Characteristics of PHCs, District's Population, GRDP per Capita, and Covid-19 Booster Vaccination Coverage in Indonesia: Negative Binomial Regression Model

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Keywords: Covid-19 Booster Vaccination, Characteristics of PHCs, District's Population, GRDP per Capita.

Abstract: Public Health Center (PHC) is one of the health facilities designated to provide Covid-19 vaccination services and has an essential role in the success of the Covid-19 booster. This article explores the relationship between characteristics of PHC, population, Gross Regional Domestic Product (GRDP) per capita) and the Covid-19 booster vaccination coverage. This article used secondary data from the Ministry of Health (MoH) dashboard, 2019 Health Facilities Research data. The observation unit was a district/city has started organizing a Covid-19 booster vaccination, and all PHC were enumerated, as many as 512 regencies/cities. The model used to determine the factors affecting coverage of the Covid-19 booster vaccination is a negative binomial regression model since the dependent variable was not Poisson distributed. The result showed that the number of doctors, midwives, and nurses in PHCs, the proportion 24 hours electricity PHCs by district/city, remote PHCs, PHCs had a cold chain, the number of residents, and GRDP per capita had a significant effect on coverage of the Covid 19 booster vaccination. Improvement in the human health workforce, 24- hour electricity, cold chain availability, accessibility to PHCs, and the villages are essential factors in increased coverage.

1 INTRODUCTION

On December 31st, 2019, Wuhan, China, received the first report of the 2019 coronavirus disease (COVID-19) outbreak. The World Health Organization (WHO) declared this outbreak a pandemic on March 11th, 2020, following the disease's global spread and the death of over 3,000 people (World Health Organization, 2020). One month later, in April 2020, the Indonesian government declared the COVID-19 pandemic a national disaster after receiving reports from all provinces confirming the presence of COVID-19 on their territory (Presiden RI, 2020).

As of July 8th, 2022, there were 551,226,298 confirmed cases of COVID-19 worldwide, with 6,345,595 deaths. There were 6,106,024 approved COVID 19 in Indonesia, with 156,781 deaths (World Health Organization, 2022). The Indonesian government is taking massive anti-epidemic measures to provide comprehensive public health protection to prevent the spread of Covid 19. These efforts include public awareness, security, and mass vaccination against COVID-19 (Kementerian Kesehatan RI, 2021).

The mass vaccination campaign in Indonesia began on January 12th, 2021, one day after the President of Indonesia and several high-ranking Indonesian officials received the Sinovac vaccine for the first time as a symbol of the campaign's start (Andrianto and Manafe, 2021). The success of COVID-19 Vaccination can be measured by the proportion of the population that must be vaccinated to prevent the spread of infectious diseases. This can be calculated using the initial reproductive rate (R0), an epidemic statistic used to explain the transmission of contagious diseases (Anderson and May, 1985, Metcalf et al., 2015, Smith, 2019). According to WHO and the Indonesian Technical Advisory Group on Immunization (ITAGI), herd immunity can be formed with a minimum vaccination target of 70% (Kementerian Kesehatan RI, 2021). Until June 26th, 2022, the first dose of COVID 19 vaccination was given to 201,229,048 people (92.24%), the second dose to 168,718,027 people (74.40%), and a booster to 50,282,986 people (20.06%) (Kementerian Kesehatan RI, 2022).

On January 12th, 2022, the Advanced Dose of

Hermawan, A.
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DOI: 10.5220/0011643200003608
In *Proceedings of the 4th International Conference on Social Determinants of Health (ICSDH 2022)*, pages 167-173
ISBN: 978-989-758-621-7; ISSN: 2975-8297

CQVID-19 Vaccination (booster) began. The COVID-19 booster vaccination is administered after a person has received a total primary vaccination dose to maintain immunity and extend the protection period. The COVID-19 Vaccination Booster is provided free of charge by the government to people aged 18 and up, with priority given to the elderly and immunocompromised patients. The elderly booster vaccination target can be implemented simultaneously in all districts/cities. In contrast, the non-elderly target is implemented in districts/cities with dose one coverage of at least 70% and quantity one coverage for the elderly of at least 60% (Direktorat Jenderal Pencegahan dan Pengendalian Penyakit, 2022).

The Public Health Center (PHC) is one of the healthcare facilities designated to administer the COVID-19 booster vaccine. The large number of PHCs spread across all sub-districts in Indonesia represents a potential health facility for achieving high booster coverage. In Indonesia, no studies on PHC and population characteristics have been conducted. The research hoped to strengthen policies for implementing the COVID-19 booster vaccination.

2 METHOD

2.1 Data Source

This study used secondary data, which came from several data sources, including the 2019 health facility research data (Rifaskes) PHCs module, which provides data on the characteristics of PHCs. The information is taken from the Health Development Policy Agency, MoH (BKPK), which may be accessed by following specified guidelines at www.litbang.kemkes.go.id. Rifaskes 2019 is a national-scale study on health facilities, specifically PHCs, hospitals, clinics, and the practice of doctors/midwives. Data collection for Rifaskes 2019 PHCs takes place between June 1st and July 31st, 2019, depending on the number of PHCs in each district/city throughout Indonesia. Data on the projected population per district/city in 2019 and GRDP per capita in 2020 are from Statistics Indonesia, and booster vaccination data are from the Ministry of Health's dashboard data on COVID-19 vaccination coverage (Kementerian Kesehatan RI, 2022). The analysis unit consists of 512 districts/cities, and two districts are excluded from the analysis because of a lack of data.

2.2 Variable

The number of people who have received booster vaccines by districts/cities until June 26th, 2022, is the dependent variable in this study (Y). This information was from the Covid 19 vaccination coverage dashboard maintained by the Ministry of Health (Kementerian Kesehatan RI, 2022). The independent variables are the Number of PHCs by district/city (X1), the number of doctors, midwives, and nurses in PHCs by district/city (X2), and the proportion of PHCs with a travel time of more than 3 hours from PHCs to the remotest villages by district/city (X3). The following variables are the proportion of PHCs with 24-hour electricity by district/city (X4), the proportion of remote PHCs by district/city (X5), and the proportion of PHCs with cold chains by district/city (X6). The availability of refrigerators (freezers open top or side/refrigerator), refrigerator thermometers, cold boxes/vaccine carriers/flasks, water pack/ cool pack and vaccine temperature monitoring thermometer, and 24-hour availability of electricity from a power source were indicators of PHCs readiness in maintaining the cold chain. To calculate X1 to X6 used Rifaskes 2019 data. The number of population by district/city (X7) is information on the number of population of districts/cities obtained from a Statistics Indonesia report book on population projections in 2019 based on the Inter-Census Survey (SUPAS) organized by Statistics Indonesia (Badan Pusat Statistik et al., 2018). The 2020 GRDP per capita (x1000) (X8) is the average income of the Indonesian population calculated from the quotient of GRDP and people in regencies/cities in 2020, as also published by Statistics Indonesia (Badan Pusat Statistik RI, 2021).

2.3 Data Analysis

The data were descriptively analyzed to obtain mean, minimum, maximum, median, and standard deviation values to describe dependent and independent variables. Data were analyzed using a Generalized Linear Models (GLMs) (Greene, 1994). GLMs are a general form of the Linear Model. In the classical linear model, Y is assumed to be normally distributed. In GLM, the Y response variable can be distributed other than normal but is included in the exponential family (Exponential Terms) (Myers and Montgomery, 1997). The equisdispersion assumption, which states that the mean value and variance value are equal, is applied in Poisson Regression. However, the equisdispersion postulate is not always met in the real world.

Overdispersion occurs when the variance value is higher than the average value. Overdispersion in Poisson regression causes the regression parameter conjecture biased because the standard error's value is underestimated. Negative binomial regression is a method for dealing with overdispersion in Poisson regression (Hilbe, 2011, Greene, 1994). There are stages in the GLMs test. The first identified the distribution and then examined correlations between predictor variables in linear regression models, also known as multicollinearity, using the Variance Inflation Factor (VIF). We excluded a variable that variable had a VIF value greater than ten. The last stage was running GLMs, a negative binomial test with family(log) link (log).Results and discussion

2.4 Descriptive Statistics

Compared to other locations, the number of persons vaccinated with boosters seems to be the highest in Java and Bali. The population of Papua, Maluku, Nusa Tenggara and Sulawesi is still below 61080. However, certain regencies/cities in Kalimantan and Sumatra seem to be doing better. It resulted in a lower population density than in the Java and Bali areas (Figure 1). One of the reasons for low vaccination coverage in some locations is insufficient access to PHC services.

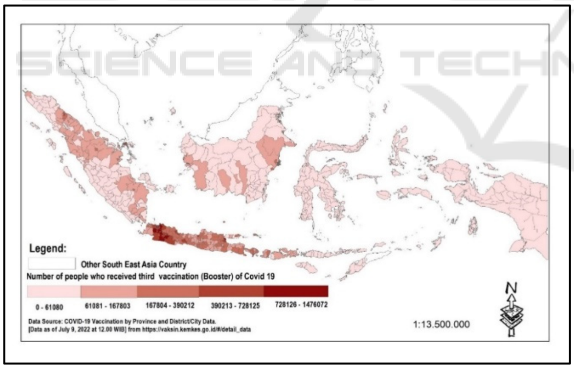

Figure 1: The number of people who have received booster vaccines.

Table 1: The statistical description of dependent and independent variables.

Variable	Statistic Descriptive				
	Mean	Minimum	Maximum	Median	SD
The number of people has received booster vaccines	98399,41	21	1476072	39824	167195,10
X1 The Number of PHCs	19,20	3	101	17	11,86
X2 The number of doctors, midwives, and nurses in PHCs	571,71	40	2177	475	367,13
X3 The proportion of PHCs with a travel time of more than 3 hours from PHCs to the remotest villages	7,99	0	100	0	14,40
X4 The proportion of PHCs with 24-hour electricity	87,08	0	100	97	21,80
X5 The proportion of remote PHCs by district/city	23,67	0	100	11	28,86
X6 The proportion of PHCs with cold chains	68,70	0	100	75	24,08
X7 The number of population	521648,90	13879	5965410	276597	647836,40
X8 The 2020 GRDP per capita (x1000)	54538,93	6851	753710	38707	62366,84

Table 1 reveals that, out of 512 regencies/cities, the average number of persons who have gotten the Covid 19 booster vaccination is 98399.41, with a minimum of 21 people and a high of 1476072, with a standard deviation of 167195.1. The Number of PHCs varies greatly, ranging from 3-101 PHCs with a median of 17 PHCs with a median number of physicians, nurses, and midwives (health professionals) PHCs in districts/cities with as many as 475 people, ranging from 40-2175 people.

The proportion of PHCs with travel time from PHCs to the remotest village of more than 3 hours, PHCs with 24-hour electricity, remote PHCs, and the proportion of PHCs with cold chain availability from storage until the vaccination spot ranges from 0 to 100 percent. The median percentage of PHCs with travel duration from PHCs to the remotest village of more than 3 hours (0 %) and the proportion of remote PHCs

(11 %) indicate that access to the community is limited in the coverage of the Covid 19 immunization. The median percentage of health facilities with 24-hour electricity availability (97%) and good cold chain availability (75 %) is, on the other hand, relatively high. Similarly, the range of population (13879-5965410) and GRDP per capita (6851-753710) is reasonably comprehensive, with a significant standard deviation. So, the data look varies greatly

2.5 Identification of Distribution

First, identify the distribution of the Y response variable using *the histogram*. Based on figure 2, the distribution of the Y response variable is not a bell-shaped curve (normally distributed) but right-skewed. Count data numbers identified as having a Poisson distribution (Maxwell et al., 2018). Identifying whether or not the bound variables follow the Poisson distribution is necessary. This distribution test used the Kolmogorov-Smirnov Test with a significance threshold of 0.05. The test findings indicated that the data for the Y variable was not Poisson distributed (P value < 0.005) (Table 2). Hence a negative binomial regression model was used for the GLM test.

2.6 Multicollinearity Test

Multicollinearity appears when two or more independent variables in the regression model are correlated. A little multicollinearity can occasionally result in significant issues, but when it is moderate to high, it becomes a problem that needs to be addressed (Daoud, 2017). We use the variance of inflation factor (VIF) to identify multicollinearity. We omitted the

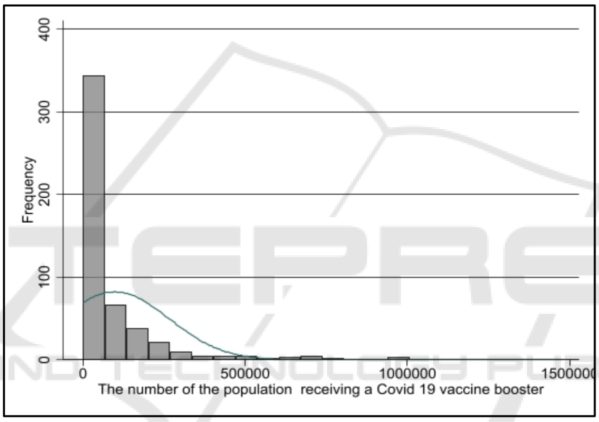

Figure 2: Histogram of Y variable.

Table 2: Kolmogorov Smirnov test.

The number of the population receiving a Covid 19 vaccine booster		Result test
N		511
Poisson Parameter	Mean	98399,41
Most Extreme Differences	Absolute	0,742
	Positive	0,742
	Negative	-0,254
Kolmogorov-Smirnov Z		16,766
Nilai P		0,000

Table 3. Multicollinearity Test.

Variable	VIF
X1 The number of PHCs	4,96
X2 The number of doctors, midwives, and nurses in PHCs	4,29
X3 The proportion of PHCs with a travel time of more than 3 hours from PHCs to the remotest villages	3,81
X4 The proportion of PHCs with 24-hour electricity	3,77
X5 The proportion of remote PHCs by district/city	2,46
X6 The proportion of PHCs with cold chains	1,92
X7 The Number of Population	1,78
X8 The 2020 GRDP per capita (x1000)	1,03

Table 4: Modelling using negative binomial regression predicts factors affecting the population receiving a Covid-19 booster vaccine.

Variable	Coef (95% CI)	Standard error	Pr (>|z|)
X1 The number of PHCs	$1x10^{-3}$	0,009	0,894
X2 The number of doctors, midwives, and nurses in PHCs	$4.8x10^{-4}$	0,000	0,019
X3 The proportion of PHCs with a travel time of more than 3 hours from PHCs to the remotest villages	$-7x10^{-3}$	0,004	0,097
X4 The proportion of PHCs with 24-hour electricity	$8x10^{-3}$	0,004	0,049
X5 The proportion of remote PHCs by district/city	$-6x10^{-3}$	0,002	0,010
X6 The proportion of PHCs with cold chains	$1,2x10^{-2}$	0,004	0,001
X7 The Number of Population	$1x10^{-6}$	0,000	0,000
X8 The 2020 GRDP per capita (x1000)	$3x10^{-6}$	0,000	0,000
Constant	8,39	0,329	0,000

variable if the variable exhibits multicollinearity (VIF > 10). Table 3 demonstrates that all independent variables have a VIF value of 10, indicating no multicollinearity in all variables. So, we included all variables in the ensuing study.

2.7 Generalized Linear Model (GLM)

GLM modelling will use a negative binomial distribution with a link function (log). The results demonstrated that the number of doctors, nurses, and midwives in PHCs, the proportion of PHCs with 24-hour electricity, remote PHCs, and PHCs with cold chain availability, as well as the population and GRDP per capita (x1000), had a significant impact on the coverage of the Covid 19 booster vaccination (Table 4).

The number of doctors, nurses, and midwives at the PHCs, the proportion of PHCs with 24-hour electricity, the Number of PHCs with a cold chain, the district population, and the GRDP per capita (x1000) have a positive impact. It indicates that the coverage of the Covid 19 booster vaccine increases as the number or fraction of variables increases. On the other hand, the proportion of remote PHCs and the fraction of PHCs with more than a three-hour travel time to the most distant villages had a negative effect on vaccination coverage for Covid 19 boosters. The higher the proportion, the lower the vaccine coverage.

The GLMs Model for Negative Binomial Regression distribution summarized:

$$\mu = Exp\,(8.39\,x10^{0} + 4.8x10^{-4}X_2 + 8x10^{-3}X_4 - 6x10^{-3}X5 + 1,2x10^{-2}X_6 + 1x10^{-6}X_7 + 3x10^{-6}X_8)$$

The study found that the number of doctors, nurses, and midwives at the PHCs positively impacts COVID-19 booster vaccination. This finding was still consistent with previous studies. The number or density of health workers affects the health indicators outcome such as life expectancy (Nguyen et al., 2016), immunization coverage (Mitchell et al., 2008), neonatal mortality (Sousa et al., 2013) and skilled birth attendant (Mayhew et al., 2008). Health workers are an integral part of the health system and play an essential role in achieving effective healthcare delivery. Health workers with adequate quantity and quality are essential because they directly affect the quality of health services (World Health Organisation, 2013, Ghosh, 2014).

The cold chain is used to keep vaccinations in potent condition during storage. It is also known as the supply chain for vaccinations or the immunization supply chain. From the point of manufacture to the point of administration, the cold chain comprises several linkages intended to keep vaccines within the temperatures specified by the WHO (2-8°C). Health facility freezers may be powered by electricity, solar energy, or gas to remain at the recommended temperature. A refrigerator for a medical facility should be chosen based on the most dependable power source (World Health Organization Department of Immunization, 2015). So, it was important that the availability of a cold chain and electricity as a power source in delivery services for COVID-19 booster vaccination.

The proportion of remote PHCs by district/city and PHCs with a travel time of more than 3 hours from PHCs to the remotest villages negatively impacts Covid-19 booster vaccination. Both are indicators of access to transport the Covid-19 vaccine booster and to deliver the vaccine to the receivers. Access will make it difficult for officials to provide covid 19 vaccine boosters. This result remains consistent with earlier research, which showed that accessing PHCs is a major obstacle to ensuring immunization services.(Ayeni et al., 1987, Al-Taiar et al., 2010, Hierink et al., 2021, Nainggolan et al., 2016). GRDP per capita is one of the indicators of the success of development implementation that can be used as a macro benchmark is economic growth (Romhadhoni et al., 2019). GRDP at the prevailing price describes the added value of goods and services calculated using the price per current year, while GRDP based on constant prices shows the added value of goods and services calculated using the prevailing price in one year as the base year (Badan Pusat Statistik RI, 2021). This study found that GRDP per capita affects Covid-19 booster vaccination success in districts/cities in Indonesia.

3 CONCLUSION

The study reveals that Java and Bali are regions with the highest number of people who have received Covid 19 booster vaccines. The number of doctors, nurses, and midwives at the PHCs, the proportion of PHCs with 24-hour electricity, the proportion of PHCs with a cold chain, the district population, and the GRDP per capita (x1000) have a positive impact. On the other hand, the proportion of remote PHCs and the fraction of PHCs with more than a three-hour travel time to the most distant villages had a negative effect on vaccination coverage for Covid 19 boosters. Improvement in the human health workforce, 24-hour electricity, cold chain availability, accessibility to PHCs, and the villages are essential factors in increased coverage

ACKNOWLEDGEMENTS

We would like to thank the Head of NIHRD MoH for allowing the author to analyze the 2019 Health Facility Research (Rifaskes) data. We also would like to thank Drs. Max Joseph Herman Apt., M.Kes for guiding me in writing this article

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