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Spatial Durbin Model on the Utilization of Delivery at Health Facilities: A 2017 Indonesian Demographic and Health Survey Analysis

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Abstract

The utilization of delivery at health facilities is a major intervention in reducing 16 to 33% of deaths. This study aimed to determine the model of utilization of delivery at health facilities in Indonesia in 2017 and its influential factors. This study used secondary data from the 2017 Indonesian Demographic and Health Survey using a Spatial Durbin Model (SDM) approach. The population was mothers aged 15 – 49 years, spread across 34 provinces of Indonesia, and had 15,321 samples. The results showed that the Moran's I value was positive (0.146) and significant at p-value = 0.007, indicating clustered regions with similar characteristics. The SDM modeling estimation results (R2 = 91.61%) presented those dependent and independent variables that influenced the utilization of delivery at health facilities and its influential factors. The significant and most dominant direct factor that influenced the utilization of delivery at health facilities was pregnancy visits, while the most dominant indirect factor was socioeconomic status. Therefore, further policy planning is expected to be based on regional specificities, and effective intervention programs should be designed based on these factors.

Keywords: delivery, health facilities, Spatial Durbin Model, utilization

Introduction

Pregnancy and childbirth are momentous times in a woman's life. The World Health Organization (WHO) estimates that 287,000 women died during and after pregnancy and childbirth in 2020.[1] Maternal mortality is a priority on the Sustainable Development Goals (SDGs) agenda. The global maternal mortality rate (MMR) in 2000-2020 decreased from 339 deaths to 223 deaths per 100,000 live births worldwide, according to the WHO.[1] In Southeast Asia, Indonesia ranked the third highest MMR in 2023 at 173 deaths per 100,000 live births after Cambodia and Myanmar.[2] As a developing country, not only does Indonesia have the largest population among Southeast Asian countries, but it is also an archipelagic country with natural resources that vary between regions. This is characterized by people living in urban and rural areas working in various sectors. Indonesia is a large and diverse country. Diversity is a valuable asset but has the potential to precipitate inequality and polarization that would trigger social instability. Therefore, an appropriate policy design is needed; in this case, information support from various dimensions is needed to see the phenomenon as a whole.[3]

Major interventions to reduce maternal mortality include the utilization of skilled birth attendance (SBA) at health facilities by providing safe delivery, reducing actual and potential complications, and improving the survival of most mothers and newborns.[4] It is estimated that utilization of delivery facilities could reduce maternal mortality by 16 to 33%.[5] The 2012 Indonesian Demographic and Health Survey (IDHS) data figured that delivery coverage at health facilities in Indonesia was 56%, increasing to 73.6% in 2017. This increase still leaves a gap, in which the achievement is higher in urban areas (88.1%) than in rural areas (60%). Apart from the area of residence, the delivery coverage in health facilities for women in the lowest quintile economic group (45%) is also still below the national average (73.6%).[6]

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The phenomenon of low delivery coverage in health facilities among women in rural areas is due to barriers to accessing health facilities where women from middle to lower economic groups have the lowest health insurance coverage, so they prefer to deliver to traditional birth attendants rather than health facilities. This needs attention for maternal health and safety reasons.[6] The 2022 delivery trend at health facilities demonstrated a slight decrease in the proportion of women who gave birth assisted by the SBA from 95.93% (2021) to 95.79% in 2022.[7] However, disparities in such achievement still occur. Research shows significant differences between regions,[8] where most provinces in Indonesia already have SBA-assisted delivery outcomes of more than 90%, which is still not evenly distributed. In contrast, Papua and Maluku, two provinces with achievements below 80%, need to be prioritized to achieve maximum coverage.[9]

Previous studies have explored factors associated with the utilization of delivery at health facilities,[10–14] but few studies have explored them using spatial analysis.[15,16] Spatial analysis is deemed more accurate as it is capable of addressing phenomena based on geographical aspects. Spatial analysis can also show the distribution of an object on a location map and explain the distribution type.[17] The Spatial Durbin Model (SDM) is a spatial regression analysis model that analyzes influential factors in social, economic, and health issues. The SDM functions to produce regression estimates to determine a relationship between variable X and variable Y based on the presence of spatial effects or dependencies in it.[18] Hence, this study applied the SDM to determine a relationship between spatial dependencies and influential factors to the utilization of delivery at health facilities, which could support further policies and strengthen existing studies in Indonesia.[19]

Method

This study used secondary data from the 2017 IDHS that was part of an international survey in a series of demographic and health survey programs organized by the Inner City Fund. The 2017 IDHS is a big data at provincial level, including data on giving-birth women aged 15-49 years spread across all provinces in Indonesia and factors thought to influence the extent of utilization of delivery at health facilities in 2017. The location of the study was in 34 provinces in Indonesia based on the 2017 IDHS report.[6] The sample size was 15,321 people spread across 34 provinces in Indonesia, obtained by examining all the mothers who used health services from their first to sixth child.

Variables for the SDM analysis consisted of a dependent variable (the rate of mothers using health facilities for delivery/Y) and independent variables: rates of mothers aged 20-35 years (X1), working mothers (X2), mothers with lower socioeconomic status (X3), mothers with insurance (X4), mothers in urban areas (X5), mothers with antenatal care (ANC) visits ≥4 (X6), women with complications (X7), and women with a planned pregnancy (X8) utilizing health facilities for delivery.

The analysis in this study used a survey data analysis with complex sample design, so that the results obtained could represent the population in which each unit had its own weight in each region. The stages of analysis included describing the rate of utilization of delivery at health facilities and its influential factors from a territorial point of view by using thematic maps and testing effects of spatial dependency between locations. Different methods of testing were taken to determine the existence of spatial effects: spatial dependence and heterogeneity in the data. The spatial dependence or autocorrelation between locations was tested using Moran's I method. The hypothesis used was H_1: $I_M \neq 0$ (i.e. there were dependencies between locations).

The final stage was a modeling using HR regression. Regression analysis is a statistical analysis to model the relationship between dependent variables (Y) and independent variables (X). This relationship can be expressed in a linear regression model. The model developed by Anselin uses a cross-sectional spatial data. The general model of the General Spatial Model is shown below: [20]

$$\mathbf{y} = \rho \boldsymbol{W_1 y} + \mathbf{X\beta}$$

$$\text{where } \mathbf{u} = \lambda \mathbf{W_2 u} + \boldsymbol{\varepsilon}, \text{and } \boldsymbol{\varepsilon} \sim \mathrm{N}(0.\sigma^2 \mathbf{I}) \text{ [20]}$$

The matrices of W_1 and W_2 were weights indicating a proximity between locations. The diagonal was zero or $w_{ij} = 0$ for i = j and $w_{ij} \neq 0$ for I ≠ j where i (i = 1,2,., n) and j (j = 1,2, n) were observations or locations. While the SDM is characterized by the addition of spatial lags in the independent variable. The SDM model was expressed in the following equation:[20]

$$\mathbf{y} = \rho\mathbf{W_1 y} + \mathbf{\beta_0} + \mathbf{X\beta_1} + \mathbf{W_1 X\beta_2} + \boldsymbol{\varepsilon}$$
$$\text{where } \boldsymbol{\varepsilon} \sim \mathrm{N}(0.\sigma^2\mathbf{I})^{20}$$

Results

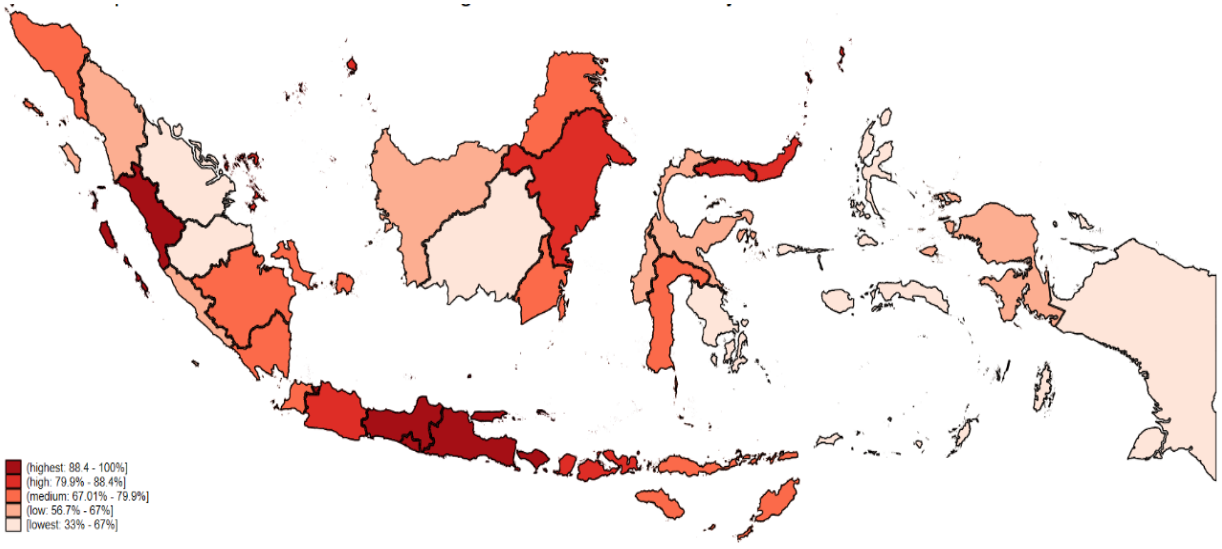

Figure 1. Spatial Distribution of the Percentage of the Utilization of Delivery at Indonesian Health Facilities, 2017 (Source: Personal Data Analysis Result by using STATA 15)

The average rate of mothers utilizing health facilities for delivery in Indonesia was 72.5%. It was categorized as high if a province reached the rate at greater than 72.5% and as low if less than or equal to 72.5%. Five provinces with highest rates were the Special Region of Yogyakarta (100%), Bali (98.8%), the Special Capital Region of Jakarta (97.6), Central Java (96.4%), and West Sumatra (93.9%). In contrast, seven provinces representing each of Indonesian islands were at lowest rates: Maluku Island (Maluku Province at 33% and North Maluku Province at 38.1%), Kalimantan Island (South Kalimantan Province at 41.8%), Papua Island (Papua Province at 48.4%), Sulawesi Island (Southeast Sulawesi Province at 51.6%), and Sumatra Island (Riau Province at 55.5% and Jambi Province at 56%).

Table 1. The Results of Linear Regression Analysis of Delivery Utilization in Health Facilities in Indonesia

Variable (Proportion)	Coef.	SE	T	p-value	[95% Conf.]	
Age	-0.352	0.793	-0.45	0.658	-2.011	1.299
Education	0.218	0.467	0.47	0.645	-0.756	1.193
Parity	0.005	0.626	0.01	0.993	-1.300	1.311
Knowledge	0.166	0.324	0.51	0.613	-0.509	0.843
Occupation	0.204	0.266	0.76	0.453	-0.352	0.761
Socioeconomic	0.130	0.727	0.18	0.860	-1.387	1.647
Insurance	0.390	0.222	1.75	0.095	-0.073	0.854
Decision	-0.143	0.296	-0.48	0.635	-0.761	0.475
Region	0.195	0.159	1.23	0.235	-0.137	0.528
Distance	-0.324	0.624	-0.52	0.610	-1.627	0.979
Visit	1.278	0.499	2.56	0.019	0.237	2.319
Complication	0.678	0.864	0.78	0.442	-1.124	2.481
Planning	0.127	0.208	0.61	0.546	-0.306	0.561

Table 2. Classic Assumption Test on the utilization of delivery at health facilities in Indonesia

Assumption Test	Test Name	Estimation	Criteria	Conclusion
Error Normality	Shapiro-Wilk W	0.951	p-value = 0.3175	Not fit
Homogeneity	Breusch-Pagan	0.420	p-value = 0.515	Fit
Multicollinearity	VIF	<10	<10	Fit
Autocorrelation	Durbin Watson	2.270	<-2 < DW <2	Not fit

Notes: VIF = Variance Inflation Factors, DW = Durbin Watson.

Based on the results of classical regression analysis at the initial stage above, all risk factors do not have a significant effect on the utilization of health facilities for delivery. However, this result was influenced by several assumptions that have not been met, such as normality and autocorrelation; therefore, the above results become biased and invalid. The next stage was detecting the existence of spatial influence on the utilization of health facilities for delivery. One way to determine a spatial dependency between locations was to perform spatial autocorrelation, in this case, by using Moran's I, Geary's C, and Getis & Ord G test statistics.

Hypothesis:

H0: No spatial autocorrelation between locations

H1: There is spatial auto-correlation between locations

Table 3. Spatial Autocorrelation Test on the Utilization of Delivery at Health Facilities in Indonesia

Variable	Moran's I		Geary's C		Getis & Ord's G	
	I	p-value*	C	p-value	G	p-value
Benefit	0.146	0.007	0.708	0.002	0.263	0.014

*): significant at p-value of ≤0.05

Based on the three criteria using Moran's I, Geary's C, and Getis & Ord G test statistics, the benefit variable was found consistently identified as having significant spatial autocorrelation with values of I = 0.146 (p-value = 0.007), C = 0.708 (p-value = 0.002), and G = 0.263 (p-value = 0.014). This indicated that the utilization of delivery at health facilities was interrelated between regions. The Moran's I value was positive, indicating clustered regions with similar characteristics. Hence, provinces with a high rate of utilization would also influence mothers aged 15-49 years to highly utilize health facilities in their nearby areas for their deliveries, and vice versa. The following table presents the results of spatial diagnostic test to determine appropriate spatial regression model where spatial effects are inherent in this study.

Table 4. Spatial Diagnostic Test on the utilization of delivery at health facilities in Indonesia

Test	Statistic	p-value
Spatial error:		
Moran's I	0.675	0.49
Lagrange multiplier	0.207	0.64
Robust Lagrange multiplier	0.000	0.98
Spatial lag:		
Lagrange multiplier	3.560	0.05*
Robust Lagrange multiplier	3.353	0.06

*): significant at p-value of ≤0.05

Based on the diagnostic test above, the selection of the spatial regression model to be carried out was spatial lag using the Lagrange multiplier function, in which the area approach calculates the influence of spatial lag weighted on the dependent variable, which was the utilization delivery at health facilities. Spatial modelling applied in this study was the SDM with the maximum likelihood estimation method because using the usual ordinary least square method estimation method would produce biased and inconsistent parameters. This spatial regression model was a development of the Spatial Autoregressive Model (SAR) in which the spatial lag was not only weighted on the benefit variable, but also had the characteristic of a spatial lag on the factor variable (X) in this study. The SDM concerned is as follows:

$$Y_i = \rho \sum_{j=1}^{n} W_{ij} Y_j + \alpha + \sum_{k=1}^{p} \beta_k X_{ik} + \theta_k \sum_{j=1}^{n} (W_{ij} X_{kj}) + \varepsilon_i$$

Notes:

ρ = spatial lag parameter of variable Y
W = weight matrix, size n x n
Y = vector of response variables, of size n x l
α = constant
β = regression parameter
X = risk factor variable matrix, size n x p
θ = spatial lag parameter of variable X
ε = error vector, of size n x l

The determinants for the utilization of delivery at health facilities with the Spatial Durbin equation obtained are as follows:

$$Utilization_i = 26.61 \sum_{j=1}^{34} w_{ij} Utilization_j - 174.56 + 0.02 * Age + 0.03 * Jobs + 0.18 * Socioeconomic + 0.6 * Insurance + 0.35 * Region + 1.84 * ANC\ Visit + 0.65 * Complication + 0.19 * Pregnancy\ Planning + \theta_k \sum_{j=1}^{34} (w_{ij} x_{kj})$$

So, the details of the final spatial Durbin model (pseudo R2 = 91.61) obtained are as follows:

Table 5. The Final Spatial Durbin Model on the Utilization of Delivery in Health Facilities in Indonesia

Variables	Coef	Direct				Indirect			
		dy/dx	95% CI		p-value	dy/dx	95% CI		p-value
Age	0.020	0.020	0.013	0.027	<0.001*	0.000	-0.010	0.011	0.934
Occupation	0.034	0.039	-0.261	0.340	0.796	0.409	-0.319	1.138	0.271
Socioeconomic	0.179	0.217	-0.516	0.951	0.562	2.821	1.202	4.439	0.001*
Insurance	0.609	0.608	0.403	0.813	0.000*	-0.017	-0.297	0.262	0.902
Region	<0.001	0.355	0.209	0.502	0.000*	0.394	0.006	0.783	0.046*
ANC visit	0.350	1.822	1.325	2.319	0.000*	-1.723	-2.378	-1.068	<0.001*
Complication	0.654	0.655	-0.110	1.421	0.093	0.058	-1.054	1.170	0.918
Planning	0.197	0.205	-0.043	0.455	0.106	0.643	0.154	1.131	0.010*

Notes: ANC = antenatal care; *): significant at p-value of ≤0.05

The most dominant and positive variable directly affecting the utilization of delivery at health facilities was ANC visit, while socioeconomic had the most dominant indirect effect among women aged 15-49 years in Indonesia. Indirectly, a pregnant woman's socioeconomic status influenced the utilization of delivery at health facilities with a p-value of 0.001. For every 1% increase in the socioeconomic status of pregnant women, the indirect effect of thr utilization of delivery at health facilities increased by 2.8%.

The age and insurance status of a pregnant woman had a significant direct effect on the utilization of delivery at a health facility with a p-value of <5% (<0.001). By region, pregnant women residing in urban areas had a significant effect on the utilization of delivery at health facilities in Indonesia with a p-value of <5% (<0.001). For every 1% increase in pregnant women residing in urban areas, the utilization of delivery at health facilities increased by 0.35%. ANC visits were the most dominant factor influencing the utilization of delivery at health facilities with a p-value of <0.001. For every 1% increase in pregnant women with a minimum of four ANC visits during pregnancy, the rate of the utilization of delivery at health facilities increased by 1.82%.

Discussion

Studies conducted in developing countries had also shown significant regional variations in the utilization of delivery at health facilities.[15,21-22] This may be due to inaccessible health facilities and inequality in the distribution of skilled resources (health workers) in remote areas. It may also be due to sociocultural and socioeconomic differences among women in different regions and limited access to information on maternal health services. When delivery at health facilities is low, possible causes include unsupportive societal traditions and unavailable funds, in addition to considerations of the location and maximum carrying capacity of each health facility, the geographical distribution of

the population, the landscape that the patient must traverse to reach the health facility, and the mode of transport.[22] Hence, if a gap was found in factors such as geographical variations in the topography of the region (for example. mountainous areas, uneven land contours, large areas of the forest) with an impact on transportation barriers, it would further lower the interest of mothers to give birth at health facilities.[23] Furthermore, the spatial study is pivotal due to the spatial influence where the location of province is separated between regions.

The utilization of delivery at health facilities in the Western Indonesia is likely better than in the Eastern Indonesia.[19] This condition is in line with the development process in Indonesia, which also tends to show disparities between the Western and Eastern regions. This situation is motivated by an archipelagic state of Indonesia. Economic movements and development between regions make the development gap between regions continue. Such gap also affected people's accessibility to health facilities, including the utilization of delivery at health facilities.[24] The development process in the West compared to the East could be observed,[3,25] specifically the Java Island that is the centers of Indonesian Government and various activities in the economy, education, transportation, technology, and so forth compared to other Indonesian islands.[26] Another study in the West Africa also found similar results.[27] This proves that spatially, geographical conditions in a region contribute to creating disparities, including the utilization of delivery at health facilities.

Many factors are associated with the utilization of facility-based delivery in Indonesia. The most direct determinant is ANC visit. This finding is in line with previous studies in Ghana[28] and Zambia.[29] This suggests that the process of interaction during ANC is a determinant factor in the subsequent utilization of maternal services. This is related to the expectations and satisfaction with the health services received by patients,[30] including their perspectives on the services received. In addition, women having more of ANC visits were more likely to receive information on complications associated with home delivery, thus motivating them to utilize delivery at health facilities with SBA.[29]

The indirect factor is socioeconomic, in which this finding is consistent with studies in Ghana[31] and Zambia.[29] This is likely because higher socioeconomic status could help women pay all the costs charged for delivery at a health facility. A better economic status may further improve health-seeking behavior and autonomy in healthcare decision-making, thus having an indirect positive influence on overall health service utilization. This reinforces the idea that socioeconomic influences the preference to deliver at a health facility.

Conclusion

The distribution pattern of the utilization of delivery at health facilities shows the existence of regional groupings based on their characteristics. Five provinces with the highest number of utilization presentations are the Special Region of Yogyakarta, Bali, the Special Capital Region of Jakarta, Central Java, and West Sumatra; while, the lowest ones are Maluku, North Maluku, South Kalimantan, Papua, Southeast Sulawesi, Riau, and Jambi Provinces. Based on the results of estimating parameters of the SDM modelling, the lag of dependent and independent variables affects the modelling of childbirth utilization and its influential factors. Directly influential variables are age, insurance ownership, region, and ANC visits; while indirectly influential variables are socioeconomic and pregnancy planning.

Abbreviations

WHO: World Health Organization; MMR: maternal mortality rate; SBA: skilled birth attendance, IDHS: Indonesian Demographic and Health Survey; SDM: Spatial Durbin Model; ANC: antenatal car; VIF: Variance Inflation Factors; DW: Durbin Watson.

Ethics Approval and Consent to Participate

The 2017 IDHS has obtained ethical approval from the Health Research and Development Agency of the Indonesian Ministry of Health. Respondents' identities have all been removed from the dataset. Respondents have provided written consent for their involvement in this study. The use of the 2017 IDHS data for this study has received permission from ICF International for analysis: https://dhsprogram.com/data/new-user-registration.cfm

Competing Interest

The authors declare that there are no competing interests, financial or otherwise that might influence the presentation of the work described in this manuscript.

Availability of Data and Materials

The data is available online and can be accessed on https://dhsprogram.com/.

Authors' Contribution

ISW, IG, MRM, and TR were equally participated in the conceptualization of the study design and interpretation of the data, critically revised the manuscript, and approved the final manuscript.

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