.000
Postnatal care	Received some care	1	
	Received no care	1.50 (1.34 to 1.69)	0.000
Child's place of delivery	Home	1	
	Public health institution	0.55 (0.47 to 0.64)	0.000
	Private health institution	0.62 (0.54 to 0.72)	0.000
Maternal healthcare decision making	By herself	1	
	Jointly with husband	0.86 (0.76 to 0.96)	0.010

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3 After accounting for the other remaining variables, geographic region and place of  
4 residence were significantly associated with coverage. The likelihood of being  
5 unimmunised was highest among children who lived in Maluku and Papua. Children  
6 who lived in this region were almost twice as likely to be unimmunised compared to  
7 those who lived in Java (AOR 1.94; 95% CI 1.42 to 2.64). Similarly, children who  
8 lived in Sumatera had considerably higher odds of being unimmunised (AOR 1.51;  
9 95% CI 1.24 to 1.83). In contrast, children from Bali and Nusa Tenggara were less  
10 likely to be unimmunised (AOR 0.71; 95% CI 0.54 to 0.94). Those who lived in rural  
11 areas were also less likely to be unimmunised compared to their urban counterparts  
12 (AOR 0.82; 95% CI 0.69 to 0.96).  
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26 The likelihood of being unimmunised differed significantly across the age groups.  
27 Older children were more likely to be unimmunised compared to those in the youngest  
28 age group. The odds ranged from 1.24 (95% CI 1.08 to 1.42) to 1.39 (95% CI 1.20 to  
29 1.60). Of all age groups, children aged 36-47 months had the highest odds of being  
30 unimmunised (AOR 1.39; 95% CI 1.20 to 1.60).  
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39 The child's birth order and family size were also significantly correlated with  
40 immunisation status. As a child's birth order or family size increased, the likelihood of  
41 being unimmunised also increased. A second child was 18% more likely to be  
42 unimmunised compared to a first child (AOR 1.18; 95% CI 1.03 to 1.35), while a fifth  
43 child had 68% higher chance of being unimmunised (AOR 1.68; 95% CI 1.28 to  
44 2.19). Accordingly, children who came from bigger families had higher likelihood of  
45 being unimmunised. Those who lived in households with ten or more family members  
46 were 47% more likely to be unimmunised (AOR 1.47; 95% CI 1.11 to 1.93).  
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3 Children whose mothers had no education were at least twice as likely to be  
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5 unimmunised than those whose mothers were high-school graduates or higher (AOR  
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7 2.13; 95% CI 1.22 to 3.72). Similarly, the odds of being unimmunised were  
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9 significantly higher among the poorer (AOR 1.30; 95% CI 1.06 to 1.59) and the  
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11 poorest (AOR 1.58; 95% CI 1.26 to 1.99). Also, those without health insurance were  
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13 more likely to be unimmunised (AOR 1.16; 95% CI 1.04 to 1.30).  
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17 The odds of being unimmunised were strikingly higher amongst children without  
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19 antenatal or postnatal care. Children who were born without antenatal care were more  
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21 than three times as likely to be unimmunised (AOR 3.28; 95% CI 2.09 to 5.15).  
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23 Likewise, those who had no postnatal care had a 50% higher chance of being  
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25 unimmunised (AOR 1.50; 95% CI 1.34 to 1.69). Additionally, children who were born  
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27 in health institution were less likely to be unimmunised compared to those who were  
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29 born at home (AOR 0.55; 95% CI 0.47 to 0.64). Furthermore, children whose parents  
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31 jointly decided on maternal healthcare and whose fathers worked in clerical, services,  
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33 and sales were significantly less likely to be unimmunised (AOR 0.86; 95% CI 0.76 to  
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35 0.96 and AOR 0.82; 95% CI 0.67 to 1.00, respectively).  
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## 40 DISCUSSION

### 41 Main Findings

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44 Our study investigated, for the first time, the factors associated with routine  
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46 immunisation coverage of children aged 12-59 months in Indonesia, using data from  
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48 2012 IDHS. Our analysis revealed that only 31.5% of the children had been fully  
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50 immunised. After accounting for all confounders, 13 factors were significantly  
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52 associated with low coverage in Indonesia: geographic region, place of residence,  
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3 child's age, child's birth order, family size, mother's education, father's occupation,  
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5 household wealth index, insurance coverage, antenatal care, postnatal care, child's  
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7 place of delivery, and maternal healthcare decision making.  
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11 There are discrepancies between the coverage level reported by the officials and the  
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13 one discovered in this study. In 2012, the Indonesian MOH reported coverage level of  
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15 86.8%.[32] The coverage level determined through 2012 IDHS is therefore much  
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17 lower than that contained in the official report.  
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21 While our study analysed cross-sectional survey data, the official report used  
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23 administrative data which are commonly employed to assess immunisation coverage  
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25 in low-resource settings.[33] The estimate is obtained by dividing the number of doses  
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27 administered at health services by the expected target population.[33, 34] Although  
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29 this is readily available, results can be unreliable, particularly when there are  
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31 uncertainties surrounding the total number of age-eligible children.[33, 35]  
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35 The discrepancy between estimates obtained from administrative and survey data have  
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37 also been reported in the past.[35-38] Administrative estimates tend to be higher than  
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39 those obtained from the survey,[34] which is observed in our finding as well.  
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41 Comparisons of administrative and survey estimates are made more complicated by  
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43 the fact that the number of age-eligible children included in each analysis differ.[34]  
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45 The estimate from administrative data includes children aged 0-11 months, while the  
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47 survey usually includes children aged up to 59 months.[34, 35] The coverage from  
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49 MOH report was of children aged 0-11 months, because they are the youngest group  
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51 eligible to receive the full schedule of routine immunisation. Measles vaccine, for  
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53 example, is the last one on the schedule and is given starting at the age of nine  
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55 months. However, it could be administered up to the age of 12 months.[39] There are  
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3 also booster campaign and backlog fighting initiative for children up to three years of  
4 age, as well as other supplemental immunisation activities which targeted children  
5 aged 9-59 months.[39] This is all part of routine immunisation programme in  
6 Indonesia. Therefore, estimates from administrative data would not have covered the  
7 entire target population of routine immunisation coverage. This indicates a weakness  
8 in the surveillance system and highlights the need of quality assurance of  
9 immunisation data.  
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### 20 **Factors Associated with Immunisation Coverage**

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22 After accounting for all observed confounders, geographic region was significantly  
23 associated with coverage. The six geographic regions used in our analysis represented  
24 the six largest islands in Indonesia. Each has its own population density, religious  
25 affiliation and political situation, economic potential, and level of development. Our  
26 analysis suggested that children from the Maluku and Papua region had the highest  
27 odds of being unimmunised. The Maluku and Papua region is located in the  
28 easternmost part of Indonesia and is economically deprived. It is the largest yet least  
29 developed region with ongoing conflicts. Eligible children most likely lived in remote  
30 areas without access to health services. It is therefore not surprising that we found  
31 these children to have the highest likelihood of being unimmunised. Our research  
32 confirms that geographical disparities may contribute to low coverage, particularly in  
33 developing countries with a large population.[14] Similar findings were reported from  
34 India[37] and Nigeria.[16]  
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52 Children from urban areas have been reported to have better immunisation status  
53 compared to their rural counterparts.[31] By contrast, our results revealed that  
54 children who lived in rural areas were less likely to be unimmunised. Although health  
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3 services are better and more easily accessible in urban areas compared to rural  
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5 areas.[29] this fact likely masks the extent of urban poverty.[31] Estimates suggest  
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7 that one third of urban populations in developing countries are actually living in  
8  
9 slums.[40] With limited access to health services and poor quality of life, it is  
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11 certainly likely that urban children had higher odds of being unimmunised.  
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13 Unfortunately, we lacked information to distinguish between urban areas with higher  
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15 socioeconomic status and the slums. Further research in this field could assist strategic  
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17 planning and resource allocation.  
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22 Our analysis revealed that children of older age groups were significantly more likely  
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24 to be unimmunised compared to those in the youngest group. In other words, later  
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26 birth years were associated with better immunisation coverage. It may indicate a  
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28 positive trend of the immunisation programme performance over the years.[41]  
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32 As the birth order increases, the likelihood of a child being unimmunised increases. A  
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34 possible explanation is that parents may have developed confidence in their child's  
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36 healthcare as a result of years of experience from previous children, and could dismiss  
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38 the importance of immunisation.[42, 43] On the contrary, it could be that the first-born  
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40 experienced adverse reaction to immunisation, leading the parents to believe that  
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42 immunisation was risky.[43]  
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46 Consistently, children who came from larger families were more likely to be  
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48 unimmunised. The number of household members has been linked with health  
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50 outcome in many developing countries. As the number of family members increases,  
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52 the quality of care they receive decreases.[29, 42] This is because limited family  
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54 resources are spread more sparsely, reducing the level of health investment received  
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56 by each household member.  
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3 Our data revealed that children whose mothers had no education were at least twice as  
4 likely to be unimmunised compared to those whose mothers were high-school  
5 graduates. This indicates that maternal education is a major determinant of  
6 immunisation coverage in Indonesia. The obvious explanation is that literacy and  
7 educational attainment facilitate understanding of the recommended immunisation  
8 schedule.[41] This suggests that improving the programme to achieve the target of  
9 herd immunity might be helpful only in the short term. It highlights the need for a  
10 long-term investment in human capital, especially in Indonesian women.[29]

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12 Children whose fathers work in clerical, services, or sales were less likely to be  
13 unimmunised compared to children of professionals. This is unexpected, given that  
14 people who work in clerical, services, or sales are usually of a lower socioeconomic  
15 status and may find it difficult to obtain permission for work leave in order to enable  
16 their children to be immunised.[16] Nonetheless, our result confirmed previous  
17 finding which reported similar association in Bangladesh.[18] Fathers who were  
18 professionals were significantly less likely to have their children fully immunised, as  
19 they tend to work long hours and are too preoccupied to be involved in their child's  
20 healthcare.

21  
22 Wealth is a well-established indicator of access to health services in many countries  
23 regardless of income groups. Our analysis indicated that children from poorer and  
24 poorest households were more likely to be unimmunised. Given that immunisation  
25 services are available free of charge in Indonesia, the indirect cost of immunisation  
26 may be the relevant factor instead. Lost work days and transport costs could deter  
27 parents from enabling their child to be immunised.[44, 45] The likelihood of being  
28 unimmunised was also higher among children without health insurance. This is  
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3 reasonable because health insurance alleviate the burden of out-of-pocket spending,  
4 including indirect cost of immunisation. Most studies from developing countries have  
5 reported that health insurance has a positive impact on increasing healthcare  
6 utilisation.[46]  
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12 The odds of being unimmunised were considerably higher amongst children without  
13 antenatal and postnatal care. Children who were born without antenatal care were at  
14 least three times more likely to be unimmunised. Likewise, children who did not  
15 receive postnatal care had a 50% greater chance of being unimmunised (AOR 1.50;  
16 95% CI 1.34 to 1.69). This finding reflects the importance of information received by  
17 mothers during antenatal and postnatal care. Their visits might have equipped them  
18 with the necessary knowledge on child immunisation. In Indonesia, at least four  
19 antenatal visits are recommended during pregnancy. However, this service has been  
20 underutilised[30] and the negative implication of missed opportunities for  
21 immunisation coverage is almost certain.  
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36 There was a significant association between a child's place of delivery and  
37 immunisation coverage. Children who were born in public or private health institution  
38 were less likely to be unimmunised compared to those who were born at home. This is  
39 most likely because children who were born at health facilities were vaccinated, or  
40 were given recommendation to be vaccinated, immediately after birth. Furthermore, a  
41 study from Kenya has shown that women who deliver at home or unassisted may have  
42 a distrust of modern medicine and a stronger preference for traditional remedies.[47]  
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52 By extension, they could have a sceptical view about childhood immunisation.[48]  
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55 Our analysis also showed that children who were born in private health institution had  
56 greater odds of being unimmunised relative to those who were born in public health  
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3 institution (AOR 0.62; 95% CI 0.54 to 0.72 and AOR 0.55; 95% CI 0.47 to 0.64,  
4  
5 respectively). In Indonesia, private health institution do not benefit from government's  
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7 healthcare funding, although they do operate under the ministerial decree to deliver  
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9 routine immunisation. Consequently, there is no financial incentive for private health  
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11 institution to ensure that children are fully immunised. Therefore, strengthening the  
12  
13 implementation of the ministerial decree for private health institution may help in  
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15 improving immunisation coverage.  
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19 Children whose parents jointly decide on maternal healthcare were less likely to be  
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21 unimmunised. This emphasises the importance of family support in utilising health  
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23 services, confirming what had been outlined by Andersen in his theoretical  
24  
25 framework.[15] The combination of both mother's autonomy and father's  
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27 involvement in the decision making process seemed to be essential. This suggests that  
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29 interventions which educate and involve fathers might have the potential to increase  
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31 immunisation coverage.[49]  
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35 Although our findings were consistent with reports from other lower middle income  
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37 countries, we found that several factors were not significant predictors of coverage in  
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39 Indonesia. Despite reports from India, a child's sex did not affect coverage in  
40  
41 Indonesia. This is consistent with studies from Nigeria undertaken by Antai[16] and  
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43 Adebisi[51]. It appears that gender could predict immunisation status only if the child  
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45 is from a society where gender inequality is prevalent.[50] We also found no  
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47 correlation between a mother's age and her child's immunisation status. Previous  
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49 studies have reported that the odds of a child being unimmunised is greater for both  
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51 younger and older mothers, suggesting a U-shaped association.[29] However, this  
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3 association might be mitigated by patterns of other co-existing variables in our  
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5 analysis, such as the child's birth order and the mother's level of education.  
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### 8 9 **Strengths and Limitations**

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11 To our knowledge, this study was the first to identify factors associated with routine  
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13 immunisation coverage of children in Indonesia. We used the 2012 IDHS dataset,  
14  
15 which was the most recent one. Although the computations required a huge amount of  
16  
17 time, the large sample size allowed us to analyse many potential predictors  
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19 simultaneously. It also increased the validity of our results. Furthermore, we used  
20  
21 multilevel modelling to account for the hierarchical structure of the data. We have also  
22  
23 adjusted our analysis in order to meet the local context and produce better estimates.  
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25 However, our results should be considered in the light of potential limitations.  
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30 As with other secondary analysis of cross-sectional survey data, caution should be  
31  
32 exercised in inferring causality between the socioeconomic factors and immunisation  
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34 coverage. In addition, the nature of our data source and analysis potentially limit  
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36 generalisability. There is a need to verify the validity of the observed associations  
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38 using longitudinal data.  
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43 Information on a child's immunisation status was subject to bias, because we included  
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45 mother's report as a source of information. As such, we relied on the mother's ability  
46  
47 to recall her child's immunisation status accurately. Nonetheless, mother's report is  
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49 considered a valid measure of coverage in the absence of a health card, especially in  
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51 developing countries.[51] We therefore believe that our reliance on mother's report is  
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53 reasonable and not likely to have introduced bias into our study.  
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3 The selection of variables included in this study relied on the information available  
4 from the dataset. Other potential predictors that were previously identified in lower  
5 middle income setting, such as ethnicity and religion, could not be assessed in this  
6 study. Categorisation of original responses from the survey might have also influenced  
7 the results.  
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15 The 2012 IDHS selected participants through a two-stage stratified sampling design.  
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17 The primary sampling unit was the CBs and the complete list of households in each  
18 CB became the basis for second-stage sampling. However, there was no household  
19 identifier in the dataset as it may compromise the participants' anonymity. Therefore,  
20 we could only build a two-level model (i.e. children nested within CBs) instead of a  
21 three-level model (i.e. children within households nested within CBs). We recognise  
22 that children living in the same household could have shared similar health  
23 characteristics, which reflects parent-specific knowledge or beliefs on  
24 immunisation.[14] However, our analysis of variables that served as a proxy of parent-  
25 specific knowledge or beliefs (i.e. mother's exposure to media and mother's tobacco  
26 use history) emerged as being insignificant. Therefore, we have good reason to believe  
27 that this limitation is unlikely to have any impact on the validity of our analysis.  
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43 Finally, we classified immunisation status into 'fully immunised' and 'unimmunised'  
44 based on whether the child received full schedule of immunisation or otherwise.  
45 While other studies have utilised three distinct categories: fully immunised, partly  
46 immunised, and unimmunised, we dichotomised our outcome variable and did not  
47 distinguish partly immunised from unimmunised. This is because our study focused  
48 on factors associated with the coverage of routine immunisation, which is the  
49 complete uptake of recommended vaccination. However, reasons for Indonesian  
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3 children being partly immunised and unimmunised might differ, and future research  
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5 can potentially address this question.  
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## 8 9 **CONCLUSION**

10  
11 In this study, we examined variables that contribute to a child's immunisation status in  
12  
13 Indonesia. Our results suggested that immunisation coverage is suboptimal due to  
14  
15 socioeconomic factors. Amongst the demographic groups, children who lived in  
16  
17 Maluku and Papua region and children from the poorest households have the lowest  
18  
19 coverage. We also identified maternal education and antenatal care visits as key  
20  
21 factors that policymakers can target to improve immunisation coverage in Indonesia.  
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25 Beyond mapping trend of coverage nationally, we recommend regular monitoring and  
26  
27 evaluation of coverage at province and district levels. This is important in order to  
28  
29 identify high-risk areas and implement targeted activities in the communities.  
30  
31 Increasing awareness and financial support for deprived households with more than  
32  
33 one child may help reduce the indirect cost and motivate parents to immunise their  
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35 children. Promoting equal access to education, encouraging institutional deliveries,  
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37 and scaling up utilisation of antenatal and postnatal care may significantly improve  
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39 coverage in Indonesia.  
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## 45 **5. List of Abbreviations**

46	CB	Census Block
47		
48	EPI	Expanded Programme on Immunisation
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50	GVAP	Global Vaccine Action Plan
51		
52	IDHS	Indonesia Demographic and Health Survey
53		
54	MOH	Ministry of Health
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## 6. Declarations

### 6.1 Acknowledgements

We are grateful to the ICF International for granting us access to the datasets and to the Indonesia Endowment Fund for Education (LPDP) for funding PH a master scholarship at the Department of Primary Care and Public Health Sciences, King's College London. This analysis was part of PH dissertation.

### 6.2 Author Contributions

PH and AD participated in the design of the study. PH performed the analysis and prepared the manuscript. AD provided data analysis advice and revision of the manuscript. All authors read and approved the final manuscript.

### 6.3 Competing Interests

All authors have completed the ICMJE uniform disclosure form at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) and declare: PH had financial support from LPDP for the submitted work, no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work

### 6.4 Licence for Publication Statement

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### 20 **6.5 Ethics Approval**

21  
22 This study did not require ethical approval as it used unidentifiable secondary  
23 data. Permission to use the dataset was obtained from ICF International, who  
24 obtained approval to conduct IDHS in 2012. No identifiable information was  
25 included in the dataset and no attempt was made to identify any individual  
26 interviewed in the survey.  
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### 35 **6.6 Data Sharing**

36  
37 The electronic datasets analysed in this study are available for legitimate research  
38 purposes from the Measure DHS website: <http://www.dhsprogram.com/>.  
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### 44 **6.7 Transparency Declaration**

45  
46 This manuscript is an honest, accurate, and transparent account of the study being  
47 reported. No important aspects of the study have been omitted, and that any  
48 discrepancies from the study as planned have been explained.  
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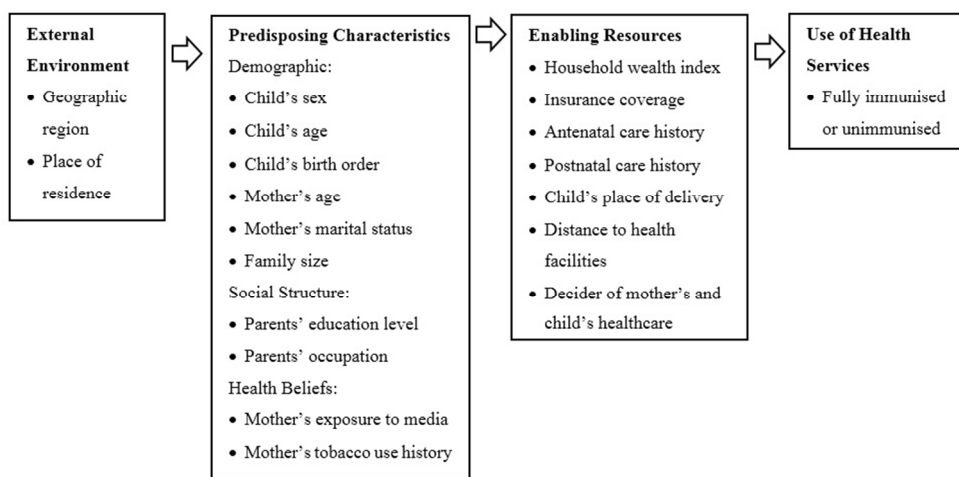


Figure 1: Theoretical framework of factors potentially associated with immunisation coverage in Indonesia, informed by Andersen's Behavioural Health Model.

265x133mm (96 x 96 DPI)

review only



## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Within the title
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Within the abstract
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 6
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	Page 7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 7
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	Page 7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 8-9
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 8-9
Bias	9	Describe any efforts to address potential sources of bias	Page 9
Study size	10	Explain how the study size was arrived at	Page 9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 8-9
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Page 9-10
		(b) Describe any methods used to examine subgroups and interactions	Page 10
		(c) Explain how missing data were addressed	Page 9
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods	Page 10

		taking account of sampling strategy	
		(e) Describe any sensitivity analyses	Page 9
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	Page 9
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Table 1
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	Page 10
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 2 and Table 3
		(b) Report category boundaries when continuous variables were categorized	Table 1, Table 2 and Table 3
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 10
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	Page 20
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 27
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 21-27
Generalisability	21	Discuss the generalisability (external validity) of the study results	Limitation section
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Acknowledgements section

1  
2 \*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and  
3 unexposed groups in cohort and cross-sectional studies.  
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5  
6 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and  
7 published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely  
8 available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at  
9 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is  
10 available at [www.strobe-statement.org](http://www.strobe-statement.org).  
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# BMJ Open

## Determinants of immunisation coverage of children aged 12-59 months in Indonesia: a cross-sectional study.

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3 1 **Determinants of immunisation coverage of children aged 12-59 months in**  
4 **Indonesia: a cross-sectional study.**  
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## 1. Abstract

Objectives: Despite the adoption of WHO's Expanded Programme on Immunisation in Indonesia since 1977, a large proportion of children are still completely unimmunised or only partly immunised. This study aimed to assess factors associated with low immunisation coverage of children in Indonesia.

Setting: Children aged 12-59 months in Indonesia.

Participants: The socioeconomic characteristics and immunisation status of the children were obtained from the most recent Demographic and Health Survey, the 2012 IDHS. Participants were randomly selected through a two-stage stratified sampling design. Data from 14,401 children aged 12-59 months nested within 1,832 census blocks were included in the analysis. Multilevel logistic regression models were constructed to account for hierarchical structure of the data.

Results: The mean age of the children was 30 months and they were equally divided by sex. According to the analysis, 32% of the children were fully immunised in 2012. Coverage was significantly lower amongst children who lived in Maluku and Papua region (Adjusted Odds Ratio: 1.94; 95% Confidence Interval [1.42 to 2.64]), were 36-47 months old (1.39 [1.20 to 1.60]), had higher birth order (1.68 [1.28 to 2.19]), had greater family size (1.47 [1.11 to 1.93]), whose mother had no education (2.13 [1.22 to 3.72]), and from the poorest households (1.58 [1.26 to 1.99]). The likelihood of being unimmunised was also higher amongst children without health insurance (1.16 [1.04 to 1.30]) and those who received no antenatal (3.28 [2.09 to 5.15]) and postnatal care (1.50 [1.34 to 1.69]).

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3 1 Conclusions: Socioeconomic factors were strongly associated with the likelihood of  
4  
5 2 being unimmunised in Indonesia. Unimmunised children were geographically  
6  
7 3 clustered and lived amongst the most deprived population. To achieve WHO target of  
8  
9 4 protective coverage, public health interventions must be designed to meet the needs of  
10  
11 5 these high risk groups.  
12

## 13 14 15 6 **2. Keywords**

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18 7 Immunisation coverage; routine immunisation; determinants; Indonesia; Indonesia  
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20 8 Demographic and Health Survey; multilevel analysis.  
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## 23 24 9 **3. Strengths and Limitations of This Study**

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26  
27 10 • Our study investigated, for the first time, the factors associated with routine  
28  
29 11 immunisation coverage of children in Indonesia using data from the most  
30  
31 12 recent Demographic and Health Survey.  
32  
33 13 • The large sample size allowed us to analyse many potential predictors  
34  
35 14 simultaneously and produce reliable estimates.  
36  
37 15 • We used multilevel modelling to account for the hierarchical structure of the  
38  
39 16 data.  
40  
41 17 • However, we could only build a two-level model (i.e. children nested within  
42  
43 18 census blocks) instead of the ideal three-level model (i.e. children within  
44  
45 19 households nested within census blocks) because there was no household  
46  
47 20 identifier in the dataset, as it may compromise the participants' anonymity.  
48  
49 21 • The selection of variables included in this study also relied on the information  
50  
51 22 available from the dataset.

## 52 53 54 23 **4. Main Text**

## 55 56 57 24 **BACKGROUND**

1 In 1974, the World Health Organisation initiated the Expanded Programme on  
2 Immunisation (EPI) with the goal of providing universal immunisation for all  
3 children.[1] The first diseases targeted were diphtheria, tetanus, pertussis, polio,  
4 measles, and tuberculosis.[1] New and increasingly sophisticated vaccines have  
5 become available, and more children than ever before are being vaccinated today.[2,  
6 3] Global coverage increased from 74% in 2000 to 86% in 2014.[4] As a result, the  
7 annual number of child deaths fell from 9.6 million in 2000 to 5.9 million in 2015.[1,  
8 4] Immunisation drives this reduction in child mortality and the collective recognition  
9 has led to the development of the Global Vaccine Action Plan (GVAP), a framework  
10 to help countries achieve universal child immunisation by 2020.[3] The target, as  
11 stated in the United Nations Sustainable Development Goals, is to end preventable  
12 child deaths by 2030.[5]

13 Despite this progress, vaccine-preventable diseases are still responsible for 1.5 million  
14 child deaths each year.[6] Almost 18.7 million children were not given routine  
15 immunisation in 2014 and 75% of them live in only ten countries in Africa and  
16 Asia.[4] Although some regions have successfully maintained a high level of  
17 immunisation coverage, there are pockets of unimmunised children which induce the  
18 continuous spread of diseases and outbreaks.[2] This highlights the fact that global  
19 coverage may hide variability between countries. It also suggests that the  
20 achievements are still fragile. Should this trend continue, the goals of providing  
21 universal immunisation for all children by 2020 and ending vaccine-preventable  
22 deaths by 2030 could not be achieved, and the cost of such failure would be close to  
23 26 million deaths.[3]



1 One of the ten countries that are home to the highest number of unimmunised children  
2 is Indonesia.[4] Indonesia is a lower middle income country located in Southeast  
3 Asia.[7] It has an estimated population of over 255 million in 2015, 10% of whom are  
4 children under the age of five.[8] Child mortality rate in Indonesia currently stands at  
5 27 deaths per 1,000 births and ranks 101st out of 175 countries.[9] Approximately  
6 36% of child deaths were caused by infectious diseases.[10] For most of these  
7 diseases, vaccines are available to prevent child deaths.

8 The Indonesian Ministry of Health (MOH), which organises public health matters  
9 within the Indonesian government, has adopted and implemented the EPI guidelines  
10 since 1977 through a routine immunisation programme that is compulsory for all  
11 children.[11] Even so, a large number of young children in Indonesia are still either  
12 completely unimmunised or only partly immunised. In 2013, the MOH has reported  
13 that only 59.2% of children were fully immunised.[11] There were also striking gaps  
14 within the country as coverage was as low as 29.2% at a certain area in Indonesia.[11]  
15 These figures were well below the 90% advised threshold that is required to maintain  
16 herd immunity and prevent the spread of diseases.[3] As the fourth most-populous  
17 country in the world with a great proportion of young children, the risk of large and  
18 uncontrollable outbreaks in Indonesia is more likely than ever.

19 In order to significantly increase coverage in Indonesia, a strategy proposed by GVAP  
20 is to identify and engage the unimmunised children.[3] These children are often the  
21 ones carrying a heavier burden of diseases.[3] There is particular concern that diseases  
22 may thrive when unimmunised children are residentially segregated from immunised  
23 children.[2] It is therefore critical to know who they are, where they live, and what

1 factors might have contributed to their unimmunised status, in order to ascertain  
2 where greater efforts are needed.

3 While administrative and geographic barriers may contribute to low coverage in a  
4 country with such a large population,[12] GVAP explicitly highlights the importance  
5 of socioeconomic factors in determining coverage.[3] Theory suggests that factors  
6 such as income level, employment status, and education are major determinants of  
7 healthcare utilisation[13] and a growing body of empirical evidence advances such  
8 association. The socioeconomic characteristics attached to routine immunisation  
9 coverage, and the extent these factors may play a role, vary by country.[12, 14-24]  
10 However, no such research has been done in Indonesia.

11 In this study, we used data from the 2012 Indonesia Demographic and Health Survey  
12 (IDHS) which collected information on both the immunisation status and the  
13 socioeconomic characteristics of Indonesian children under five years of age. Our aim  
14 was to identify the socioeconomic factors associated with routine immunisation  
15 coverage of children in Indonesia. The results should help in identifying susceptible  
16 subgroups of the population that require additional resources and focused attention.

## 17 **METHODS**

### 18 **Data Source**

19 This study is a secondary data analysis of the most recent DHS in Indonesia. The  
20 IDHS is conducted routinely by the national statistics authority Statistics Indonesia, in  
21 collaboration with the National Population and Family Planning Board, the Indonesian  
22 MOH, and ICF International.[25] Studies on its quality suggest that DHS is nationally  
23 representative, with little evidence of systematic bias.[26]

1 Data was collected from May 7 to July 31, 2012. Participants were selected through a  
2 two-stage stratified sampling design. The primary sampling unit was the census block  
3 (CB) and the complete list of households in each CB became the basis for second-  
4 stage sampling. A total of 46,024 households were chosen as the sample. From 44,302  
5 occupied households, 45,607 women aged 15-49 were successfully interviewed,  
6 yielding a response rate of 96%.

7 The Women's Questionnaire included questions about the woman's background  
8 characteristics and her children aged under five, for whom immunisation and health  
9 data were collected. The dataset had one record for every child of each interviewed  
10 woman, born in the five years preceding the survey. Data were obtained for 18,021  
11 children.

## 12 **Outcome Variable**

13 The outcome variable in the analysis was the child's immunisation status. Information  
14 on immunisation status was collected from two sources, the health card or health book  
15 shown to the interviewer, or if unavailable, from the mother's report. The health card  
16 or health book was available 85.77% of the time.

17 The outcome variable was categorised as 'fully immunised' if they had received the  
18 full schedule of routine immunisation and otherwise 'unimmunised', regardless of the  
19 source of the information. Routine immunisation referred to three doses of DTP  
20 vaccines, four doses of polio vaccine, one dose of measles vaccine, one dose of BCG  
21 vaccine, and four doses of hepatitis B vaccine, scheduled to be received by the age of  
22 12 months.[11] The proportion of children who had been fully immunised defined  
23 immunisation coverage.[27]

1 In a small number of cases, where health cards were unavailable and mothers  
2 indicated that they did not know about the immunisation status (1.51%), the child was  
3 considered as not fully immunised. The fact that mothers responded ‘don’t know’ is  
4 likely to reflect that the child was not fully immunised[12, 28] and fits better in the  
5 ‘unimmunised’ category.

## 6 **Independent variables**

7 Selection of independent variables was based on the literature review and variables  
8 available in the dataset. Twenty-two independent variables were identified as potential  
9 factors and Andersen’s Behavioural Health Model[13] was used as a framework to  
10 group the factors into three main groups: external environment, predisposing, and  
11 enabling factors (Figure 1). The model has been commonly used to examine factors  
12 associated with health service utilisation, including immunisation uptake.[21, 29]

13 Predisposing characteristics consist of demographic factors, social structure such as  
14 educational attainment and occupation, and health beliefs which involves health-  
15 related knowledge and behaviours.[13] Enabling resources are related to individuals’  
16 personal and community support which enable them to use health services, reflected  
17 by income level, insurance coverage, and other factors that could affect one’s access  
18 to health services.[13] Lastly, external environment incorporates wider social and  
19 environmental determinants of health.[13]

20 Categorisation of continuous variables and description of categorical variables were  
21 undertaken according to the literature. The child’s age (12-59 months) was categorised  
22 into groups at one-year intervals. Similarly, the mother’s age (15-49 years) was

1 categorised into groups at five-year intervals. The child's birth order and family size  
2 were also categorised into groups based on previously published literatures.

3 Following IDHS protocol[25] household wealth index was constructed based on  
4 household amenities and assets (radio, television, refrigerator, bicycle, motorcycle, or  
5 car) and dwelling characteristics (electricity, flooring, roofing, water source, toilet  
6 facilities, and sleeping arrangements). It was categorised into quintiles from poorest to  
7 richest. In the absence of direct information on household income or expenditures,  
8 wealth index is considered a robust measure of household income level.[30] Insurance  
9 coverage represented any health insurance provided through social security or local  
10 government, by employer, privately-purchased, or other insurance. Antenatal care  
11 represented any pregnancy-related care provided by skilled health personnel or  
12 traditional birth attendants during the pregnancy, irrespective of the type of provider  
13 and the number of visits. Similarly, postnatal care represented any examination by  
14 skilled health personnel or traditional birth attendants within two months of the child's  
15 birth, irrespective of the type of provider and the number of visits.

16 The 33 provinces in Indonesia were categorised into six island-based regions.[25] The  
17 child's place of delivery was classified into three categories: home, public health  
18 institution, and private health institution. Public health institution included public  
19 hospitals, public clinics, health centres, village health posts, and delivery posts.  
20 Private health institution included private hospitals, private clinics, maternity  
21 hospitals, maternity home, and also private practices of obstetrician, general  
22 practitioner, nurse, midwife, and village midwife.

### 23 **Statistical Analysis**

1  
2  
3 1 The original dataset comprised of 18,021 children aged 0-59 months distributed  
4  
5 2 among 1,840 CBs. For the purpose of the analysis, we excluded 3,620 children who  
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7 3 were under one year old because they were not old enough to have received the full  
8  
9 4 schedule of routine immunisation in Indonesia. The final sample, therefore, contained  
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11 5 14,401 children from 1,832 CBs. From this, we had 656 children (4.6%) with missing  
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13 6 immunisation status because they were no longer alive at the time of the survey,  
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15 7 leaving complete observations of 13,745 children (95.4%). Given the small number of  
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17 8 missing values, we used complete-case analysis and no sensitivity analysis was  
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19 9 required.

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23  
24 10 Data analysis was conducted using STATA 14 software. Frequency and percentage  
25  
26 11 were used to report baseline characteristics of the children. Cross tabulation was  
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28 12 undertaken to demonstrate the proportion of different categories with respect to  
29  
30 13 immunisation status. The immunisation status as outcome variable was coded into 0  
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32 14 for 'fully immunised' and 1 for otherwise 'unimmunised'.

33  
34  
35  
36 15 Univariate analysis was used to separately evaluate of the effect of each independent  
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38 16 variable on the outcome variable. Test of trends across ordered groups were evaluated.  
39  
40 17 Variables with a univariate P-value of less than 0.2 were then selected as candidates  
41  
42 18 for the multivariate analysis.

43  
44  
45  
46 19 Multilevel logistic regression was used to estimate immunisation status in multivariate  
47  
48 20 context while accounting for clustering. Model fitting using residuals were checked. A  
49  
50 21 two-level model was used for the multivariate analysis (i.e. children nested within  
51  
52 22 CBs). This was run using the *meqrlogit* command in STATA 14, a method based on  
53  
54 23 maximum likelihood and robust to missing values. Associations between independent  
55  
56 24 variables and the likelihood of children being unimmunised were assessed  
57  
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1 simultaneously. The results were expressed as adjusted odds ratio (AOR) with 95%  
2 CI.

### 3 RESULTS

#### 4 Descriptive Statistics

5 A total of 14,401 children from 1,832 CBs were included in the analysis. Our result  
6 showed that only 31.5% (95% CI 30.7% to 32.3%) of the children aged 12-59 months  
7 had been fully immunised at the time of the survey. The baseline characteristics of  
8 sample were presented in Table 1.

9 Table 1: Baseline characteristics of sample (n=14,401).

Characteristics		Frequency <sup>†</sup>	Percentage (%)
Immunisation status	Fully immunised	4331	31.5
	Unimmunised	9414	68.5
<b>External Environment</b>			
Geographic region	Sumatera	4061	29.5
	Java	3079	22.4
	Bali and Nusa Tenggara	1220	9.0
	Kalimantan	1447	10.5
	Sulawesi	2381	17.3
	Maluku and Papua	1557	11.3
Place of residence	Urban	6307	45.9
	Rural	7438	54.1
<b>Predisposing Characteristics</b>			
Child's sex	Male	7092	51.6
	Female	6653	48.4
Child's age (months)	12-23	3501	25.5
	24-35	3413	24.8
	36-47	3378	24.6
	48-59	3453	25.1
Child's birth order	1 <sup>st</sup>	5929	35.9
	2 <sup>nd</sup> - 4 <sup>th</sup>	7533	54.8
	≥ 5 <sup>th</sup>	1283	9.3
Mother's age (years)	15-19	262	1.9
	20-24	2381	17.3
	25-29	3928	28.6
	30-34	3454	25.2
	35-39	2410	17.5
	40-44	1104	8.0
	45-49	206	1.5
Mother's marital status	Married	13168	95.8
	Living with partner	176	1.3
	Widowed	118	0.8
	Divorced	231	1.7
	No longer living together	43	0.3
	Never in union	9	0.1
Family size (number of	≤ 4	5314	38.6

household members)	5-9	7637	55.6
	≥ 10	794	5.8
Mother's educational level	Higher	1819	13.2
	Secondary	7221	52.6
	Primary	4291	31.2
	No education	414	3.0
Father's educational level	Higher	1740	12.7
	Secondary	7438	54.2
	Primary	4204	30.6
	No education	311	2.3
	Don't know	24	0.2
Mother's occupation	Professional	1018	7.4
	Agricultural	1855	13.5
	Industrial	1571	11.4
	Clerical, services, and sales	3236	23.6
	Did not work	6052	44.1
	Don't know	2	0.0
Father's occupation	Professional	1336	9.8
	Agricultural	3550	25.9
	Industrial	4884	35.6
	Clerical, services, and sales	3709	27.0
	Did not work	225	1.6
	Don't know	12	0.1
Mother's exposure to media (newspaper, magazine, radio, or television)	At least once a week	11528	83.9
	Less than once a week	1527	11.1
	Not at all	686	5.0
Mother's tobacco use history	Smokes nothing	13317	96.9
	Uses tobacco	424	3.1
<b>Enabling Resources</b>			
Household wealth index	Richest	2108	15.3
	Richer	2276	16.6
	Middle	2504	18.2
	Poorer	2722	19.8
	Poorest	4135	30.1
Covered by health insurance	Yes	5580	40.6
	No	8156	59.4
Antenatal care	Received some care	10861	96.2
	Received no care	640	3.8
Postnatal care	Received some care	7395	65.7
	Received no care	3813	33.8
	Don't know	53	0.5
Child's place of delivery	Home	6325	46.2
	Public health institution	2527	18.4
	Private health institution	4823	35.2
	Other	28	0.2
Distance to health facilities	Not a big problem	11915	86.9
	Big problem	1792	13.1
Maternal healthcare decision making	By herself	4758	35.7
	Jointly with husband	6567	49.3
	Husband alone	1972	14.7
	By others	34	0.3
Child healthcare decision making	By herself	4497	36.3
	Jointly with husband	1407	10.5
	Husband alone	6255	46.2
	By others	225	1.8

1 † Total number varies between categories because of missing values.

2 The mean age of the children was 30 months and they were equally divided by sex.

3 More than half of them were second- to fourth-born. The mothers were 25 to 29 years



1 old on average and almost all were married at the time of the survey. Most of the  
2 families had five to nine household members.

3 Majority of the mothers were secondary school graduates. Although educational  
4 attainment was approximately equal for both parents, nearly half of the mothers did  
5 not work. A large proportion of the mothers were exposed to media at least once a  
6 week and almost all reported that they did not smoke around the time of the survey.

7 In terms of enabling resources, half of the children lived in the poorer and poorest  
8 households. Additionally, almost two-thirds of the children were not covered by  
9 health insurance. While only a small proportion were born without antenatal care,  
10 much more children were born without postnatal care. Nearly half of the children were  
11 delivered at home although most mothers reported that distance to health facilities  
12 were not a big problem. Lastly, the majority of mothers reported that they were  
13 involved in the decision making process of their own healthcare as well as their  
14 children's.

### 15 **Univariate Analysis**

16 The association between each independent variable and the likelihood of being  
17 unimmunised was investigated one by one. The result were shown in Table 2.

18 Table 2: Univariate analysis results for factors associated with low immunisation  
19 coverage of children aged 12-59 months in Indonesia.

Characteristics		Status (%)				Unadjusted OR (95% CI)		P- value
		Fully immunised		Unimmunised				
<b>External Environment</b>								
Geographic region	Sumatera	1135	(26.2%)	2926	(31.8%)	1.68	(1.52 to 1.86)	0.000
	Java	1215	(28.1%)	1864	(19.8%)	1		
	Bali and Nusa Tenggara	525	(12.1%)	695	(7.4%)	0.86	(0.75 to 0.99)	0.032
	Kalimantan	490	(11.3%)	957	(10.2%)	1.27	(1.12 to 1.45)	0.000

	Sulawesi	672	(15.5%)	1709	(18.2%)	1.66	(1.48	to	0.000
	Maluku and Papua	294	(6.8%)	1263	(13.4%)	2.80	(2.42	to	0.000
						3.24)			
Place of residence	Urban	2232	(51.5%)	4075	(43.3%)	1			
	Rural	2099	(48.5%)	5339	(56.7%)	1.39	(1.30	to	0.000
						1.50)			
<b>Predisposing Characteristics</b>									
Child's sex	Male	2255	(52.1%)	4837	(51.4%)	1			
	Female	2076	(47.9%)	4577	(48.6%)	1.03	(0.96	to	0.455
						1.10)			
Child's age (months)	12-23	1246	(28.8%)	2255	(24.0%)	1			
	24-35	1066	(24.6%)	2347	(24.9%)	1.22	(1.10	to	0.000
						1.34)			
	36-47	1011	(23.3%)	2367	(25.1%)	1.30	(1.17	to	0.000
						1.43)			
	48-59	1008	(23.3%)	2445	(26.0%)	1.34	(1.21	to	0.000
						1.48)			
Child's birth order	1 <sup>st</sup>	1675	(38.7%)	3254	(34.6%)	1			
	2 <sup>nd</sup> – 4 <sup>th</sup>	2413	(55.7%)	5120	(54.4%)	1.29	(1.21	to	0.000
						1.37)			
	≥ 5 <sup>th</sup>	243	(5.6%)	1040	(11.0%)	1.41	(1.27	to	0.000
						1.57)			
Mother's age (years)	15-19	67	(1.5%)	195	(2.1%)	1			
	20-24	704	(16.2%)	1677	(17.8%)	0.82	(0.61	to	0.178
						1.10)			
	25-29	1219	(28.2%)	2709	(28.8%)	0.76	(0.57	to	0.064
						1.02)			
	30-34	1166	(26.9%)	2288	(24.3%)	0.67	(0.51	to	0.007
						0.90)			
35-39	815	(18.8%)	1595	(16.9%)	0.67	(0.50	to	0.007	
					0.90)				
	40-44	301	(7.0%)	803	(8.5%)	0.92	(0.67	to	0.579
						1.25)			
	45-49	59	(1.4%)	147	(1.6%)	0.86	(0.57	to	0.458
						1.29)			
Mother's marital status	Married	4159	(96.0%)	9009	(95.7%)	1			
	Living with partner	50	(1.2%)	126	(1.3%)	1.16	(0.84	to	0.368
						1.62)			
	Widowed	37	(0.9%)	81	(0.9%)	1.01	(0.68	to	0.958
						1.49)			
	Divorced	70	(1.6%)	161	(1.7%)	1.06	(0.80	to	0.678
					1.41)				
	No longer living together	11	(0.3%)	32	(0.3%)	1.34	(0.68	to	0.400
						2.67)			
	Never in union	4	(0.0%)	5	(0.1%)	0.58	(0.15	to	0.413
						2.15)			
Family size (number of household members)	≤ 4	1746	(40.3%)	3568	(37.9%)	1			
	5-9	2381	(55.0%)	5256	(55.8%)	1.08	(1.00	to	0.044
						1.16)			
	≥ 10	204	(4.7%)	590	(6.3%)	1.42	(1.20	to	0.000
						1.68)			
Mother's educational level	Higher	756	(17.5%)	1063	(11.3%)	1			
	Secondary	2451	(56.6%)	4770	(50.7%)	1.38	(1.25	to	0.000
						1.54)			
	Primary	1081	(25.0%)	3210	(34.1%)	2.11	(1.88	to	0.000
					2.37)				
	No education	43	(0.9%)	371	(3.9%)	6.14	(4.41	to	0.000
						8.53)			
Father's educational level	Higher	717	(16.6%)	1023	(10.9%)	1			
	Secondary	2508	(58.0%)	4930	(52.5%)	1.38	(1.24	to	0.000
						1.53)			
	Primary	1054	(24.4%)	3150	(33.5%)	2.09	(1.86	to	0.000
					2.36)				
	No education	42	(1.0%)	269	(2.9%)	4.49	(3.20	to	0.000

	Don't know	3	(0.0%)	21	(0.2%)	6.30 4.91 (1.46 to 0.010 16.5)
Mother's occupation	Professional	428	(9.9%)	590	(6.3%)	1
	Agricultural	405	(9.4%)	1450	(15.4%)	2.60 (2.20 to 0.000 3.07)
	Industrial	480	(11.1%)	1091	(11.6%)	1.65 (1.40 to 0.000 1.94)
	Clerical, services, and sales	1069	(24.7%)	2167	(23.0%)	1.47 (1.27 to 0.000 1.70)
	Did not work	1944	(44.9%)	4108	(43.7%)	1.53 (1.34 to 0.000 1.76)
Father's occupation	Professional	520	(12.0%)	816	(8.7%)	1
	Agricultural	809	(18.7%)	2741	(29.2%)	2.16 (1.89 to 0.000 2.47)
	Industrial	1584	(36.7%)	3300	(35.1%)	1.33 (1.17 to 0.000 1.50)
	Clerical, services, and sales	1350	(31.2%)	2359	(25.1%)	1.11 (0.98 to 0.102 1.27)
	Did not work	58	(1.4%)	167	(1.8%)	1.83 (1.33 to 0.000 2.52)
	Don't know	2	(0.0%)	10	(0.1%)	3.19 (0.70 to 0.136 14.6)
Mother's exposure to media (newspaper, magazine, radio, or television)	At least once a week	3814	(88.1%)	7714	(82.0%)	1
	Less than once a week	373	(8.6%)	1154	(12.2%)	1.53 (1.35 to 0.000 1.73)
	Not at all	142	(3.3%)	544	(5.8%)	1.89 (1.57 to 0.000 2.29)
Mother's tobacco use history	Smokes nothing	4246	(98.0%)	9071	(96.4%)	1
	Uses tobacco	85	(2.0%)	339	(3.6%)	1.87 (1.47 to 0.000 2.37)
<b>Enabling Resources</b>						
Household wealth index	Richest	914	(21.1%)	1194	(12.7%)	1
	Richer	834	(19.2%)	1442	(15.3%)	1.32 (1.17 to 0.000 1.49)
	Middle	883	(20.4%)	1621	(17.2%)	1.41 (1.25 to 0.000 1.58)
	Poorer	848	(19.6%)	1874	(19.9%)	1.69 (1.50 to 0.000 1.90)
	Poorest	852	(19.7%)	3283	(34.9%)	2.95 (2.63 to 0.000 3.31)
Covered by health insurance	Yes	1993	(46.0%)	3587	(38.1%)	1
	No	2336	(54.0%)	5820	(61.9%)	1.38 (1.29 to 0.000 1.49)
Antenatal care	Received some care	3668	(99.0%)	7193	(94.8%)	1
	Received no care	38	(1.0%)	394	(5.2%)	5.29 (3.78 to 0.000 7.39)
Postnatal care	Received some care	2732	(73.8%)	4663	(61.7%)	1
	Received no care	958	(25.9%)	2855	(37.8%)	1.75 (1.60 to 0.000 1.90)
	Don't know	14	(0.3%)	39	(0.5%)	1.63 (0.88 to 0.117 3.01)
Child's place of delivery	Home	1376	(31.8%)	4949	(52.8%)	1
	Public health institution	1041	(24.1%)	1486	(15.9%)	0.40 (0.36 to 0.000 0.44)
	Private health institution	1905	(44.0%)	2918	(31.1%)	0.43 (0.40 to 0.000 0.46)
	Other	6	(0.1%)	22	(0.2%)	1.02 (0.41 to 0.967 2.52)
Distance to health facilities	Not a big problem	3885	(89.9%)	8030	(85.6%)	1

	Big problem	438	(10.1%)	1354	(14.4%)	1.50 (1.33 to 1.68)	0.000
Maternal healthcare decision making	By mother herself	1461	(34.7%)	3297	(36.1%)	1	
	Jointly with husband	2193	(52.1%)	4374	(47.9%)	0.88 (0.96)	0.003
	Husband alone	543	(12.9%)	1429	(15.7%)	1.17 (1.31)	0.010
	By others	10	(0.3%)	24	(0.3%)	1.06 (2.23)	0.870
Child healthcare decision making	By mother herself	1469	(37.0%)	3028	(36.0%)	1	
	Jointly with husband	2015	(50.8%)	4240	(50.4%)	1.12 (1.28)	0.076
	Husband alone	424	(10.7%)	983	(11.7%)	1.02 (1.11)	0.621
	By others	59	(1.5%)	166	(1.9%)	1.36 (1.85)	0.045

Geographic region came out as a significant predictor of immunisation coverage in our univariate analysis. The majority, one third, of children who were fully immunised lived in Java, while the lowest coverage was reported in Maluku and Papua. The odds of being unimmunised were almost threefold amongst children who lived in Maluku and Papua (OR 2.80; 95% CI 2.42 to 3.24). On the contrary, we found that children from Bali and Nusa Tenggara had the least likelihood of being unimmunised (OR 0.86; 95% CI 0.75 to 0.99). Our univariate analysis also showed that children from rural areas were significantly more likely to be unimmunised compared to their urban counterparts (OR 1.39; 95% CI 1.30 to 1.50).

Although coverage was approximately equal for both sexes, the child's age and birth order were significantly associated with coverage. Older children were more likely to be unimmunised compared to the youngest ones. The odds of being unimmunised amongst the older children ranged from 1.22 to 1.34. Similarly, children who were not first-born had significantly higher chance of being unimmunised. The odds of being unimmunised increased as the child's age and birth order increased ( $p < 0.000$ ).

We found that children whose mothers were 30-39 years old at the time of the survey were less likely to be unimmunised (OR 0.67; 95% CI 0.50 to 0.90). However, there

1 was no clear trend across the age groups. We also found that children who came from  
2 bigger families were significantly more likely to be unimmunised. The likelihood  
3 increased by 8% up to 42%. As the number of household members increased, the  
4 likelihood of a child to be unimmunised increased ( $p<0.000$ ).

5 Although their marital status was not a significant predictor of coverage, each parent  
6 educational attainment was significantly associated with coverage. As parents'  
7 educational attainment increased, the likelihood of being unimmunised decreased  
8 ( $p<0.000$ ). Hence, children from uneducated parents had the highest odds of being  
9 unimmunised. Those whose mothers had no education were at least six times more  
10 likely to be unimmunised (OR 6.14; CI 95% 4.41 to 8.53). Likewise, children whose  
11 fathers were uneducated had greater than fourfold chance of being unimmunised (OR  
12 4.49; 95% CI 3.20 to 6.30).

13 Additionally, parents' occupation, mother's exposure to media, and mother's tobacco  
14 use history were significantly associated with coverage. Across the occupational  
15 groups, children whose parents worked in agriculture had the highest odds of being  
16 unimmunised. Children whose mothers worked in agriculture were 2.6 times more  
17 likely to be unimmunised (OR 2.60; 95% CI 2.20 to 3.07), while children whose  
18 fathers worked in agriculture were 2.16 times more likely to be unimmunised (OR  
19 2.16; 95% CI 1.89 to 2.47). Regarding mother's exposure to media, the child's  
20 likelihood of being unimmunised increased as the frequency of media exposure  
21 decreased ( $p<0.000$ ). Finally, children whose mothers smoked tobacco around the  
22 time of the survey had 87% higher chance of being unimmunised (OR 1.87; 95% CI  
23 1.47 to 2.37).

1 We found that as the household wealth index increased, the likelihood of being  
2 unimmunised decreased ( $p < 0.000$ ). Hence, children from poorest households had the  
3 highest odds of being unimmunised (OR 2.95; 95% CI 2.63 to 3.31). We also found  
4 that children who had no health insurance were significantly more likely to be  
5 unimmunised compared to those who had insurance (OR 1.38; 95% CI 1.29 to 1.49).

6 Our univariate analysis indicated that antenatal and postnatal care visits were  
7 significant predictors of coverage in Indonesia. Our results showed that children who  
8 were born without antenatal care were at least five times more likely to be  
9 unimmunised (OR 5.29; 95% CI 3.78 to 7.39). Likewise, those who were born without  
10 postnatal care were 75% more likely to be unimmunised (OR 1.75; 95% CI 1.60 to  
11 1.90).

12 In terms of access to health services, we found that children who were born in health  
13 institution were significantly less likely to be unimmunised compared to those who  
14 were born at home. Specifically, children who were born at public health institution  
15 had the least likelihood of being unimmunised (OR 0.40; 95% CI 0.36 to 0.44). In  
16 addition, children whose mothers think that distance to health facilities was a big  
17 problem had 50% higher chance of being unimmunised (OR 1.50; 95% CI 1.33 to  
18 1.68).

### 19 **Multivariate Analysis**

20 Out of the 22 independent variables, child's sex and mother's marital status were  
21 excluded. Table 3 summarised the significant results of our multilevel logistic  
22 regression analysis between the remaining 20 independent variables and the likelihood  
23 of being unimmunised.

1 Table 3: Multivariate analysis results for factors significantly associated with low  
 2 immunisation coverage of children aged 12-59 months in Indonesia.

Characteristics		AOR (95% CI)	P- value
<b>External Environment</b>			
Geographic region	Sumatera	1.51 (1.24 to 1.83)	0.000
	Java	1	
	Bali and Nusa Tenggara	0.71 (0.54 to 0.94)	0.016
	Maluku and Papua	1.94 (1.42 to 2.64)	0.000
Place of residence	Urban	1	
	Rural	0.82 (0.69 to 0.96)	0.013
<b>Predisposing Characteristics</b>			
Child's age (months)	12-23	1	
	24-35	1.24 (1.08 to 1.42)	0.002
	36-47	1.39 (1.20 to 1.60)	0.000
	48-59	1.36 (1.17 to 1.58)	0.000
Child's birth order	1 <sup>st</sup>	1	
	2 <sup>nd</sup> - 4 <sup>th</sup>	1.18 (1.03 to 1.35)	0.016
	≥ 5 <sup>th</sup>	1.68 (1.28 to 2.19)	0.000
Family size (number of household members)	≤ 4	1	
	≥ 10	1.47 (1.11 to 1.93)	0.006
Mother's educational level	Higher	1	
	No education	2.13 (1.22 to 3.72)	0.008
Father's occupation	Professional	1	
	Clerical, services, and sales	0.82 (0.67 to 1.00)	0.047
<b>Enabling Resources</b>			
Household wealth index	Richest	1	
	Poorer	1.30 (1.06 to 1.59)	0.011
	Poorest	1.58 (1.26 to 1.99)	0.000
Covered by health insurance	Yes	1	
	No	1.16 (1.04 to 1.30)	0.010
Antenatal care	Received some care	1	
	Received no care	3.28 (2.09 to 5.15)	0.000
Postnatal care	Received some care	1	
	Received no care	1.50 (1.34 to 1.69)	0.000
Child's place of delivery	Home	1	
	Public health institution	0.55 (0.47 to 0.64)	0.000
	Private health institution	0.62 (0.54 to 0.72)	0.000
Maternal healthcare decision making	By herself	1	
	Jointly with husband	0.86 (0.76 to 0.96)	0.010

3 After accounting for the other remaining variables, geographic region and place of  
 4 residence were significantly associated with coverage. The likelihood of being  
 5 unimmunised was highest among children who lived in Maluku and Papua. Children  
 6 who lived in this region were almost twice as likely to be unimmunised compared to  
 7 those who lived in Java (AOR 1.94; 95% CI 1.42 to 2.64). Similarly, children who  
 8 lived in Sumatera had considerably higher odds of being unimmunised (AOR 1.51;  
 9 95% CI 1.24 to 1.83). In contrast, children from Bali and Nusa Tenggara were less  
 10 likely to be unimmunised (AOR 0.71; 95% CI 0.54 to 0.94). Those who lived in rural

1 areas were also less likely to be unimmunised compared to their urban counterparts  
2 (AOR 0.82; 95% CI 0.69 to 0.96).

3 The likelihood of being unimmunised differed significantly across the age groups.  
4 Older children were more likely to be unimmunised compared to those in the youngest  
5 age group. The odds ranged from 1.24 (95% CI 1.08 to 1.42) to 1.39 (95% CI 1.20 to  
6 1.60). Of all age groups, children aged 36-47 months had the highest odds of being  
7 unimmunised (AOR 1.39; 95% CI 1.20 to 1.60).

8 The child's birth order and family size were also significantly correlated with  
9 immunisation status. As a child's birth order or family size increased, the likelihood of  
10 being unimmunised also increased. A second child was 18% more likely to be  
11 unimmunised compared to a first child (AOR 1.18; 95% CI 1.03 to 1.35), while a fifth  
12 child had 68% higher chance of being unimmunised (AOR 1.68; 95% CI 1.28 to  
13 2.19). Accordingly, children who came from bigger families had higher likelihood of  
14 being unimmunised. Those who lived in households with ten or more family members  
15 were 47% more likely to be unimmunised (AOR 1.47; 95% CI 1.11 to 1.93).

16 Children whose mothers had no education were at least twice as likely to be  
17 unimmunised than those whose mothers were high-school graduates or higher (AOR  
18 2.13; 95% CI 1.22 to 3.72). Similarly, the odds of being unimmunised were  
19 significantly higher among the poorer (AOR 1.30; 95% CI 1.06 to 1.59) and the  
20 poorest (AOR 1.58; 95% CI 1.26 to 1.99). Also, those without health insurance were  
21 more likely to be unimmunised (AOR 1.16; 95% CI 1.04 to 1.30).

22 The odds of being unimmunised were strikingly higher amongst children without  
23 antenatal or postnatal care. Children who were born without antenatal care were more



1 than three times as likely to be unimmunised (AOR 3.28; 95% CI 2.09 to 5.15).  
2 Likewise, those who had no postnatal care had a 50% higher chance of being  
3 unimmunised (AOR 1.50; 95% CI 1.34 to 1.69). Additionally, children who were born  
4 in health institution were less likely to be unimmunised compared to those who were  
5 born at home (AOR 0.55; 95% CI 0.47 to 0.64). Furthermore, children whose parents  
6 jointly decided on maternal healthcare and whose fathers worked in clerical, services,  
7 and sales were significantly less likely to be unimmunised (AOR 0.86; 95% CI 0.76 to  
8 0.96 and AOR 0.82; 95% CI 0.67 to 1.00, respectively).

## 9 **DISCUSSION**

### 10 **Main Findings**

11 Our study investigated, for the first time, the factors associated with routine  
12 immunisation coverage of children aged 12-59 months in Indonesia, using data from  
13 2012 IDHS. Our analysis revealed that only 31.5% of the children had been fully  
14 immunised. After accounting for all confounders, 13 factors were significantly  
15 associated with low coverage in Indonesia: geographic region, place of residence,  
16 child's age, child's birth order, family size, mother's education, father's occupation,  
17 household wealth index, insurance coverage, antenatal care, postnatal care, child's  
18 place of delivery, and maternal healthcare decision making.

19 There are discrepancies between the coverage level reported by the officials and the  
20 one discovered in this study. In 2012, the Indonesian MOH reported coverage level of  
21 86.8%.<sup>[31]</sup> The coverage level determined through 2012 IDHS is therefore much  
22 lower than that contained in the official report.

1 While our study analysed cross-sectional survey data, the official report used  
2 administrative data which are commonly employed to assess immunisation coverage  
3 in low-resource settings.[32] The estimate is obtained by dividing the number of doses  
4 administered at health services by the expected target population.[32, 33] Although  
5 this is readily available, results can be unreliable, particularly when there are  
6 uncertainties surrounding the total number of age-eligible children.[32, 34]

7 The discrepancy between estimates obtained from administrative and survey data have  
8 also been reported in the past.[34-37] Administrative estimates tend to be higher than  
9 those obtained from the survey,[33] which is observed in our finding as well.

10 Comparisons of administrative and survey estimates are made more complicated by  
11 the fact that the number of age-eligible children included in each analysis differ.[33]

12 The estimate from administrative data includes children aged 0-11 months, while the  
13 survey usually includes children aged up to 59 months.[33, 34] The coverage from  
14 MOH report was of children aged 0-11 months, because they are the youngest group  
15 eligible to receive the full schedule of routine immunisation. Measles vaccine, for  
16 example, is the last one on the schedule and is given starting at the age of nine  
17 months. However, it could be administered up to the age of 12 months.[38] There are  
18 also booster campaign and backlog fighting initiative for children up to three years of  
19 age, as well as other supplemental immunisation activities which targeted children  
20 aged 9-59 months. This is all part of routine immunisation programme in  
21 Indonesia.[38] Therefore, estimates from administrative data would not have covered  
22 the entire target population of routine immunisation coverage. This indicates a  
23 weakness in the surveillance system and highlights the need of quality assurance of  
24 immunisation data.

## 1 **Factors Associated with Immunisation Coverage**

2 After accounting for all observed confounders, geographic region was significantly  
3 associated with coverage. The six geographic regions used in our analysis represented  
4 the six largest islands in Indonesia. Each has its own population density, religious  
5 affiliation and political situation, economic potential, and level of development. Our  
6 analysis suggested that children from the Maluku and Papua region had the highest  
7 odds of being unimmunised. The Maluku and Papua region is located in the  
8 easternmost part of Indonesia and is economically deprived. It is the largest yet least  
9 developed region with ongoing conflicts. Eligible children most likely lived in remote  
10 areas without access to health services. It is therefore not surprising that we found  
11 these children to have the highest likelihood of being unimmunised. Our research  
12 confirms that geographical disparities may contribute to low coverage, particularly in  
13 developing countries with a large population.[12] Similar findings were reported from  
14 India[38] and Nigeria.[14]

15 Children from urban areas have been reported to have better immunisation status  
16 compared to their rural counterparts.[30] By contrast, our results revealed that  
17 children who lived in rural areas were less likely to be unimmunised. Although health  
18 services are better and more easily accessible in urban areas compared to rural  
19 areas,[28] this fact likely masks the extent of urban poverty.[30] Estimates suggest  
20 that one third of urban populations in developing countries are actually living in  
21 slums.[39] With limited access to health services and poor quality of life, it is  
22 certainly likely that urban children had higher odds of being unimmunised.  
23 Unfortunately, we lacked information to distinguish between urban areas with higher

1 socioeconomic status and the slums. Further research in this field could assist strategic  
2 planning and resource allocation.

3 Our analysis revealed that children of older age groups were significantly more likely  
4 to be unimmunised compared to those in the youngest group. In other words, later  
5 birth years were associated with better coverage. It may indicate a positive trend of the  
6 immunisation programme performance over the years.[40] In the five years preceding  
7 the survey, the Indonesian government showed strong commitment towards  
8 immunisation programme. In line with global and national commitment to reduce the  
9 number of preventable child deaths, there were sharp increase in central government's  
10 budget for immunisation programme. Between the year of 2007 and 2008 alone, it  
11 increased by 40%.[41] In 2010, immunisation programme became a national priority  
12 under Presidential Instructions No.1 and No.3.[41] Among the key performance  
13 indicators was acceleration of coverage, which gradually increased between the year  
14 2007 and 2012.[11, 41] Our finding suggested that immunisation policy development  
15 in Indonesia might have played a role in improving coverage.

16 As the birth order increases, the likelihood of a child being unimmunised increases. A  
17 possible explanation is that parents may have developed confidence in their child's  
18 healthcare as a result of years of experience from previous children, and could dismiss  
19 the importance of immunisation.[42, 43] On the contrary, it could be that the first-born  
20 experienced adverse reaction to immunisation, leading the parents to believe that  
21 immunisation was risky.[43]

22 Consistently, children who came from larger families were more likely to be  
23 unimmunised. The number of household members has been linked with health  
24 outcome in many developing countries. As the number of family members increases,

1 the quality of care they receive decreases.[28, 42] This is because limited family  
2 resources are spread more sparsely, reducing the level of health investment received  
3 by each household member.

4 Our data revealed that children whose mothers had no education were at least twice as  
5 likely to be unimmunised compared to those whose mothers were high-school  
6 graduates. This indicates that maternal education is a major determinant of  
7 immunisation coverage in Indonesia. The obvious explanation is that literacy and  
8 educational attainment facilitate understanding of the recommended immunisation  
9 schedule.[40] This suggests that improving the programme to achieve the target of  
10 herd immunity might be helpful only in the short term. It highlights the need for a  
11 long-term investment in human capital, especially in Indonesian women.[28]

12 Children whose fathers work in clerical, services, or sales were less likely to be  
13 unimmunised compared to children of professionals. This is unexpected, given that  
14 people who work in clerical, services, or sales are usually of a lower socioeconomic  
15 status and may find it difficult to obtain permission for work leave in order to enable  
16 their children to be immunised.[14] Nonetheless, our result confirmed previous  
17 finding which reported similar association in Bangladesh.[16] Fathers who were  
18 professionals were significantly less likely to have their children fully immunised, as  
19 they tend to work long hours and are too preoccupied to be involved in their child's  
20 healthcare.

21 Wealth is a well-established indicator of access to health services in many countries  
22 regardless of income groups. Our analysis indicated that children from poorer and  
23 poorest households were more likely to be unimmunised. Given that immunisation  
24 services are available free of charge in Indonesia, the indirect cost of immunisation

1 may be the relevant factor instead. Lost work days and transport costs could deter  
2 parents from enabling their child to be immunised.[44, 45] The likelihood of being  
3 unimmunised was also higher among children without health insurance. This is  
4 reasonable because health insurance alleviate the burden of out-of-pocket spending,  
5 including indirect cost of immunisation. Most studies from developing countries have  
6 reported that health insurance has a positive impact on increasing healthcare  
7 utilisation.[46]

8 The odds of being unimmunised were considerably higher amongst children without  
9 antenatal and postnatal care. Children who were born without antenatal care were at  
10 least three times more likely to be unimmunised. Likewise, children who did not  
11 receive postnatal care had a 50% greater chance of being unimmunised (AOR 1.50;  
12 95% CI 1.34 to 1.69). This finding reflects the importance of information received by  
13 mothers during antenatal and postnatal care. Their visits might have equipped them  
14 with the necessary knowledge on child immunisation. In Indonesia, at least four  
15 antenatal visits are recommended during pregnancy. However, this service has been  
16 underutilised[29] and the negative implication of missed opportunities for  
17 immunisation coverage is almost certain.

18 There was a significant association between a child's place of delivery and  
19 immunisation coverage. Children who were born in public or private health institution  
20 were less likely to be unimmunised compared to those who were born at home. This is  
21 most likely because children who were born at health facilities were vaccinated, or  
22 were given recommendation to be vaccinated, immediately after birth. Furthermore, a  
23 study from Kenya has shown that women who deliver at home or unassisted may have

1 a distrust of modern medicine and a stronger preference for traditional remedies.[47]

2 By extension, they could have a sceptical view about childhood immunisation.[48]

3 Our analysis also showed that children who were born in private health institution had  
4 greater odds of being unimmunised relative to those who were born in public health  
5 institution (AOR 0.62; 95% CI 0.54 to 0.72 and AOR 0.55; 95% CI 0.47 to 0.64,  
6 respectively). In Indonesia, private health institution do not benefit from government's  
7 healthcare funding, although they do operate under the ministerial decree to deliver  
8 routine immunisation. Consequently, there is no financial incentive for private health  
9 institution to ensure that children are fully immunised. Therefore, strengthening the  
10 implementation of the ministerial decree for private health institution may help in  
11 improving immunisation coverage.

12 Children whose parents jointly decide on maternal healthcare were less likely to be  
13 unimmunised. This emphasises the importance of family support in utilising health  
14 services, confirming what had been outlined by Andersen in his theoretical  
15 framework.[13] The combination of both mother's autonomy and father's  
16 involvement in the decision making process seemed to be essential. This suggests that  
17 interventions which educate and involve fathers might have the potential to increase  
18 immunisation coverage.[49]

19 Although our findings were consistent with reports from other lower middle income  
20 countries, we found that several factors were not significant predictors of coverage in  
21 Indonesia. Despite reports from India, a child's sex did not affect coverage in  
22 Indonesia. This is consistent with studies from Nigeria undertaken by Antai[14] and  
23 Adebisi[50]. It appears that gender could predict immunisation status only if the child  
24 is from a society where gender inequality is prevalent.[50] We also found no

1 correlation between a mother's age and her child's immunisation status. Previous  
2 studies have reported that the odds of a child being unimmunised is greater for both  
3 younger and older mothers, suggesting a U-shaped association.[28] However, this  
4 association might be mitigated by patterns of other co-existing variables in our  
5 analysis, such as the child's birth order and the mother's level of education.

## 6 **Strengths and Limitations**

7 To our knowledge, this study was the first to identify factors associated with routine  
8 immunisation coverage of children in Indonesia. We used the 2012 IDHS dataset,  
9 which was the most recent one. The large sample size allowed us to analyse many  
10 potential predictors simultaneously. It also increased the validity of our results.  
11 Furthermore, we used multilevel modelling to account for the hierarchical structure of  
12 the data. We have also adjusted our analysis in order to meet the local context and  
13 produce reliable estimates. However, our results should be considered in the light of  
14 potential limitations.

15 As with other secondary analysis of cross-sectional survey data, caution should be  
16 exercised in inferring causality between the socioeconomic factors and immunisation  
17 coverage. In addition, the nature of our data source and analysis potentially limit  
18 generalisability. There is a need to verify the validity of the observed associations  
19 using longitudinal data.

20 Information on a child's immunisation status was subject to bias, because we included  
21 mother's report as a source of information. As such, we relied on the mother's ability  
22 to recall her child's immunisation status accurately. Nonetheless, mother's report is  
23 considered a valid measure of coverage in the absence of a health card, especially in



1  
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3 1 developing countries.[51] We therefore believe that our reliance on mother's report is  
4  
5 2 reasonable and not likely to have introduced bias into our study.  
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8  
9 3 The selection of variables included in this study relied on the information available  
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11 4 from the dataset. Other potential predictors that were previously identified in lower  
12  
13 5 middle income setting, such as ethnicity and religion, could not be assessed in this  
14  
15 6 study. Categorisation of original responses from the survey might have also influenced  
16  
17 7 the results.  
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20 8 The 2012 IDHS selected participants through a two-stage stratified sampling design.  
21  
22 9 The primary sampling unit was the CBs and the complete list of households in each  
23  
24 10 CB became the basis for second-stage sampling. However, there was no household  
25  
26 11 identifier in the dataset as it may compromise the participants' anonymity. Therefore,  
27  
28 12 we could only build a two-level model (i.e. children nested within CBs) instead of a  
29  
30 13 three-level model (i.e. children within households nested within CBs). We recognise  
31  
32 14 that children living in the same household could have shared similar health  
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34 15 characteristics, which reflects parent-specific knowledge or beliefs on  
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36 16 immunisation.[12] However, our analysis of variables that served as a proxy of parent-  
37  
38 17 specific knowledge or beliefs (i.e. mother's exposure to media and mother's tobacco  
39  
40 18 use history) emerged as being insignificant. Therefore, we have good reason to believe  
41  
42 19 that this limitation is unlikely to have any impact on the validity of our analysis.  
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48 20 Finally, we classified immunisation status into 'fully immunised' and 'unimmunised'  
49  
50 21 based on whether the child received full schedule of immunisation or otherwise.  
51  
52 22 While other studies have utilised three distinct categories: fully immunised, partly  
53  
54 23 immunised, and completely unimmunised, we dichotomised our outcome variable and  
55  
56 24 did not distinguish partly immunised from completely unimmunised. This is because  
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1 our study focused on factors associated with the coverage of routine immunisation,  
2 which is the complete uptake of recommended vaccination represented by the fully  
3 immunised. Reasons for Indonesian children being partly immunised and completely  
4 unimmunised might differ, and future research can potentially address this question.

## 5 **CONCLUSION**

6 In this study, we examined variables that contribute to a child's immunisation status in  
7 Indonesia. Our results suggested that immunisation coverage is suboptimal due to  
8 socioeconomic factors. Amongst the demographic groups, children who lived in  
9 Maluku and Papua region and children from the poorest households have the lowest  
10 coverage. We also identified maternal education and antenatal care visits as key  
11 factors that policymakers can target to improve immunisation coverage in Indonesia.

12 Beyond mapping trend of coverage nationally, we recommend regular monitoring and  
13 evaluation of coverage at province and district levels. This is important in order to  
14 identify high-risk areas and implement targeted activities in the communities.  
15 Increasing awareness and financial support for deprived households with more than  
16 one child may help reduce the indirect cost and motivate parents to immunise their  
17 children. Promoting equal access to education, encouraging institutional deliveries,  
18 and scaling up utilisation of antenatal and postnatal care may significantly improve  
19 coverage in Indonesia.

## 20 **5. List of Abbreviations**

21	CB	Census Block
22	EPI	Expanded Programme on Immunisation
23	GVAP	Global Vaccine Action Plan

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2  
3 1 IDHS Indonesia Demographic and Health Survey

4  
5 2 MOH Ministry of Health

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9 3 **6. Declarations**

10  
11 4 **6.1 Acknowledgements**

12  
13  
14 5 We are grateful to the ICF International for granting us access to the datasets and  
15  
16 6 to the Indonesia Endowment Fund for Education (LPDP) for funding PH a master  
17  
18 7 scholarship at the Department of Primary Care and Public Health Sciences, King's  
19  
20 8 College London. This analysis was part of PH dissertation.

21  
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23  
24 9 **6.2 Author Contributions**

25  
26  
27 10 PH and AD participated in the design of the study. PH performed the analysis and  
28  
29 11 prepared the manuscript. AD provided data analysis advice and revision of the  
30  
31 12 manuscript. All authors read and approved the final manuscript.

32  
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34  
35 13 **6.3 Competing Interests**

36  
37  
38 14 All authors have completed the ICMJE uniform disclosure form  
39  
40 15 at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) and declare: PH had financial support from  
41  
42 16 LPDP for the submitted work, no financial relationships with any organisations  
43  
44 17 that might have an interest in the submitted work in the previous three years; no  
45  
46 18 other relationships or activities that could appear to have influenced the submitted  
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48 19 work

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53 20 **6.4 Licence for Publication Statement**

1 The Corresponding Author has the right to grant on behalf of all authors and does  
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9 inclusion of electronic links from the Contribution to third party material where-  
10 ever it may be located; and, vi) licence any third party to do any or all of the  
11 above.

## 12 **6.5 Ethics Approval**

13 This study did not require ethical approval as it used unidentifiable secondary  
14 data. Permission to use the dataset was obtained from ICF International, who  
15 obtained approval to conduct IDHS in 2012. No identifiable information was  
16 included in the dataset and no attempt was made to identify any individual  
17 interviewed in the survey.

## 18 **6.6 Data Sharing**

19 The electronic datasets analysed in this study are available for legitimate research  
20 purposes from the Measure DHS website: <http://www.dhsprogram.com/>.

## 21 **6.7 Transparency Declaration**

1 This manuscript is an honest, accurate, and transparent account of the study being  
2 reported. No important aspects of the study have been omitted, and that any  
3 discrepancies from the study as planned have been explained.

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## 19 8. Figure Legends

20 Figure 1: Theoretical framework of factors potentially associated with immunisation  
21 coverage of children in Indonesia, informed by Andersen's Behavioural Health  
22 Model.

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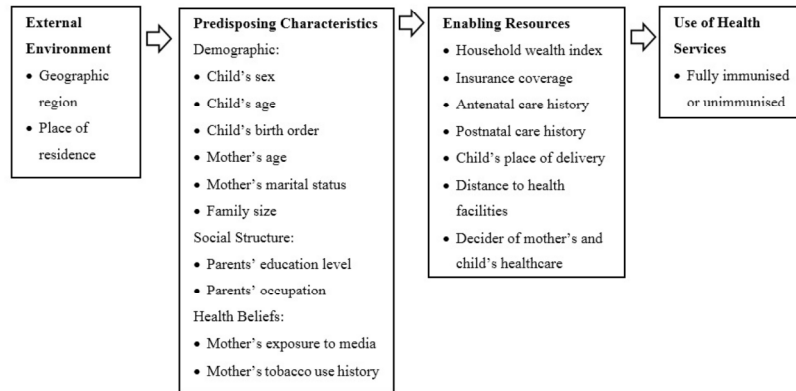


Figure 1: Theoretical framework of factors potentially associated with immunisation coverage of children in Indonesia, informed by Andersen’s Behavioural Health Model.

338x190mm (300 x 300 DPI)

Review only

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Within the title
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Within the abstract
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 6
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	Page 7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 7
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	Page 7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 8-9
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 8-9
Bias	9	Describe any efforts to address potential sources of bias	Page 9
Study size	10	Explain how the study size was arrived at	Page 9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 8-9
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Page 9-10
		(b) Describe any methods used to examine subgroups and interactions	Page 10
		(c) Explain how missing data were addressed	Page 9
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods	Page 10

		taking account of sampling strategy	
		(e) Describe any sensitivity analyses	Page 9
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	Page 9
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Table 1
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	Page 10
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 2 and Table 3
		(b) Report category boundaries when continuous variables were categorized	Table 1, Table 2 and Table 3
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 10
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	Page 20
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 27
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 21-27
Generalisability	21	Discuss the generalisability (external validity) of the study results	Limitation section
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Acknowledgements section

1  
2 \*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and  
3 unexposed groups in cohort and cross-sectional studies.  
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5  
6 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and  
7 published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely  
8 available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at  
9 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is  
10 available at [www.strobe-statement.org](http://www.strobe-statement.org).  
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# BMJ Open

## Determinants of immunisation coverage of children aged 12-59 months in Indonesia: a cross-sectional study.

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3 1 **Determinants of immunisation coverage of children aged 12-59 months in**  
4 **Indonesia: a cross-sectional study.**  
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## 1. Abstract

Objectives: Despite the adoption of WHO's Expanded Programme on Immunisation in Indonesia since 1977, a large proportion of children are still completely unimmunised or only partly immunised. This study aimed to assess factors associated with low immunisation coverage of children in Indonesia.

Setting: Children aged 12-59 months in Indonesia.

Participants: The socioeconomic characteristics and immunisation status of the children were obtained from the most recent Demographic and Health Survey, the 2012 IDHS. Participants were randomly selected through a two-stage stratified sampling design. Data from 14,401 children aged 12-59 months nested within 1,832 census blocks were included in the analysis. Multilevel logistic regression models were constructed to account for hierarchical structure of the data.

Results: The mean age of the children was 30 months and they were equally divided by sex. According to the analysis, 32% of the children were fully immunised in 2012. Coverage was significantly lower amongst children who lived in Maluku and Papua region (Adjusted Odds Ratio: 1.94; 95% Confidence Interval [1.42 to 2.64]), were 36-47 months old (1.39 [1.20 to 1.60]), had higher birth order (1.68 [1.28 to 2.19]), had greater family size (1.47 [1.11 to 1.93]), whose mother had no education (2.13 [1.22 to 3.72]), and from the poorest households (1.58 [1.26 to 1.99]). The likelihood of being unimmunised was also higher amongst children without health insurance (1.16 [1.04 to 1.30]) and those who received no antenatal (3.28 [2.09 to 5.15]) and postnatal care (1.50 [1.34 to 1.69]).

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3 1 Conclusions: Socioeconomic factors were strongly associated with the likelihood of  
4  
5 2 being unimmunised in Indonesia. Unimmunised children were geographically  
6  
7 3 clustered and lived amongst the most deprived population. To achieve WHO target of  
8  
9 4 protective coverage, public health interventions must be designed to meet the needs of  
10  
11 5 these high risk groups.  
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## 13 14 15 6 **2. Keywords**

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18 7 Immunisation coverage; routine immunisation; determinants; Indonesia; Indonesia  
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20 8 Demographic and Health Survey; multilevel analysis.  
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## 23 24 9 **3. Strengths and Limitations of This Study**

- 25  
26  
27 10 • Our study investigated, for the first time, the factors associated with routine  
28  
29 11 immunisation coverage of children in Indonesia using data from the most  
30  
31 12 recent Demographic and Health Survey.  
32  
33 13 • The large sample size allowed us to analyse many potential predictors  
34  
35 14 simultaneously and produce reliable estimates.  
36  
37 15 • We used multilevel modelling to account for the hierarchical structure of the  
38  
39 16 data.  
40  
41 17 • However, we could only build a two-level model (i.e. children nested within  
42  
43 18 census blocks) instead of the ideal three-level model (i.e. children within  
44  
45 19 households nested within census blocks) because there was no household  
46  
47 20 identifier in the dataset, as it may compromise the participants' anonymity.  
48  
49 21 • The selection of variables included in this study also relied on the information  
50  
51 22 available from the dataset.

## 52 53 54 23 **4. Main Text**

## 55 56 57 24 **BACKGROUND**

1 In 1974, the World Health Organisation initiated the Expanded Programme on  
2 Immunisation (EPI) with the goal of providing universal immunisation for all  
3 children.[1] The first diseases targeted were diphtheria, tetanus, pertussis, polio,  
4 measles, and tuberculosis.[1] New and increasingly sophisticated vaccines have  
5 become available, and more children than ever before are being vaccinated today.[2,  
6 3] Global coverage increased from 74% in 2000 to 86% in 2014.[4] As a result, the  
7 annual number of child deaths fell from 9.6 million in 2000 to 5.9 million in 2015.[1,  
8 4] Immunisation drives this reduction in child mortality and the collective recognition  
9 has led to the development of the Global Vaccine Action Plan (GVAP), a framework  
10 to help countries achieve universal child immunisation by 2020.[3] The target, as  
11 stated in the United Nations Sustainable Development Goals, is to end preventable  
12 child deaths by 2030.[5]

13 Despite this progress, vaccine-preventable diseases are still responsible for 1.5 million  
14 child deaths each year.[6] Almost 18.7 million children were not given routine  
15 immunisation in 2014 and 75% of them live in only ten countries in Africa and  
16 Asia.[4] Although some regions have successfully maintained a high level of  
17 immunisation coverage, there are pockets of unimmunised children which induce the  
18 continuous spread of diseases and outbreaks.[2] This highlights the fact that global  
19 coverage may hide variability between countries. It also suggests that the  
20 achievements are still fragile. Should this trend continue, the goals of providing  
21 universal immunisation for all children by 2020 and ending vaccine-preventable  
22 deaths by 2030 could not be achieved, and the cost of such failure would be close to  
23 26 million deaths.[3]

1 One of the ten countries that are home to the highest number of unimmunised children  
2 is Indonesia.[4] Indonesia is a lower middle income country located in Southeast  
3 Asia.[7] It has an estimated population of over 255 million in 2015, 10% of whom are  
4 children under the age of five.[8] Child mortality rate in Indonesia currently stands at  
5 27 deaths per 1,000 births and ranks 101st out of 175 countries.[9] Approximately  
6 36% of child deaths were caused by infectious diseases.[10] For most of these  
7 diseases, vaccines are available to prevent child deaths.

8 The Indonesian Ministry of Health (MOH), which organises public health matters  
9 within the Indonesian government, has adopted and implemented the EPI guidelines  
10 since 1977 through a routine immunisation programme that is compulsory for all  
11 children.[11] Even so, a large number of young children in Indonesia are still either  
12 completely unimmunised or only partly immunised. In 2013, the MOH has reported  
13 that only 59.2% of children were fully immunised.[11] There were also striking gaps  
14 within the country as coverage was as low as 29.2% at a certain area in Indonesia.[11]  
15 These figures were well below the 90% advised threshold that is required to maintain  
16 herd immunity and prevent the spread of diseases.[3] As the fourth most-populous  
17 country in the world with a great proportion of young children, the risk of large and  
18 uncontrollable outbreaks in Indonesia is more likely than ever.

19 In order to significantly increase coverage in Indonesia, a strategy proposed by GVAP  
20 is to identify and engage the unimmunised children.[3] These children are often the  
21 ones carrying a heavier burden of diseases.[3] There is particular concern that diseases  
22 may thrive when unimmunised children are residentially segregated from immunised  
23 children.[2] It is therefore critical to know who they are, where they live, and what

1 factors might have contributed to their unimmunised status, in order to ascertain  
2 where greater efforts are needed.

3 While administrative and geographic barriers may contribute to low coverage in a  
4 country with such a large population,[12] GVAP explicitly highlights the importance  
5 of socioeconomic factors in determining coverage.[3] Theory suggests that factors  
6 such as income level, employment status, and education are major determinants of  
7 healthcare utilisation[13] and a growing body of empirical evidence advances such  
8 association. The socioeconomic characteristics attached to routine immunisation  
9 coverage, and the extent these factors may play a role, vary by country.[12, 14-24]  
10 However, no such research has been done in Indonesia.

11 In this study, we used data from the 2012 Indonesia Demographic and Health Survey  
12 (IDHS) which collected information on both the immunisation status and the  
13 socioeconomic characteristics of Indonesian children under five years of age. Our aim  
14 was to identify the socioeconomic factors associated with routine immunisation  
15 coverage of children in Indonesia. The results should help in identifying susceptible  
16 subgroups of the population that require additional resources and focused attention.

## 17 **METHODS**

### 18 **Data Source**

19 This study is a secondary data analysis of the most recent DHS in Indonesia. The  
20 IDHS is conducted routinely by the national statistics authority Statistics Indonesia, in  
21 collaboration with the National Population and Family Planning Board, the Indonesian  
22 MOH, and ICF International.[25] Studies on its quality suggest that DHS is nationally  
23 representative, with little evidence of systematic bias.[26]

1 Data was collected from May 7 to July 31, 2012. Participants were selected through a  
2 two-stage stratified sampling design. The primary sampling unit was the census block  
3 (CB) and the complete list of households in each CB became the basis for second-  
4 stage sampling. A total of 46,024 households were chosen as the sample. From 44,302  
5 occupied households, 45,607 women aged 15-49 were successfully interviewed,  
6 yielding a response rate of 96%.

7 The Women's Questionnaire included questions about the woman's background  
8 characteristics and her children aged under five, for whom immunisation and health  
9 data were collected. The dataset had one record for every child of each interviewed  
10 woman, born in the five years preceding the survey. Data were obtained for 18,021  
11 children.

## 12 **Outcome Variable**

13 The outcome variable in the analysis was the child's immunisation status. Information  
14 on immunisation status was collected from two sources, the health card or health book  
15 shown to the interviewer, or if unavailable, from the mother's report. The health card  
16 or health book was available 85.77% of the time.

17 The outcome variable was categorised as 'fully immunised' if they had received the  
18 full schedule of routine immunisation and otherwise 'unimmunised', regardless of the  
19 source of the information. Routine immunisation referred to three doses of DTP  
20 vaccines, four doses of polio vaccine, one dose of measles vaccine, one dose of BCG  
21 vaccine, and four doses of hepatitis B vaccine, scheduled to be received by the age of  
22 12 months.[11] The proportion of children who had been fully immunised defined  
23 immunisation coverage.[27]

1 In a small number of cases, where health cards were unavailable and mothers  
2 indicated that they did not know about the immunisation status (1.51%), the child was  
3 considered as not fully immunised. The fact that mothers responded ‘don’t know’ is  
4 likely to reflect that the child was not fully immunised[12, 28] and fits better in the  
5 ‘unimmunised’ category.

## 6 **Independent variables**

7 Selection of independent variables was based on the literature review and variables  
8 available in the dataset. Twenty-two independent variables were identified as potential  
9 factors and Andersen’s Behavioural Health Model[13] was used as a framework to  
10 group the factors into three main groups: external environment, predisposing, and  
11 enabling factors (Figure 1). The model has been commonly used to examine factors  
12 associated with health service utilisation, including immunisation uptake.[21, 29]

13 Predisposing characteristics consist of demographic factors, social structure such as  
14 educational attainment and occupation, and health beliefs which involves health-  
15 related knowledge and behaviours.[13] Enabling resources are related to individuals’  
16 personal and community support which enable them to use health services, reflected  
17 by income level, insurance coverage, and other factors that could affect one’s access  
18 to health services.[13] Lastly, external environment incorporates wider social and  
19 environmental determinants of health.[13]

20 Categorisation of continuous variables and description of categorical variables were  
21 undertaken according to the literature. The child’s age (12-59 months) was categorised  
22 into groups at one-year intervals. Similarly, the mother’s age (15-49 years) was

1 categorised into groups at five-year intervals. The child's birth order and family size  
2 were also categorised into groups based on previously published literatures.

3 Following IDHS protocol[25] household wealth index was constructed based on  
4 household amenities and assets (radio, television, refrigerator, bicycle, motorcycle, or  
5 car) and dwelling characteristics (electricity, flooring, roofing, water source, toilet  
6 facilities, and sleeping arrangements). It was categorised into quintiles from poorest to  
7 richest. In the absence of direct information on household income or expenditures,  
8 wealth index is considered a robust measure of household income level.[30] Insurance  
9 coverage represented any health insurance provided through social security or local  
10 government, by employer, privately-purchased, or other insurance. Antenatal care  
11 represented any pregnancy-related care provided by skilled health personnel or  
12 traditional birth attendants during the pregnancy, irrespective of the type of provider  
13 and the number of visits. Similarly, postnatal care represented any examination by  
14 skilled health personnel or traditional birth attendants within two months of the child's  
15 birth, irrespective of the type of provider and the number of visits.

16 The 33 provinces in Indonesia were categorised into six island-based regions.[25] The  
17 child's place of delivery was classified into three categories: home, public health  
18 institution, and private health institution. Public health institution included public  
19 hospitals, public clinics, health centres, village health posts, and delivery posts.  
20 Private health institution included private hospitals, private clinics, maternity  
21 hospitals, maternity home, and also private practices of obstetrician, general  
22 practitioner, nurse, midwife, and village midwife.

### 23 **Statistical Analysis**



1  
2  
3 1 The original dataset comprised of 18,021 children aged 0-59 months distributed  
4  
5 2 among 1,840 CBs. For the purpose of the analysis, we excluded 3,620 children who  
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7 3 were under one year old because they were not old enough to have received the full  
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9 4 schedule of routine immunisation in Indonesia. The final sample, therefore, contained  
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11 5 14,401 children from 1,832 CBs. From this, we had 656 children (4.6%) with missing  
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13 6 immunisation status because they were no longer alive at the time of the survey,  
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15 7 leaving complete observations of 13,745 children (95.4%). Given the small number of  
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17 8 missing values, we used complete-case analysis and no sensitivity analysis was  
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19 9 required.

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24 10 Data analysis was conducted using STATA 14 software. Frequency and percentage  
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26 11 were used to report baseline characteristics of the children. Cross tabulation was  
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28 12 undertaken to demonstrate the proportion of different categories with respect to  
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30 13 immunisation status. The immunisation status as outcome variable was coded into 0  
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32 14 for 'fully immunised' and 1 for otherwise 'unimmunised'.

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35  
36 15 Univariate analysis was used to separately evaluate of the effect of each independent  
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38 16 variable on the outcome variable. Test of trends across ordered groups were evaluated.  
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40 17 Variables with a univariate P-value of less than 0.2 were then selected as candidates  
41  
42 18 for the multivariate analysis.

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46 19 Multilevel logistic regression was used to estimate immunisation status in multivariate  
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48 20 context while accounting for clustering. Model fitting using residuals were checked. A  
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50 21 two-level model was used for the multivariate analysis (i.e. children nested within  
51  
52 22 CBs). This was run using the *meqrlogit* command in STATA 14, a method based on  
53  
54 23 maximum likelihood and robust to missing values. Associations between independent  
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56 24 variables and the likelihood of children being unimmunised were assessed  
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1 simultaneously. The results were expressed as adjusted odds ratio (AOR) with 95%  
2 CI.

### 3 RESULTS

#### 4 Descriptive Statistics

5 A total of 14,401 children from 1,832 CBs were included in the analysis. Our result  
6 showed that only 31.5% (95% CI 30.7% to 32.3%) of the children aged 12-59 months  
7 had been fully immunised at the time of the survey. The baseline characteristics of  
8 sample were presented in Table 1.

9 Table 1: Baseline characteristics of sample (n=14,401).

Characteristics		Frequency <sup>†</sup>	Percentage (%)
Immunisation status	Fully immunised	4331	31.5
	Unimmunised	9414	68.5
<b>External Environment</b>			
Geographic region	Sumatera	4061	29.5
	Java	3079	22.4
	Bali and Nusa Tenggara	1220	9.0
	Kalimantan	1447	10.5
	Sulawesi	2381	17.3
	Maluku and Papua	1557	11.3
Place of residence	Urban	6307	45.9
	Rural	7438	54.1
<b>Predisposing Characteristics</b>			
Child's sex	Male	7092	51.6
	Female	6653	48.4
Child's age (months)	12-23	3501	25.5
	24-35	3413	24.8
	36-47	3378	24.6
	48-59	3453	25.1
Child's birth order	1 <sup>st</sup>	5929	35.9
	2 <sup>nd</sup> - 4 <sup>th</sup>	7533	54.8
	≥ 5 <sup>th</sup>	1283	9.3
Mother's age (years)	15-19	262	1.9
	20-24	2381	17.3
	25-29	3928	28.6
	30-34	3454	25.2
	35-39	2410	17.5
	40-44	1104	8.0
Mother's marital status	45-49	206	1.5
	Married	13168	95.8
	Living with partner	176	1.3
	Widowed	118	0.8
	Divorced	231	1.7
	No longer living together	43	0.3
Family size (number of	Never in union	9	0.1
	≤ 4	5314	38.6

household members)	5-9	7637	55.6
	≥ 10	794	5.8
Mother's educational level	Higher	1819	13.2
	Secondary	7221	52.6
	Primary	4291	31.2
	No education	414	3.0
Father's educational level	Higher	1740	12.7
	Secondary	7438	54.2
	Primary	4204	30.6
	No education	311	2.3
	Don't know	24	0.2
Mother's occupation	Professional	1018	7.4
	Agricultural	1855	13.5
	Industrial	1571	11.4
	Clerical, services, and sales	3236	23.6
	Did not work	6052	44.1
	Don't know	2	0.0
Father's occupation	Professional	1336	9.8
	Agricultural	3550	25.9
	Industrial	4884	35.6
	Clerical, services, and sales	3709	27.0
	Did not work	225	1.6
	Don't know	12	0.1
Mother's exposure to media (newspaper, magazine, radio, or television)	At least once a week	11528	83.9
	Less than once a week	1527	11.1
	Not at all	686	5.0
Mother's tobacco use history	Smokes nothing	13317	96.9
	Uses tobacco	424	3.1
<b>Enabling Resources</b>			
Household wealth index	Richest	2108	15.3
	Richer	2276	16.6
	Middle	2504	18.2
	Poorer	2722	19.8
	Poorest	4135	30.1
Covered by health insurance	Yes	5580	40.6
	No	8156	59.4
Antenatal care	Received some care	10861	96.2
	Received no care	640	3.8
Postnatal care	Received some care	7395	65.7
	Received no care	3813	33.8
	Don't know	53	0.5
Child's place of delivery	Home	6325	46.2
	Public health institution	2527	18.4
	Private health institution	4823	35.2
	Other	28	0.2
Distance to health facilities	Not a big problem	11915	86.9
	Big problem	1792	13.1
Maternal healthcare decision making	By herself	4758	35.7
	Jointly with husband	6567	49.3
	Husband alone	1972	14.7
	By others	34	0.3
Child healthcare decision making	By herself	4497	36.3
	Jointly with husband	1407	10.5
	Husband alone	6255	46.2
	By others	225	1.8

1 † Total number varies between categories because of missing values.

2 The mean age of the children was 30 months and they were equally divided by sex.

3 More than half of them were second- to fourth-born. The mothers were 25 to 29 years

1 old on average and almost all were married at the time of the survey. Most of the  
2 families had five to nine household members.

3 Majority of the mothers were secondary school graduates. Although educational  
4 attainment was approximately equal for both parents, nearly half of the mothers did  
5 not work. A large proportion of the mothers were exposed to media at least once a  
6 week and almost all reported that they did not smoke around the time of the survey.

7 In terms of enabling resources, half of the children lived in the poorer and poorest  
8 households. Additionally, almost two-thirds of the children were not covered by  
9 health insurance. While only a small proportion were born without antenatal care,  
10 much more children were born without postnatal care. Nearly half of the children were  
11 delivered at home although most mothers reported that distance to health facilities  
12 were not a big problem. Lastly, the majority of mothers reported that they were  
13 involved in the decision making process of their own healthcare as well as their  
14 children's.

### 15 **Univariate Analysis**

16 The association between each independent variable and the likelihood of being  
17 unimmunised was investigated one by one. The result were shown in Table 2.

18 Table 2: Univariate analysis results for factors associated with low immunisation  
19 coverage of children aged 12-59 months in Indonesia.

Characteristics		Status (%)				Unadjusted OR (95% CI)		P- value
		Fully immunised		Unimmunised				
<b>External Environment</b>								
Geographic region	Sumatera	1135	(26.2%)	2926	(31.8%)	1.68	(1.52 to 1.86)	0.000
	Java	1215	(28.1%)	1864	(19.8%)	1		
	Bali and Nusa Tenggara	525	(12.1%)	695	(7.4%)	0.86	(0.75 to 0.99)	0.032
	Kalimantan	490	(11.3%)	957	(10.2%)	1.27	(1.12 to 1.45)	0.000

	Sulawesi	672	(15.5%)	1709	(18.2%)	1.66	(1.48	to	0.000	
	Maluku and Papua	294	(6.8%)	1263	(13.4%)	2.80	(2.42	to	0.000	
						3.24)				
Place of residence	Urban	2232	(51.5%)	4075	(43.3%)	1				
	Rural	2099	(48.5%)	5339	(56.7%)	1.39	(1.30	to	0.000	
						1.50)				
<b>Predisposing Characteristics</b>										
Child's sex	Male	2255	(52.1%)	4837	(51.4%)	1				
	Female	2076	(47.9%)	4577	(48.6%)	1.03	(0.96	to	0.455	
						1.10)				
Child's age (months)	12-23	1246	(28.8%)	2255	(24.0%)	1				
	24-35	1066	(24.6%)	2347	(24.9%)	1.22	(1.10	to	0.000	
						1.34)				
	36-47	1011	(23.3%)	2367	(25.1%)	1.30	(1.17	to	0.000	
						1.43)				
	48-59	1008	(23.3%)	2445	(26.0%)	1.34	(1.21	to	0.000	
						1.48)				
Child's birth order	1 <sup>st</sup>	1675	(38.7%)	3254	(34.6%)	1				
	2 <sup>nd</sup> – 4 <sup>th</sup>	2413	(55.7%)	5120	(54.4%)	1.29	(1.21	to	0.000	
						1.37)				
	≥ 5 <sup>th</sup>	243	(5.6%)	1040	(11.0%)	1.41	(1.27	to	0.000	
						1.57)				
Mother's age (years)	15-19	67	(1.5%)	195	(2.1%)	1				
	20-24	704	(16.2%)	1677	(17.8%)	0.82	(0.61	to	0.178	
						1.10)				
	25-29	1219	(28.2%)	2709	(28.8%)	0.76	(0.57	to	0.064	
						1.02)				
	30-34	1166	(26.9%)	2288	(24.3%)	0.67	(0.51	to	0.007	
						0.90)				
35-39	815	(18.8%)	1595	(16.9%)	0.67	(0.50	to	0.007		
					0.90)					
40-44	301	(7.0%)	803	(8.5%)	0.92	(0.67	to	0.579		
					1.25)					
45-49	59	(1.4%)	147	(1.6%)	0.86	(0.57	to	0.458		
					1.29)					
Mother's marital status	Married	4159	(96.0%)	9009	(95.7%)	1				
	Living with partner	50	(1.2%)	126	(1.3%)	1.16	(0.84	to	0.368	
						1.62)				
	Widowed	37	(0.9%)	81	(0.9%)	1.01	(0.68	to	0.958	
						1.49)				
	Divorced	70	(1.6%)	161	(1.7%)	1.06	(0.80	to	0.678	
					1.41)					
No longer living together	11	(0.3%)	32	(0.3%)	1.34	(0.68	to	0.400		
					2.67)					
Never in union	4	(0.0%)	5	(0.1%)	0.58	(0.15	to	0.413		
					2.15)					
Family size (number of household members)	≤ 4	1746	(40.3%)	3568	(37.9%)	1				
	5-9	2381	(55.0%)	5256	(55.8%)	1.08	(1.00	to	0.044	
						1.16)				
	≥ 10	204	(4.7%)	590	(6.3%)	1.42	(1.20	to	0.000	
						1.68)				
Mother's educational level	Higher	756	(17.5%)	1063	(11.3%)	1				
	Secondary	2451	(56.6%)	4770	(50.7%)	1.38	(1.25	to	0.000	
						1.54)				
	Primary	1081	(25.0%)	3210	(34.1%)	2.11	(1.88	to	0.000	
					2.37)					
No education	43	(0.9%)	371	(3.9%)	6.14	(4.41	to	0.000		
					8.53)					
Father's educational level	Higher	717	(16.6%)	1023	(10.9%)	1				
	Secondary	2508	(58.0%)	4930	(52.5%)	1.38	(1.24	to	0.000	
						1.53)				
	Primary	1054	(24.4%)	3150	(33.5%)	2.09	(1.86	to	0.000	
					2.36)					
No education	42	(1.0%)	269	(2.9%)	4.49	(3.20	to	0.000		

	Don't know	3	(0.0%)	21	(0.2%)	6.30 4.91 (1.46 to 0.010 16.5)
Mother's occupation	Professional	428	(9.9%)	590	(6.3%)	1
	Agricultural	405	(9.4%)	1450	(15.4%)	2.60 (2.20 to 0.000 3.07)
	Industrial	480	(11.1%)	1091	(11.6%)	1.65 (1.40 to 0.000 1.94)
	Clerical, services, and sales	1069	(24.7%)	2167	(23.0%)	1.47 (1.27 to 0.000 1.70)
	Did not work	1944	(44.9%)	4108	(43.7%)	1.53 (1.34 to 0.000 1.76)
Father's occupation	Professional	520	(12.0%)	816	(8.7%)	1
	Agricultural	809	(18.7%)	2741	(29.2%)	2.16 (1.89 to 0.000 2.47)
	Industrial	1584	(36.7%)	3300	(35.1%)	1.33 (1.17 to 0.000 1.50)
	Clerical, services, and sales	1350	(31.2%)	2359	(25.1%)	1.11 (0.98 to 0.102 1.27)
	Did not work	58	(1.4%)	167	(1.8%)	1.83 (1.33 to 0.000 2.52)
	Don't know	2	(0.0%)	10	(0.1%)	3.19 (0.70 to 0.136 14.6)
Mother's exposure to media (newspaper, magazine, radio, or television)	At least once a week	3814	(88.1%)	7714	(82.0%)	1
	Less than once a week	373	(8.6%)	1154	(12.2%)	1.53 (1.35 to 0.000 1.73)
	Not at all	142	(3.3%)	544	(5.8%)	1.89 (1.57 to 0.000 2.29)
Mother's tobacco use history	Smokes nothing	4246	(98.0%)	9071	(96.4%)	1
	Uses tobacco	85	(2.0%)	339	(3.6%)	1.87 (1.47 to 0.000 2.37)
<b>Enabling Resources</b>						
Household wealth index	Richest	914	(21.1%)	1194	(12.7%)	1
	Richer	834	(19.2%)	1442	(15.3%)	1.32 (1.17 to 0.000 1.49)
	Middle	883	(20.4%)	1621	(17.2%)	1.41 (1.25 to 0.000 1.58)
	Poorer	848	(19.6%)	1874	(19.9%)	1.69 (1.50 to 0.000 1.90)
	Poorest	852	(19.7%)	3283	(34.9%)	2.95 (2.63 to 0.000 3.31)
Covered by health insurance	Yes	1993	(46.0%)	3587	(38.1%)	1
	No	2336	(54.0%)	5820	(61.9%)	1.38 (1.29 to 0.000 1.49)
Antenatal care	Received some care	3668	(99.0%)	7193	(94.8%)	1
	Received no care	38	(1.0%)	394	(5.2%)	5.29 (3.78 to 0.000 7.39)
Postnatal care	Received some care	2732	(73.8%)	4663	(61.7%)	1
	Received no care	958	(25.9%)	2855	(37.8%)	1.75 (1.60 to 0.000 1.90)
	Don't know	14	(0.3%)	39	(0.5%)	1.63 (0.88 to 0.117 3.01)
Child's place of delivery	Home	1376	(31.8%)	4949	(52.8%)	1
	Public health institution	1041	(24.1%)	1486	(15.9%)	0.40 (0.36 to 0.000 0.44)
	Private health institution	1905	(44.0%)	2918	(31.1%)	0.43 (0.40 to 0.000 0.46)
	Other	6	(0.1%)	22	(0.2%)	1.02 (0.41 to 0.967 2.52)
Distance to health facilities	Not a big problem	3885	(89.9%)	8030	(85.6%)	1

	Big problem	438	(10.1%)	1354	(14.4%)	1.50 1.68)	(1.33	to	0.000
Maternal healthcare decision making	By mother herself	1461	(34.7%)	3297	(36.1%)	1			
	Jointly with husband	2193	(52.1%)	4374	(47.9%)	0.88 0.96)	(0.82	to	0.003
	Husband alone	543	(12.9%)	1429	(15.7%)	1.17 1.31)	(1.04	to	0.010
	By others	10	(0.3%)	24	(0.3%)	1.06 2.23)	(0.51	to	0.870
Child healthcare decision making	By mother herself	1469	(37.0%)	3028	(36.0%)	1			
	Jointly with husband	2015	(50.8%)	4240	(50.4%)	1.12 1.28)	(0.99	to	0.076
	Husband alone	424	(10.7%)	983	(11.7%)	1.02 1.11)	(0.94	to	0.621
	By others	59	(1.5%)	166	(1.9%)	1.36 1.85)	(1.01	to	0.045

Geographic region came out as a significant predictor of immunisation coverage in our univariate analysis. The majority, one third, of children who were fully immunised lived in Java, while the lowest coverage was reported in Maluku and Papua. The odds of being unimmunised were almost threefold amongst children who lived in Maluku and Papua (OR 2.80; 95% CI 2.42 to 3.24). On the contrary, we found that children from Bali and Nusa Tenggara had the least likelihood of being unimmunised (OR 0.86; 95% CI 0.75 to 0.99). Our univariate analysis also showed that children from rural areas were significantly more likely to be unimmunised compared to their urban counterparts (OR 1.39; 95% CI 1.30 to 1.50).

Although coverage was approximately equal for both sexes, the child's age and birth order were significantly associated with coverage. Older children were more likely to be unimmunised compared to the youngest ones. The odds of being unimmunised amongst the older children ranged from 1.22 to 1.34. Similarly, children who were not first-born had significantly higher chance of being unimmunised. The odds of being unimmunised increased as the child's age and birth order increased ( $p < 0.000$ ).

We found that children whose mothers were 30-39 years old at the time of the survey were less likely to be unimmunised (OR 0.67; 95% CI 0.50 to 0.90). However, there

1 was no clear trend across the age groups. We also found that children who came from  
2 bigger families were significantly more likely to be unimmunised. The likelihood  
3 increased by 8% up to 42%. As the number of household members increased, the  
4 likelihood of a child to be unimmunised increased ( $p<0.000$ ).

5 Although their marital status was not a significant predictor of coverage, each parent  
6 educational attainment was significantly associated with coverage. As parents'  
7 educational attainment increased, the likelihood of being unimmunised decreased  
8 ( $p<0.000$ ). Hence, children from uneducated parents had the highest odds of being  
9 unimmunised. Those whose mothers had no education were at least six times more  
10 likely to be unimmunised (OR 6.14; CI 95% 4.41 to 8.53). Likewise, children whose  
11 fathers were uneducated had greater than fourfold chance of being unimmunised (OR  
12 4.49; 95% CI 3.20 to 6.30).

13 Additionally, parents' occupation, mother's exposure to media, and mother's tobacco  
14 use history were significantly associated with coverage. Across the occupational  
15 groups, children whose parents worked in agriculture had the highest odds of being  
16 unimmunised. Children whose mothers worked in agriculture were 2.6 times more  
17 likely to be unimmunised (OR 2.60; 95% CI 2.20 to 3.07), while children whose  
18 fathers worked in agriculture were 2.16 times more likely to be unimmunised (OR  
19 2.16; 95% CI 1.89 to 2.47). Regarding mother's exposure to media, the child's  
20 likelihood of being unimmunised increased as the frequency of media exposure  
21 decreased ( $p<0.000$ ). Finally, children whose mothers smoked tobacco around the  
22 time of the survey had 87% higher chance of being unimmunised (OR 1.87; 95% CI  
23 1.47 to 2.37).



1 We found that as the household wealth index increased, the likelihood of being  
2 unimmunised decreased ( $p < 0.000$ ). Hence, children from poorest households had the  
3 highest odds of being unimmunised (OR 2.95; 95% CI 2.63 to 3.31). We also found  
4 that children who had no health insurance were significantly more likely to be  
5 unimmunised compared to those who had insurance (OR 1.38; 95% CI 1.29 to 1.49).

6 Our univariate analysis indicated that antenatal and postnatal care visits were  
7 significant predictors of coverage in Indonesia. Our results showed that children who  
8 were born without antenatal care were at least five times more likely to be  
9 unimmunised (OR 5.29; 95% CI 3.78 to 7.39). Likewise, those who were born without  
10 postnatal care were 75% more likely to be unimmunised (OR 1.75; 95% CI 1.60 to  
11 1.90).

12 In terms of access to health services, we found that children who were born in health  
13 institution were significantly less likely to be unimmunised compared to those who  
14 were born at home. Specifically, children who were born at public health institution  
15 had the least likelihood of being unimmunised (OR 0.40; 95% CI 0.36 to 0.44). In  
16 addition, children whose mothers think that distance to health facilities was a big  
17 problem had 50% higher chance of being unimmunised (OR 1.50; 95% CI 1.33 to  
18 1.68).

### 19 **Multivariate Analysis**

20 Out of the 22 independent variables, child's sex and mother's marital status were  
21 excluded. Table 3 summarised the significant results of our multilevel logistic  
22 regression analysis between the remaining 20 independent variables and the likelihood  
23 of being unimmunised.

1 Table 3: Multivariate analysis results for factors significantly associated with low  
 2 immunisation coverage of children aged 12-59 months in Indonesia.

Characteristics		AOR (95% CI)	P- value
<b>External Environment</b>			
Geographic region	Sumatera	1.51 (1.24 to 1.83)	0.000
	Java	1	
	Bali and Nusa Tenggara	0.71 (0.54 to 0.94)	0.016
	Maluku and Papua	1.94 (1.42 to 2.64)	0.000
Place of residence	Urban	1	
	Rural	0.82 (0.69 to 0.96)	0.013
<b>Predisposing Characteristics</b>			
Child's age (months)	12-23	1	
	24-35	1.24 (1.08 to 1.42)	0.002
	36-47	1.39 (1.20 to 1.60)	0.000
	48-59	1.36 (1.17 to 1.58)	0.000
Child's birth order	1 <sup>st</sup>	1	
	2 <sup>nd</sup> - 4 <sup>th</sup>	1.18 (1.03 to 1.35)	0.016
	≥ 5 <sup>th</sup>	1.68 (1.28 to 2.19)	0.000
Family size (number of household members)	≤ 4	1	
	≥ 10	1.47 (1.11 to 1.93)	0.006
Mother's educational level	Higher	1	
	No education	2.13 (1.22 to 3.72)	0.008
Father's occupation	Professional	1	
	Clerical, services, and sales	0.82 (0.67 to 1.00)	0.047
<b>Enabling Resources</b>			
Household wealth index	Richest	1	
	Poorer	1.30 (1.06 to 1.59)	0.011
	Poorest	1.58 (1.26 to 1.99)	0.000
Covered by health insurance	Yes	1	
	No	1.16 (1.04 to 1.30)	0.010
Antenatal care	Received some care	1	
	Received no care	3.28 (2.09 to 5.15)	0.000
Postnatal care	Received some care	1	
	Received no care	1.50 (1.34 to 1.69)	0.000
Child's place of delivery	Home	1	
	Public health institution	0.55 (0.47 to 0.64)	0.000
	Private health institution	0.62 (0.54 to 0.72)	0.000
Maternal healthcare decision making	By herself	1	
	Jointly with husband	0.86 (0.76 to 0.96)	0.010

3 After accounting for the other remaining variables, geographic region and place of  
 4 residence were significantly associated with coverage. The likelihood of being  
 5 unimmunised was highest among children who lived in Maluku and Papua. Children  
 6 who lived in this region were almost twice as likely to be unimmunised compared to  
 7 those who lived in Java (AOR 1.94; 95% CI 1.42 to 2.64). Similarly, children who  
 8 lived in Sumatera had considerably higher odds of being unimmunised (AOR 1.51;  
 9 95% CI 1.24 to 1.83). In contrast, children from Bali and Nusa Tenggara were less  
 10 likely to be unimmunised (AOR 0.71; 95% CI 0.54 to 0.94). Those who lived in rural

1 areas were also less likely to be unimmunised compared to their urban counterparts  
2 (AOR 0.82; 95% CI 0.69 to 0.96).

3 The likelihood of being unimmunised differed significantly across the age groups.  
4 Older children were more likely to be unimmunised compared to those in the youngest  
5 age group. The odds ranged from 1.24 (95% CI 1.08 to 1.42) to 1.39 (95% CI 1.20 to  
6 1.60). Of all age groups, children aged 36-47 months had the highest odds of being  
7 unimmunised (AOR 1.39; 95% CI 1.20 to 1.60).

8 The child's birth order and family size were also significantly correlated with  
9 immunisation status. As a child's birth order or family size increased, the likelihood of  
10 being unimmunised also increased. A second child was 18% more likely to be  
11 unimmunised compared to a first child (AOR 1.18; 95% CI 1.03 to 1.35), while a fifth  
12 child had 68% higher chance of being unimmunised (AOR 1.68; 95% CI 1.28 to  
13 2.19). Accordingly, children who came from bigger families had higher likelihood of  
14 being unimmunised. Those who lived in households with ten or more family members  
15 were 47% more likely to be unimmunised (AOR 1.47; 95% CI 1.11 to 1.93).

16 Children whose mothers had no education were at least twice as likely to be  
17 unimmunised than those whose mothers were high-school graduates or higher (AOR  
18 2.13; 95% CI 1.22 to 3.72). Similarly, the odds of being unimmunised were  
19 significantly higher among the poorer (AOR 1.30; 95% CI 1.06 to 1.59) and the  
20 poorest (AOR 1.58; 95% CI 1.26 to 1.99). Also, those without health insurance were  
21 more likely to be unimmunised (AOR 1.16; 95% CI 1.04 to 1.30).

22 The odds of being unimmunised were strikingly higher amongst children without  
23 antenatal or postnatal care. Children who were born without antenatal care were more

1 than three times as likely to be unimmunised (AOR 3.28; 95% CI 2.09 to 5.15).  
2 Likewise, those who had no postnatal care had a 50% higher chance of being  
3 unimmunised (AOR 1.50; 95% CI 1.34 to 1.69). Additionally, children who were born  
4 in health institution were less likely to be unimmunised compared to those who were  
5 born at home (AOR 0.55; 95% CI 0.47 to 0.64). Furthermore, children whose parents  
6 jointly decided on maternal healthcare and whose fathers worked in clerical, services,  
7 and sales were significantly less likely to be unimmunised (AOR 0.86; 95% CI 0.76 to  
8 0.96 and AOR 0.82; 95% CI 0.67 to 1.00, respectively).

## 9 **DISCUSSION**

### 10 **Main Findings**

11 Our study investigated, for the first time, the factors associated with routine  
12 immunisation coverage of children aged 12-59 months in Indonesia, using data from  
13 2012 IDHS. Our analysis revealed that only 31.5% of the children had been fully  
14 immunised. After accounting for all confounders, 13 factors were significantly  
15 associated with low coverage in Indonesia: geographic region, place of residence,  
16 child's age, child's birth order, family size, mother's education, father's occupation,  
17 household wealth index, insurance coverage, antenatal care, postnatal care, child's  
18 place of delivery, and maternal healthcare decision making.

19 There are discrepancies between the coverage level reported by the officials and the  
20 one discovered in this study. In 2012, the Indonesian MOH reported coverage level of  
21 86.8%.<sup>[31]</sup> The coverage level determined through 2012 IDHS is therefore much  
22 lower than that contained in the official report.

1 While our study analysed cross-sectional survey data, the official report used  
2 administrative data which are commonly employed to assess immunisation coverage  
3 in low-resource settings.[32] The estimate is obtained by dividing the number of doses  
4 administered at health services by the expected target population.[32, 33] Although  
5 this is readily available, results can be unreliable, particularly when there are  
6 uncertainties surrounding the total number of age-eligible children.[32, 34]

7 The discrepancy between estimates obtained from administrative and survey data have  
8 also been reported in the past.[34-37] Administrative estimates tend to be higher than  
9 those obtained from the survey,[33] which is observed in our finding as well.

10 Comparisons of administrative and survey estimates are made more complicated by  
11 the fact that the number of age-eligible children included in each analysis differ.[33]

12 The estimate from administrative data includes children aged 0-11 months, while the  
13 survey usually includes children aged up to 59 months.[33, 34] The coverage from  
14 MOH report was of children aged 0-11 months, because they are the youngest group  
15 eligible to receive the full schedule of routine immunisation. Measles vaccine, for  
16 example, is the last one on the schedule and is given starting at the age of nine  
17 months. However, it could be administered up to the age of 12 months.[38] There are  
18 also booster campaign and backlog fighting initiative for children up to three years of  
19 age, as well as other supplemental immunisation activities which targeted children  
20 aged 9-59 months. This is all part of routine immunisation programme in  
21 Indonesia.[38] Therefore, estimates from administrative data would not have covered  
22 the entire target population of routine immunisation coverage. This indicates a  
23 weakness in the surveillance system and highlights the need of quality assurance of  
24 immunisation data.

## 1 **Factors Associated with Immunisation Coverage**

2 After accounting for all observed confounders, geographic region was significantly  
3 associated with coverage. The six geographic regions used in our analysis represented  
4 the six largest islands in Indonesia. Each has its own population density, religious  
5 affiliation and political situation, economic potential, and level of development. Our  
6 analysis suggested that children from the Maluku and Papua region had the highest  
7 odds of being unimmunised. The Maluku and Papua region is located in the  
8 easternmost part of Indonesia and is economically deprived. It is the largest yet least  
9 developed region with ongoing conflicts. Eligible children most likely lived in remote  
10 areas without access to health services. It is therefore not surprising that we found  
11 these children to have the highest likelihood of being unimmunised. Our research  
12 confirms that geographical disparities may contribute to low coverage, particularly in  
13 developing countries with a large population.[12] Similar findings were reported from  
14 India[38] and Nigeria.[14]

15 Children from urban areas have been reported to have better immunisation status  
16 compared to their rural counterparts.[30] By contrast, our results revealed that  
17 children who lived in rural areas were less likely to be unimmunised. Although health  
18 services are better and more easily accessible in urban areas compared to rural  
19 areas,[28] this fact likely masks the extent of urban poverty.[30] Estimates suggest  
20 that one third of urban populations in developing countries are actually living in  
21 slums.[39] With limited access to health services and poor quality of life, it is  
22 certainly likely that urban children had higher odds of being unimmunised.  
23 Unfortunately, we lacked information to distinguish between urban areas with higher

1 socioeconomic status and the slums. Further research in this field could assist strategic  
2 planning and resource allocation.

3 Our analysis revealed that children of older age groups were significantly more likely  
4 to be unimmunised compared to those in the youngest group. In other words, later  
5 birth years were associated with better coverage. It may indicate a positive trend of the  
6 immunisation programme performance over the years.[40] In the five years preceding  
7 the survey, the Indonesian government showed strong commitment towards  
8 immunisation programme. In line with global and national commitment to reduce the  
9 number of preventable child deaths, there were sharp increase in central government's  
10 budget for immunisation programme. Between the year of 2007 and 2008 alone, it  
11 increased by 40%.[41] In 2010, immunisation programme became a national priority  
12 under Presidential Instructions No.1 and No.3.[41] Among the key performance  
13 indicators was acceleration of coverage, which gradually increased between the year  
14 2007 and 2012.[11, 41] Our finding suggested that immunisation policy development  
15 in Indonesia might have played a role in improving coverage.

16 As the birth order increases, the likelihood of a child being unimmunised increases. A  
17 possible explanation is that parents may have developed confidence in their child's  
18 healthcare as a result of years of experience from previous children, and could dismiss  
19 the importance of immunisation.[42, 43] On the contrary, it could be that the first-born  
20 experienced adverse reaction to immunisation, leading the parents to believe that  
21 immunisation was risky.[43]

22 Consistently, children who came from larger families were more likely to be  
23 unimmunised. The number of household members has been linked with health  
24 outcome in many developing countries. As the number of family members increases,

1 the quality of care they receive decreases.[28, 42] This is because limited family  
2 resources are spread more sparsely, reducing the level of health investment received  
3 by each household member.

4 Our data revealed that children whose mothers had no education were at least twice as  
5 likely to be unimmunised compared to those whose mothers were high-school  
6 graduates. This indicates that maternal education is a major determinant of  
7 immunisation coverage in Indonesia. The obvious explanation is that literacy and  
8 educational attainment facilitate understanding of the recommended immunisation  
9 schedule.[40] This suggests that improving the programme to achieve the target of  
10 herd immunity might be helpful only in the short term. It highlights the need for a  
11 long-term investment in human capital, especially in Indonesian women.[28]

12 Children whose fathers work in clerical, services, or sales were less likely to be  
13 unimmunised compared to children of professionals. This is unexpected, given that  
14 people who work in clerical, services, or sales are usually of a lower socioeconomic  
15 status and may find it difficult to obtain permission for work leave in order to enable  
16 their children to be immunised.[14] Nonetheless, our result confirmed previous  
17 finding which reported similar association in Bangladesh.[16] Fathers who were  
18 professionals were significantly less likely to have their children fully immunised, as  
19 they tend to work long hours and are too preoccupied to be involved in their child's  
20 healthcare.

21 Wealth is a well-established indicator of access to health services in many countries  
22 regardless of income groups. Our analysis indicated that children from poorer and  
23 poorest households were more likely to be unimmunised. Given that immunisation  
24 services are available free of charge in Indonesia, the indirect cost of immunisation



1 may be the relevant factor instead. Lost work days and transport costs could deter  
2 parents from enabling their child to be immunised.[44, 45] The likelihood of being  
3 unimmunised was also higher among children without health insurance. This is  
4 reasonable because health insurance alleviate the burden of out-of-pocket spending,  
5 including indirect cost of immunisation. Most studies from developing countries have  
6 reported that health insurance has a positive impact on increasing healthcare  
7 utilisation.[46]

8 The odds of being unimmunised were considerably higher amongst children without  
9 antenatal and postnatal care. Children who were born without antenatal care were at  
10 least three times more likely to be unimmunised. Likewise, children who did not  
11 receive postnatal care had a 50% greater chance of being unimmunised (AOR 1.50;  
12 95% CI 1.34 to 1.69). This finding reflects the importance of information received by  
13 mothers during antenatal and postnatal care. Their visits might have equipped them  
14 with the necessary knowledge on child immunisation. In Indonesia, at least four  
15 antenatal visits are recommended during pregnancy. However, this service has been  
16 underutilised[29] and the negative implication of missed opportunities for  
17 immunisation coverage is almost certain.

18 There was a significant association between a child's place of delivery and  
19 immunisation coverage. Children who were born in public or private health institution  
20 were less likely to be unimmunised compared to those who were born at home. This is  
21 most likely because children who were born at health facilities were vaccinated, or  
22 were given recommendation to be vaccinated, immediately after birth. Furthermore, a  
23 study from Kenya has shown that women who deliver at home or unassisted may have

1 a distrust of modern medicine and a stronger preference for traditional remedies.[47]

2 By extension, they could have a sceptical view about childhood immunisation.[48]

3 Our analysis also showed that children who were born in private health institution had  
4 greater odds of being unimmunised relative to those who were born in public health  
5 institution (AOR 0.62; 95% CI 0.54 to 0.72 and AOR 0.55; 95% CI 0.47 to 0.64,  
6 respectively). In Indonesia, private health institution do not benefit from government's  
7 healthcare funding, although they do operate under the ministerial decree to deliver  
8 routine immunisation. Consequently, there is no financial incentive for private health  
9 institution to ensure that children are fully immunised. Therefore, strengthening the  
10 implementation of the ministerial decree for private health institution may help in  
11 improving immunisation coverage.

12 Children whose parents jointly decide on maternal healthcare were less likely to be  
13 unimmunised. This emphasises the importance of family support in utilising health  
14 services, confirming what had been outlined by Andersen in his theoretical  
15 framework.[13] The combination of both mother's autonomy and father's  
16 involvement in the decision making process seemed to be essential. This suggests that  
17 interventions which educate and involve fathers might have the potential to increase  
18 immunisation coverage.[49]

19 Although our findings were consistent with reports from other lower middle income  
20 countries, we found that several factors were not significant predictors of coverage in  
21 Indonesia. Despite reports from India, a child's sex did not affect coverage in  
22 Indonesia. This is consistent with studies from Nigeria undertaken by Antai[14] and  
23 Adebisi[50]. It appears that gender could predict immunisation status only if the child  
24 is from a society where gender inequality is prevalent.[50] We also found no

1 correlation between a mother's age and her child's immunisation status. Previous  
2 studies have reported that the odds of a child being unimmunised is greater for both  
3 younger and older mothers, suggesting a U-shaped association.[28] However, this  
4 association might be mitigated by patterns of other co-existing variables in our  
5 analysis, such as the child's birth order and the mother's level of education.

## 6 **Strengths and Limitations**

7 To our knowledge, this study was the first to identify factors associated with routine  
8 immunisation coverage of children in Indonesia. We used the 2012 IDHS dataset,  
9 which was the most recent one. The large sample size allowed us to analyse many  
10 potential predictors simultaneously. It also increased the validity of our results.  
11 Furthermore, we used multilevel modelling to account for the hierarchical structure of  
12 the data. We have also adjusted our analysis in order to meet the local context and  
13 produce reliable estimates. However, our results should be considered in the light of  
14 potential limitations.

15 As with other secondary analysis of cross-sectional survey data, caution should be  
16 exercised in inferring causality between the socioeconomic factors and immunisation  
17 coverage. In addition, the nature of our data source and analysis potentially limit  
18 generalisability. There is a need to verify the validity of the observed associations  
19 using longitudinal data.

20 Information on a child's immunisation status was subject to bias, because we included  
21 mother's report as a source of information. As such, we relied on the mother's ability  
22 to recall her child's immunisation status accurately. Nonetheless, mother's report is  
23 considered a valid measure of coverage in the absence of a health card, especially in

1  
2  
3 1 developing countries.[51] We therefore believe that our reliance on mother's report is  
4  
5 2 reasonable and not likely to have introduced bias into our study.  
6  
7

8  
9 3 The selection of variables included in this study relied on the information available  
10  
11 4 from the dataset. Other potential predictors that were previously identified in lower  
12  
13 5 middle income setting, such as ethnicity and religion, could not be assessed in this  
14  
15 6 study. Categorisation of original responses from the survey might have also influenced  
16  
17 7 the results.  
18  
19

20  
21 8 The 2012 IDHS selected participants through a two-stage stratified sampling design.  
22  
23 9 The primary sampling unit was the CBs and the complete list of households in each  
24  
25 10 CB became the basis for second-stage sampling. However, there was no household  
26  
27 11 identifier in the dataset as it may compromise the participants' anonymity. Therefore,  
28  
29 12 we could only build a two-level model (i.e. children nested within CBs) instead of a  
30  
31 13 three-level model (i.e. children within households nested within CBs). We recognise  
32  
33 14 that children living in the same household could have shared similar health  
34  
35 15 characteristics, which reflects parent-specific knowledge or beliefs on  
36  
37 16 immunisation.[12] However, our analysis of variables that served as a proxy of parent-  
38  
39 17 specific knowledge or beliefs (i.e. mother's exposure to media and mother's tobacco  
40  
41 18 use history) emerged as being insignificant. Therefore, we have good reason to believe  
42  
43 19 that this limitation is unlikely to have any impact on the validity of our analysis.  
44  
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48  
49 20 Finally, we classified immunisation status into 'fully immunised' and 'unimmunised'  
50  
51 21 based on whether the child received full schedule of immunisation or otherwise.  
52  
53 22 While other studies have utilised three distinct categories: fully immunised, partly  
54  
55 23 immunised, and completely unimmunised, we dichotomised our outcome variable and  
56  
57 24 did not distinguish partly immunised from completely unimmunised. This is because  
58  
59  
60

1 our study focused on factors associated with the coverage of routine immunisation,  
2 which is the complete uptake of recommended vaccination represented by the fully  
3 immunised. Reasons for Indonesian children being partly immunised and completely  
4 unimmunised might differ, and future research can potentially address this question.

## 5 **CONCLUSION**

6 In this study, we examined variables that contribute to a child's immunisation status in  
7 Indonesia. Our results suggested that immunisation coverage is suboptimal due to  
8 socioeconomic factors. Amongst the demographic groups, children who lived in  
9 Maluku and Papua region and children from the poorest households have the lowest  
10 coverage. We also identified maternal education and antenatal care visits as key  
11 factors that policymakers can target to improve immunisation coverage in Indonesia.

12 Beyond mapping trend of coverage nationally, we recommend regular monitoring and  
13 evaluation of coverage at province and district levels. This is important in order to  
14 identify high-risk areas and implement targeted activities in the communities.  
15 Increasing awareness and financial support for deprived households with more than  
16 one child may help reduce the indirect cost and motivate parents to immunise their  
17 children. Promoting equal access to education, encouraging institutional deliveries,  
18 and scaling up utilisation of antenatal and postnatal care may significantly improve  
19 coverage in Indonesia.

## 20 **5. List of Abbreviations**

21	CB	Census Block
22	EPI	Expanded Programme on Immunisation
23	GVAP	Global Vaccine Action Plan

1  
2  
3 1 IDHS Indonesia Demographic and Health Survey

4  
5 2 MOH Ministry of Health

6  
7  
8  
9 3 **6. Declarations**

10 4 **6.1 Acknowledgements**

11  
12  
13  
14 5 We are grateful to the ICF International for granting us access to the datasets and  
15  
16 6 to the Indonesia Endowment Fund for Education (LPDP) for funding PH a master  
17  
18 7 scholarship at the Department of Primary Care and Public Health Sciences, King's  
19  
20 8 College London. This analysis was part of PH dissertation.

21  
22  
23  
24 9 **6.2 Author Contributions**

25  
26  
27 10 PH and AD participated in the design of the study. PH performed the analysis and  
28  
29 11 prepared the manuscript. AD provided data analysis advice and revision of the  
30  
31 12 manuscript. All authors read and approved the final manuscript.

32  
33  
34  
35 13 **6.3 Competing Interests**

36  
37  
38 14 All authors have completed the ICMJE uniform disclosure form  
39  
40 15 at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) and declare: PH had financial support from  
41  
42 16 LPDP for the submitted work, no financial relationships with any organisations  
43  
44 17 that might have an interest in the submitted work in the previous three years; no  
45  
46 18 other relationships or activities that could appear to have influenced the submitted  
47  
48 19 work

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53 20 **6.4 Licence for Publication Statement**

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10 ever it may be located; and, vi) licence any third party to do any or all of the  
11 above.

## 12 **6.5 Ethics Approval**

13 This study did not require ethical approval as it used unidentifiable secondary  
14 data. Permission to use the dataset was obtained from ICF International, who  
15 obtained approval to conduct IDHS in 2012. No identifiable information was  
16 included in the dataset and no attempt was made to identify any individual  
17 interviewed in the survey.

## 18 **6.6 Data Sharing**

19 The electronic datasets analysed in this study are available for legitimate research  
20 purposes from the Measure DHS website: <http://www.dhsprogram.com/>.

## 21 **6.7 Transparency Declaration**

1 This manuscript is an honest, accurate, and transparent account of the study being  
2 reported. No important aspects of the study have been omitted, and that any  
3 discrepancies from the study as planned have been explained.

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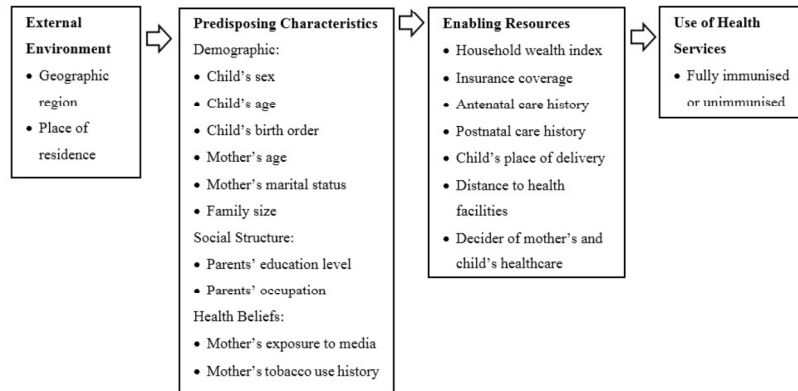
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## 19 8. Figure Legends

20 Figure 1: Theoretical framework of factors potentially associated with immunisation  
21 coverage of children in Indonesia, informed by Andersen's Behavioural Health  
22 Model.



26 Figure 1: Theoretical framework of factors potentially associated with immunisation coverage of children in  
27 Indonesia, informed by Andersen's Behavioural Health Model.

28  
29 338x190mm (300 x 300 DPI)

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Within the title
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Within the abstract
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 6
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	Page 7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 7
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	Page 7
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 8-9
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 8-9
Bias	9	Describe any efforts to address potential sources of bias	Page 9
Study size	10	Explain how the study size was arrived at	Page 9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 8-9
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Page 9-10
		(b) Describe any methods used to examine subgroups and interactions	Page 10
		(c) Explain how missing data were addressed	Page 9
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods	Page 10

		taking account of sampling strategy	
		(e) Describe any sensitivity analyses	Page 9
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	Page 9
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Table 1
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	Page 10
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 2 and Table 3
		(b) Report category boundaries when continuous variables were categorized	Table 1, Table 2 and Table 3
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 10
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	Page 20
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 27
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 21-27
Generalisability	21	Discuss the generalisability (external validity) of the study results	Limitation section
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Acknowledgements section



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2 \*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and  
3 unexposed groups in cohort and cross-sectional studies.  
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6 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and  
7 published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely  
8 available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at  
9 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is  
10 available at [www.strobe-statement.org](http://www.strobe-statement.org).  
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