

Delayed Immunization and Health of Children below 5yo during COVID-19 Pandemic

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Abstract This research addresses two investigations regarding the impact of pandemic COVID-19 on children's health in West Java, a province with the second highest number of children registered orphaned due to COVID-19. First, this study examines the probability of delayed immunization for children under 2yo and second it observes the health conditions of children aged below 5yo during pandemic in the same survey area. This research was conducted through a telephone survey of 500 respondents spread across 14 districts and 7 municipalities in West Java, a province that ranked number five among the provinces in Indonesia with the highest number of COVID-19 cases, with Bandung Metropolitan Area (BMA) indicating the largest number of cases after the Jakarta Greater Area. The analysis is estimated using probit regression for both models. The result shows parents are more likely to delay their children's immunization because they feel it is not safe to bring their children to a health facility. Increases in age of children positively contribute to probability of delayed immunization. Having a community health center close to home contributes to not delaying immunization. Investigations on the health conditions of children aged 5yo show that vaccinated toddlers were less likely to have health issues, particularly if they had regular meal frequency and had a habit of drinking milk. Mothers' education positively contributes to low health issues of children. Pandemic disrupts children's access to health care services particularly immunization. Children are more likely to have health issues when they do not receive basic immunization as well as internal factors such as dietary habits and mothers' education.

Keywords Immunization, Child, Pandemic COVID-19, Java, Indonesia

1. Introduction

The COVID-19 pandemic has caused several problems in aspects of people's lives, such as economic, health, and social aspects [1], [2]. In general, the COVID-19 pandemic has not only exacerbated public health problems, but also become the initial trigger for a crisis, both in terms of public health, economy, and even politics [3]. The global crisis due to COVID-19 has prompted many countries to implement social distancing policies, including closing community activities such as public spaces, shops and schools, and limiting economic activity.

According to the most recent Ministry of Health regular data report, Indonesia's coverage of the full range of basic immunizations has dramatically declined since the start of the pandemic, falling from 84.2 percent in 2020 to 79.6 percent in 2021 [4]. As a result, it may lead to more severe morbidity and death, which would place a cost on the state and impede economic recovery in addition to the issues generated by COVID-19. At the regional level, Java Island is the core of the COVID-19 virus in Indonesia, accounting for 82% of all confirmed cases and 70% of all deaths. As a result, the effect of COVID-19 is more severe for places on Java Island [5].

Immunization has a major role in improving health and

reducing mortality, especially in early childhood. In primary health care, immunization is an important component in protecting individuals from diseases that can be prevented by immunization (PD3I) [6], [7]. One of the most important health care facilities for implementing immunization programs is Posyandu. Posyandu, or pos pelayanan terpadu (integrated service post), is a community-based activity for health services in Indonesia.

BIAN or Bulan Imunisasi Anak Nasional (National Child Immunization Month) is a major Government-led catch-up campaign to complete the immunization status of children under five years old. The BIAN program was started in 2022 by the Indonesian Ministry of Health to increase basic immunization coverage, which has substantially decreased as a consequence of the COVID-19 pandemic.

Complete immunization status was defined as having received each of the following antigens in Indonesia: BCG vaccination, which prevents TB, 1 dose; hepatitis B vaccine, 4 doses (including 1 at birth); DPT vaccine, 3 doses; Haemophilus influenza type B vaccine, 3 doses; polio vaccine, 4 doses; and measles vaccine, 1 dose (see Table 1 for all types of primary childhood immunization schedule).

Table 1. Primary Childhood Immunization Schedule for Children Below 24 Months

No	Type of Immunization
1	Hepatitis B Vaccine
2	Polio Vaccine
3	BCG Vaccine
4	DPT Vaccine
5	Hib Vaccine
6	PCV Vaccine
7	Rotavirus Vaccine
8	MR/MMR Vaccine
9	Typhoid Vaccine
10	Hepatitis A Vaccine
11	Varicella Vaccine
12	Influenza Vaccine
13	Hib Vaccine

Source: IDAI 2020 Immunization Schedule from IDAI Official Website (2020) [8]

Several studies related to immunization during the pandemic revealed that there was a significant decrease in immunization at the beginning of the pandemic month in high-income countries when social distancing was implemented [9]–[11]. A study conducted by Chandir, Siddiqi, Mehmood, et al. and Chandir, Siddiqi, Setayesh, et al. using electronic immunization record data in Pakistan concluded that there was a 50% decrease in immunization during the lockdown policy [12], [13]. Furthermore, a

study conducted by Girma Masresha et al. in 15 African countries found a decrease of 10% in more than half of the countries [14]. Then Dinleyici et al. concluded that countries with lower immunization coverage in the pre-COVID-19 period experienced greater declines in the immunization of children. Reducing the number of children who have been immunized for a long time will have a significant impact in terms of serious outbreak risks such as measles [15].

This research aims to investigate two objectives. First is that it investigates factors contributing to parents' decisions about immunization for children under 2yo during the COVID-19 pandemic. In this case, we look at the probability of parents of children aged below 2yo to postpone/delay immunization due to the COVID-19 pandemic. Second is that this research investigates the factors contributing to the health status of children under 5yo during the COVID-19 pandemic. This study was conducted in 14 districts and 7 cities in West Java Province as the area with the first COVID-19 case in Indonesia. In addition, West Java Province is the third most vulnerable province in Java to the COVID-19 pandemic [16]. This study contributes to the body of knowledge regarding the importance of childhood vaccination and children's health status during the COVID-19 pandemic.

2. Materials and Methods

2.1. Study Design and Sample Size

The data used in this study is primary data obtained through a phone survey spread over 14 districts and 7 cities in West Java Province where the majority of respondents are from Kuningan Regency, Bandung Regency, Depok City and Sumedang Regency. The target samples are parents of children under the age of five, and the data collection process took place between November 1st until 27th, 2021.

As stated before, this study will investigate two objectives. First, we investigate the probability of parents of children aged below 2yo postpone/delay immunization due to the COVID-19 pandemic. In this case, we construct a dataset of children aged below 2yo because children/babies have to finish all the required vaccinations for the first two years of life.

Second, we investigate the health status of children below 5yo during the COVID-19 pandemic. For this, we construct a dataset of children aged below 5yo. In this case, we look at whether the children have experienced health complaints in the last four weeks.

The socioeconomic conditions of the households are separated into two categories based on the characteristics of parents and children, and are evaluated using a number of variables. Indicators used on the part of parents include age, place of residence, gender, marital status, education, occupation and income. The indicators used for the

children's characteristics are children's age and gender and children's health status. In addition, there is also health information such as access to health services during COVID-19 or parents' access to *Posyandu* services, and child immunization status.

2.2. Data Analysis

A total sample of 500 participants were interviewed, including mothers with children under 5yo. After processing the data collection, we obtained a total of 454 respondents who were willing to fill out the questionnaire. There were 129 respondents from the dataset who were discarded due to incomplete data filled in the questionnaire. Therefore, the total data used in this study after processing amounted to 325 respondents.

For the first model, we use probit regression to analyze the factors that contribute to parents' decisions about their children's immunization under 2yo. The dependent variable in the first model is delayed immunization which is a dummy variable with value of 1 if parents choose to delay immunization and 0 otherwise. In addition, the independent variables are the parents' subjective opinion about safety of the health center (1=safe and 0=unsafe), characteristics of parents (including residence, mothers' education, and revenue), characteristics of children (including age of child, child gender, experiencing outpatient care, and diet), and access to health care.

In the second model, we investigate the health status of children aged below 5yo. We collect data from all mothers who have children aged below 5yo to investigate the health status of their children. The dependent variable in the second model is child health status measured by a dummy variable with 1 if their children have had health complaints in the last four weeks and 0 otherwise. While, the independent variables are children and parent characteristics.

The probit model is a non-linear regression model that uses a dummy variable with a value of 1 or 0 as the dependent variable. In general, the probit model can be written as follows.

$$P_i = \Phi(Y_i)$$

$$= \Phi(\beta_0 + \beta_1 X_{1i} + \dots + \beta_p X_{pi}) \quad (1)$$

From the above equation, the function can be transformed into linear form as follows.

$$\Phi^{-1}(P_i) = \beta_0 + \beta_k X_{ki} + \dots + \beta_p X_{pi} \quad (2)$$

Where P_i is the probability of delayed immunization in the first model and the probability of experiencing health problems in the second model. While $\Phi^{-1}(P_i)$ is a normal cumulative distribution function (CDF), β_k and X_{ki} respectively are the coefficients of the regression model parameters and independent variables such as parents' subjective opinions about safety of the health center, parents' characteristics, and children's characteristics.

3. Results

3.1. Descriptive Analysis

Table 2 is dataset (sample) for the analysis of the first model group of children below 2yo. The table shows a summary of the characteristics of the respondents/parents for the children below 2yo. The majority of respondents are mothers (90.70 percent) with the age 26-35 years old. Almost 59 percent of the respondents had completed secondary education. In terms of household income, there are 55.04 percent of families with an income less than 2.5 million rupiah. The majority of children are between 16 and 24 months old and 52 percent are boys. The status of children's health shows that most children have had good health in the past month and the number of children who consume three meals per day amounted to around 72 percent.

This dataset shows that during the COVID-19 pandemic, there are 62.02% children aged below 2yo experienced no delays in immunization while 37.98% experienced delays. This shows that during the COVID-19 pandemic, the immunization program is still running, which is in line with the program that has been conducted by the Indonesian Ministry of Health.

Table 2. Summary Statistics of Children 0-24 months (N=129)

Variable	Percent
Parents' characteristics	
Gender	
Male	9.30
Female	90.70
Parents' Age (year)	
17-25	19.38
26-35	62.79
26-45	17.83
Parents' Education	
Elementary	8.53
Secondary Education	58.13
Bachelor	31.78
Master/Doctor Degree	1.55
Household Characteristics	
HH income	
<Rp.1.500.000	31.01
>Rp.1.500.000-Rp.2.500.000	24.03
>Rp.2.500.000-Rp.3.500.000	12.40
>Rp.3.500.000	32.56
Have Posyandu in the Community	
Yes	25.58
No	74.42
Children's Characteristics	
Age (month)	
Newborn:0-3	25.58
Infant:3-16	31.01
Toddler:16-24	43.41
Gender	
Boy	51.94
Girl	48.06
Child's health status	
Unwell	3.10
Quite healthy	27.13
Very healthy	69.77
Immunization	
No delayed	62.02
Delayed	37.98
Dietary	
Consume three meals in a day	72.87
Consume less than three meals in a day	27.13
Outpatient	
Yes	88.37
No	11.63

Source: survey data in 14 districts and 7 municipalities

Table 3 shows a group of children below 5 years old, which is the sample for the analysis of the second model. The data show similar characteristics to those below 2yo. In this dataset, around 91.08 percent of respondents/parents who answered the questionnaire are mothers between 26-35 years old (64.31 percent). In other characteristics, 58.46 percent of parents have completed their education to the upper secondary level and 67.69 percent of mothers are housewives.

The household characteristics of this group of data show that there are 51.07 percent of households with an income

less than 2.5 million rupiah. Around 42.15 percent of the households are located near the integrated service post (*Posyandu*). And around 57.85 percent of households are located far from the *Posyandu*. When it comes to children's characteristics, it shows that the majority of children are girls. Approximately 73 percent of children have good health conditions and around 1.8 percent have poor health conditions. In the immunization section, around 31.69 percent of mothers delayed immunization for their babies. Around 76 percent of children tend to have three meals a day and almost 93 percent never go for outpatient care.

Table 3. Summary Statistics of Children Below 5yo (N=325)

Variable	Percent
Parents' characteristics	
Gender	
Male	8.92
Female	91.08
Parents' Age (year)	
17-25	13.23
26-35	64.31
26-45	21.23
46-55	0.92
>56	0.31
Parents' Education	
Elementary	8.62
Secondary Education	58.46
Bachelor	31.38
Household Characteristics	
HH Income	
<Rp.1.500.000	25.85
>Rp.1.500.000-Rp.2.500.000	25.85
>Rp.2.500.000-Rp.3.500.000	16.31
>Rp.3.500.000	32
Have Posyandu (Community health care) in the Community	
Yes	42.15
No	57.85

Table 3 Continued

Children's Characteristics	
Age (month)	
Newborn:0-3	2.77
Infant:3-12	13.85
Toddler:12-60	83.38
Gender	
Girl	54.15
Boy	45.85
Child's health status	
Unwell	1.85
Quite healthy	25.23
Very healthy	72.92
Immunization	
No delayed	68.31
Delayed	31.69
Dietary	
Consume three meals in one day	76.00
Consume less than three meals in one day	24.00
Outpatient	
Yes	7.38
No	92.62

Source: survey data in 14 districts and 7 municipalities

3.2. Estimation Results

Table 4 presents estimation results of model 1, the probability of parents of children aged below 2yo postpone/delay immunization due to the COVID-19 pandemic. The more parents feel safe going to health facilities, the lower the probability of delayed immunization, which decreases by 0.296. It shows that parents who feel it is not safe to get immunizations for their children are more likely to delay immunizations. This result confirms that safety in health care centers is the most

important factor for mothers to consider when do immunization for their children.

Increases in age of children positively contribute to probability of delayed immunization by 0.011. The further the household's location from the posyandu the more likely that immunization will be delayed with probability of by 0.155. This shows that the distance to health facilities is one of the things that parents consider when bringing their children to receive immunizations.

Table 4. Probit regression on delayed immunization for children 0-24 months

Variables	Coefficients	Margins
Immunization Delayed (1=Delayed, 0=Otherwise)		
Feel Safe to go to health facility (1=Safe, 0=Unsafe)	-0.910*** (0.253)	-0.296*** (0.072)
Residence (1=Regency, 0=Municipality)	-0.110 (0.341)	0.036 (0.014)
Mother Education (Years of Schooling)	-0.012 (0.045)	-0.003 (0.014)
Revenue (log)	0.114 (0.170)	0.037 (0.055)
Age of Child	0.035* (0.018)	0.011** (0.005)
Child gender (1=Female, 0=male)	-0.268 (0.238)	-0.087 (0.077)
Outpatient care (1=Yes, 0=Otherwise)	0.484 (0.307)	0.157* (0.098)
Consume three meals in a day (1=Yes. 0=Otherwise)	0.105 (0.278)	0.034 (0.090)
Posyandu (Community Health Care) (1=Yes. 0=Otherwise)	-1.835* (2.385)	-0.155* (0.092)
Constant		-1.835 (2.835)
N		129

Robust standard errors in parentheses.

***p≤0.01, **p≤0.05, *p≤0.1

Source: Data Processing Results

The second objective of this paper is to investigate the health status of children below 5yo during the pandemic. The result (See Table 5) shows that immunization, drinking milk, children's diet as well as parental education contribute to children's health status.

Children who have completed immunizations experience a decrease in the probability of health complaints by 0.170. Children who regularly drink milk

show a less likely chance of experiencing health complaints by 0.213. Children who eat three meals a day have a lower chance of experiencing health complaints by 0.112. Parental awareness of children's health is an indispensable aspect where parental education can be a parameter. A one-year increase in parents' education decreases the probability of experiencing health complaints by 0.018.

Table 5. Probit Regression on health status of children under 5yo

Variables	Coefficients	Margins
Health Status (1=Experiencing health complaints, 0 =otherwise)		
Meet required Immunization (1=Yes, 0=otherwise)	-0.462** (0.184)	-0.170** (0.066)
Drink Milk (1=Yes, 0=No)	-0.579*** (0.215)	-0.213*** (0.077)
Child's meal frequency		
1=Once	-0.304*	-0.112*
2=Twice	(0.159)	(0.057)
3=Thrice		
Go to Posyandu (1=Yes, 0=otherwise)	0.175 (0.165)	0.064 (0.060)
Child gender (1=Female, 0=male)	-0.066 (0.144)	-0.024 (0.053)
Age of Child	0.003 (0.004)	0.001 (0.001)
Parent Revenue (log)	-0.033 (0.101)	-0.012 (0.037)
Marriage Status (1=Married, 0=otherwise)	-0.344 (0.674)	-0.127 (0.248)
Mother Education (Years of Schooling)	-0.051* (0.027)	-0.018* (0.010)
Constant		2.787* (1.515)
N		325

Note: Robust standard errors in parentheses.

***p<0.01, **p<0.05, *p<0.1

Source: Data Processing Results

4. Discussion

Analysis of the factors that affect parents' decisions to do immunization during the COVID-19 pandemic indicates that the factor that has the most significant influence on the sustainability of the immunization program is related to the fear of parents bringing their children to health facilities. As Zhai Y and Du X [17] reported, one of the factors that underlie parents' anxiety to get health services is due to high virus transmission, uneven vaccination, and no pharmacological treatment for healing. The most recent Indonesian Basic Health Survey report reveals that around 58 percent of children aged between 12 and 23 months had received all recommended vaccinations, which was lower than the government's target of 93 percent. In addition, the province of West Java is an area with a fairly high number of COVID-19 cases, so it is not surprising that people prefer to postpone immunization for their children. The same thing was stated by Buonsenso et al., Moraga-Llop et al. and WHO [18]–[20] which stated that the factors that

cause disruption are that many people feel worried about COVID-19 in health care settings, feel afraid to interact with the virus in waiting rooms, and try to avoid contact with individuals who have been exposed to COVID-19. In addition, parents are reluctant to leave their homes because they have to face transportation disturbances caused by being in every corner of the area [21]. Many studies have revealed that parents' anxiety was the most influential factor influencing the immunization schedule. The findings suggest a similar view about the importance of parents knowledge about health care status and services that contribute to their decisions on child vaccination [22].

The proportion of fully immunized children in Java is 67 percent although Java is the most populous island in Indonesia [23]. According to a recent study in Aceh and West Sumatra, Yufika A, Wagner AL, Nawawi Y, et al. [24] concluded that the majority of parents would not want their children to get immunization due to parents' hesitancy. The reason behind this is that parents worry about going to healthcare centers because of COVID-19 contracting. The

impact of COVID-19 on decreasing child immunization coverage is also reported in several other countries around the world. Several studies report that most parents have concerns about bringing their children to health either to obtain immunization or other services. Santoli et al. reported that there was a significant decline in immunization coverage in the United States when parents failed to bring their children for immunization, particularly non-influenza childhood vaccines [25].

Our estimation of the age of children shows that children approaching the age of 24 months have a greater probability to delay their immunizations during COVID-19. Ackerson et al. reported that children approaching one year are more likely to have completed some immunizations before COVID-19 and that children older than 24 months were more likely not to delay their immunizations compared to younger children because most older children had received their immunizations several months earlier [21].

The estimation of this study finds that distance to health care centers has a significant relationship with immunization delays. These results are in line with a study conducted by Mekonnen et al.; Hu et al.; Le Polain de Waroux et al. [26]–[28] which stated that the long distances to health care facilities were the main factor in delaying immunization by parents. Kitamura T et al. [29] emphasized that although most immunizations are provided free of charge, indirect costs may contribute to the ease with which a mother brings their child to receive immunizations at health services. The findings support the view about the role of community health care for children [30].

The investigation into the health status of children under 5yo during a pandemic (model 2) shows that children who have received immunizations have better health than children who have not received immunizations. This result is also in line with a study conducted by Hamid et al., [31] which stated that children with full immunization will minimize the occurrence of new diseases. A routine and scheduled vaccination in children will produce trained immunity from the innate immune system as well as antibody protection in children [32], [33].

Estimation of this study also finds that children who have the habit of drinking milk until the age of 5yo have a greater chance of not experiencing health problems. Setyarini et al. [34] stated that children who are given milk will have a positive influence on children's health, especially children's mental health problems. Breast milk is the best food for children, especially babies, with a higher nutritional content than artificial foods or milk from animals. In addition, Wijayanti & Meilisa [35] revealed in their research that breastfeeding children tend to have a normal weight compared to children who are not breastfed and tend to be overweight. Antibody substances for the baby's immune system are obtained by the fetus in the womb through the placenta which are also found in breast milk [36].

The other important factor based on this study in order to avoid children's health complaints is dietary habits. Children with three meals a day can prevent health complaints. However, this study only observes a general diet without looking at food quality such as nutritional content, calories and nutrients. Haines et al. found that eating more, especially when with family, makes children healthier [37]. This is because the food choices given are more considered by the family, such as providing more food that has nutrients [38].

Mother education contributes to preventing children from having health problems. This result was consistent with a study by Reiss et al. [39] which found that parental education has an influence on children's health because parents with higher education tend to know information related to nutritional and nutritional adequacy. In addition, Setyarini et al. [34] state that the majority of parents with a high level of education do not experience health complaints. Aslam & Kingdon [40] revealed that father's education is positively related to health-seeking behavior and mother's education is related to child health outcomes.

The knowledge of father regarding health aspects obtained through school has an influence on a child's immunization decisions, and through higher media exposure and better health knowledge, mother will contribute to the health of children [41]. Educated mothers of children have the ability to process information, particularly, to learn and implement the new method of childcare [42].

While our research has provided valuable insights into the state of immunization and child health during the COVID-19 pandemic in Indonesia, it is important to acknowledge some limitations that may affect the generalizability of our findings. Some limitations in this study are related to data, data treatment, and population diversity. In addition, the data in this study were collected during the COVID-19 pandemic by telephone survey, which may have influenced the answers given by respondents.

5. Conclusions

COVID-19 pandemic is the major disruption to the health program particularly for accelerating the immunization program in Indonesia. This study finds that the COVID-19 pandemic induced parents to delay immunization due to hesitancy and prevention of contacting COVID-19 in the health care center. However, the closer the age of the children to 24 months the more likely parents are to follow immunization schedules without delay. The closer to the *Posyandu*, the more likely parents are not to delay their child's immunization.

The investigation into the health condition of children below 5yo within the same survey area shows that children who meet basic immunization are more likely to have a good health status. Regular milk consumption and eating

frequency also contribute to healthy children as well as mother education.

The study contributes to the literature on the impact of the COVID-19 pandemic on the decision of immunization. Such that it will shed light on the importance of future innovation, better resource allocation and enhance preparedness of health service during disruption (pandemic) to maintain the basic service of health care/ health centers such as children's vaccination/immunizations.

The study also contributes to the literature on the health status of children during the COVID-19 pandemic. Understanding children's unique vulnerabilities to certain diseases or health conditions is vital in designing targeted interventions and treatments.

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