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Spatial Modeling of Infant Mortality Rate In Sampang Regency : An Ecological Study

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Abstract

Infant mortality rate (IMR) is one of the indicators to measure public health status and community welfare. In the last 3 years (2014-2016), the infant mortality rate in Sampang Regency has increased. The purpose of this study is to develop spatial-based modeling of factors affecting infant mortality rates in Sampang. Researchers used an ecological study design where secondary data came from the Health Office and the Central Bureau of Statistics in Sampang Regency. The dependent variable is infant mortality rate, while the independent variables are delivery assisted by health workers, exclusive breastfeeding coverage, neonatal complications handled, K4 visit coverage, LBW percentage, midwife to population ratio, percentage of clean and healthy household behavior. Data has been analyzed and processed using Geoda and Quantum GIS applications. Based on statistical tests, the spatial model is obtained: $\hat{y}_i$= -21.82+0.706 $\sum_{(i=1,i\neq j)}$^n $w_{ij}y_i$-0.61* childbirth attended by health worker+0.10* neonatal complications attended by health worker+1.89* LBW babies. Each variable of childbirth assisted by health workers increased by 10, it can decrease the infant mortality rate by 6.1 cases. Each variable of neonatal complications not handled by health workers rises 10 units, it can increase the infant mortality rate by 1 case. each variable of LBW babies rises 1 unit and it can increase infant mortality cases by 1.89 cases. The results of this study can be used to reduce infant mortality rates that occur by intervening in existing factors.

Keywords: Infant mortality rate, spatial modeling, LBW

1. Introduction

Infant mortality rate (IMR) is one of the indicators that can be used to measure public health status indicators and community welfare indicators. IMR measurement is a strategic way to measure the achievement of health and development performance in the region (Sholiha, 2017). Infant Mortality Rate (IMR) is an indicator that is directly related to child survival targets and reflects the social and economic conditions and environment in which children live (Lazuwardi, 2018).

Infant mortality is a death that occurs between the time after the baby is born until the baby is not yet one year old. This infant mortality rate shows the number of deaths of infants aged 0 years out of every 1000 live births or can also be referred to as the probability of an infant dying before reaching one year of age (Heft-Neal et al., 2018).

There are many factors that influence the IMR rate, the 2002-2003 Indonesian Demographic and Health Survey categorized the causes of IMR into two groups of causes, namely socioeconomic and biodemographic factors. Socioeconomic factors include place of residence, education, wealth index. Biodemographic variables include maternal age, parity. In addition, there are several other variables that affect IMR, including the baby's weight at birth, routine antenatal check-ups, labor attendants, and complications during delivery (Adewuyi et al., 2017; Dinas Kesehatan Provinsi Jawa Timur, 2017).

According to UNICEF, the infant mortality rate (IMR) in the world is still relatively high where the infant mortality rate reaches 10 million deaths, as many as 90% of infant mortality cases occur in developing countries. The highest IMR occurs in the East Asia and Pacific region which reaches 69 per 1000 babies followed by the Latin America and Caribbean region which reaches 67 per 1000 babies (UNICEF, 2014).

In Indonesia, the infant mortality rate from 1991 to 2015 has decreased significantly. IMR in 1991 reached 68 per 1000 live births, decreased to 34 per 1000 live births in 2007 and continued to decline until in 2015 it became 22 per 1000 live births (Kementerian Kesehatan Republik Indonesia, 2016). In East Java province the infant mortality rate (IMR) tends to decrease, in 2013 the IMR in East Java reached 27.5 per 1000 live births, in 2014 it became 26.6 per 1000 live births while in 2015 it became 25.3 per 1000 live births (Dinas Kesehatan Provinsi Jawa Timur, 2016). Meanwhile, in Sampang district the number of infant deaths is increasing. In 2014 the number of infant deaths under the age of 1 year reached 1.7 per 1000 infants. In 2015 it increased to 10 deaths per 1000 babies. In 2016 the infant mortality rate increased again to 12 cases per 1000 babies (BPS Kabupaten Sampang, 2016).

There are several risk factors that can cause infant mortality, such as pregnancy examination and consultation, low body weight, type and shape of pregnancy, and age of pregnancy. In addition, the factor of labor is also one of the important factors that affect the incidence of infant mortality. In addition, lifestyle and behavioral factors in caring for infants such as exclusive breastfeeding behavior and personal hygiene behavior as well as the application of a clean and healthy lifestyle also play a role in the incidence of infant mortality (Garcia et al., 2019; Vijay and Patel, 2020).

The high infant mortality rate that occurs in Sampang Regency indicates the low health status of mothers and infants. in addition, there is still low access and quality of maternal and child health services, especially during labor and afterwards. Therefore, it is necessary to conduct further research to determine the factors that cause infant mortality in sampang district. The purpose of this study was to develop a spatial-based modeling of factors affecting infant mortality in Sampang.

To detect environmental conditions, remote sensing technology and Geographic Information System (GIS) can be used. The mapping that has been done is expected to produce a distribution map of the risk of infant mortality in Sampang Regency as well as mapping of social risk factors and the physical environment at risk. (Ferreira-guerrero et al., 2018). Spatial analysis can be utilized as a strategy for prevention and other interventions related to infant mortality by considering the form of intervention according to the amount of risk so as to create effective and efficient interventions according to the risk characteristics of each region so that it will have an impact on reducing infant mortality cases in Sampang Regency (Shaweno et al., 2018).

2. Methode

This research is an ecological study with an area-based spatial approach conducted in Sampang district. This research was conducted in Sampang Regency using secondary data published by the Sampang Regency Health Office and Sampang Regency Central Bureau of Statistics.

The population in this study were all sub-districts located in the administrative area of Sampang Regency. The variables to be studied are infant mortality rate as the dependent variable and the independent variables studied are childbirth assisted by health workers, exclusive breastfeeding coverage, neonatal complications handled, K4 visit coverage, percentage of LBW, midwife to population ratio, percentage of household PHBS. The data obtained was then analyzed to see the relationship between the independent variable and the dependent variable spatially with a 90% confidence level, data analysis was carried out using Quantum GIS and Geoda applications.

The quantum GIS application is used to map risk areas related to the independent and dependent variables to be analyzed.

Geoda application is used to conduct Spatial modeling analysis both Spatial Autoregressive Models (SAR) and spatial error models (SEM).

Before conducting SAR and SEM analysis, researchers tested spatial effects using the Lagrange Multiplier (LM) test. The Lagrange Multiplier (LM) test is used as a basis for selecting the appropriate spatial regression model (LeSage and Pace, 2009). The first step in this test is to create a simple regression model through Ordinary Least Square (OLS). Then identify the existence of a spatial model using the LM test.

If LM_{error} is significant then the appropriate model is SEM, and if LM_{lag} is significant then the appropriate model is SAR. If both are significant then the appropriate model is Spatial Autoregressive Moving Average (SARMA). Robust Lagrange Multiplier test is also performed when both are significant. This test consists of Robust LM_{error} and Robust LM_{lag}. The Lagrange Multiplier test consists of LM_{lag} and LM_{error}.

LM_{lag} is used for SAR model identification. The Spatial Autoregressive model is a model that combines a simple regression model with a spatial lag on the dependent variable using cross section data. This model is the development of the first order autoregressive model, where the response variable in addition to being influenced by the lag of the response variable itself is also influenced by predictor variables. Spatial Error Model is a spatial error model where there is spatial correlation in the error. The spatial error model is formed if $W1 = 0$ and $\rho = 0$, so this model assumes that the autoregressive process is only in the error model

3. Results and Discussion

3.1 Results

The results of the analysis that has been done in Figure 1, infant mortality cases that occurred in sampang district in 2017 almost occurred in all existing sub-districts except in ketapang sub-district which had an infant mortality rate of 0. There are 4 areas that have a high infant mortality rate (12-18 per 1000 babies) namely in sreseh, tambelangan, omben and camplong sub-districts. Areas in the northern area of Sampang Regency have a lower infant mortality rate than areas in the southern area. This is shown in the infant mortality rate in the Banyuates, Ketapang, Sokobanah and Robatal areas which have an infant mortality rate of 0-6 per 1000 births.

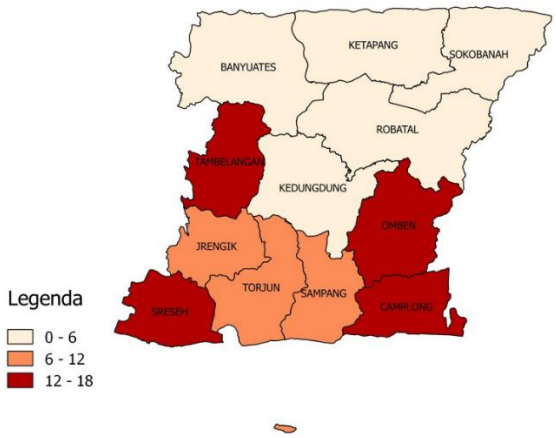

Fig 1. Distribution of Infant Mortality Cases in Sampang Regency in 2017

The percentage of births attended by health workers is good, according to Figure 2 there is only 1 sub-district that has a percentage achievement below 90%, namely Tambelangan sub-district, while the areas of Banyuates, Ketapang, Robatal, Kedungdung and Camplong have a percentage of births attended by health workers in the high range of 90 - 100%, while the areas of Sokobanah, Omben, Sampang, Torjun, Jrengik and Sreseh have a percentage achievement of births attended by health workers reaching 100%.

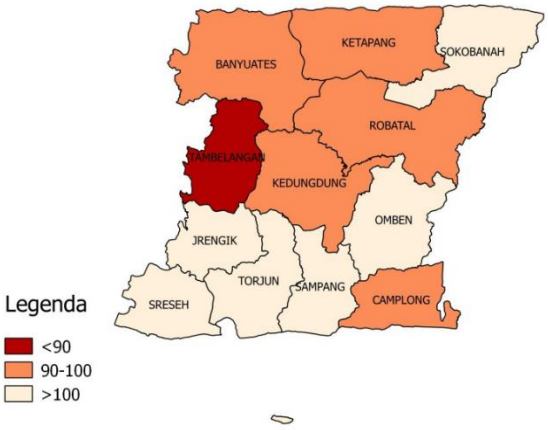

Fig 2. Percentage of Births Assisted by Health Workers in Sampang Regency in 2017

The percentage of exclusive breastfeeding coverage is generally not good, according to Figure 3 overall sub-districts have a percentage of 50- 75%, namely in Banyuates, Ketapang, Sokobanah, Tambelangan, Kedungdung, Jrengik, Sreseh, Torjun and Omben sub-districts and there is 1 sub-district that has an achievement below 50%, namely in Robatal sub-district. There is 1 sub-district that has an achievement of a fairly good percentage of exclusive breastfeeding, namely in Camplong sub-district.

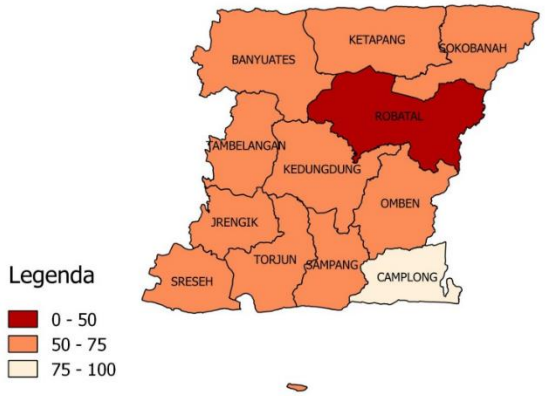

Fig 3. Percentage of Exclusive Breastfeeding Coverage in Sampang District in 2017

The percentage of neonatal complications treated fluctuates between regions. According to Figure 4, there are several sub-districts that have good achievements of 50 - 75% namely Sokobanah, Robatal, Kedungdung, Torjun, Sampang and Camplong sub-districts and there are several sub-districts that have very poor percentages <50%, namely in the banyuates sub-district area. There are several sub-districts that have a good percentage of neonatal complications treated with percentage achievements of 75 - 100% namely Ketapang, Tambelangan, Jrengik, Sreseh and omben sub-districts.

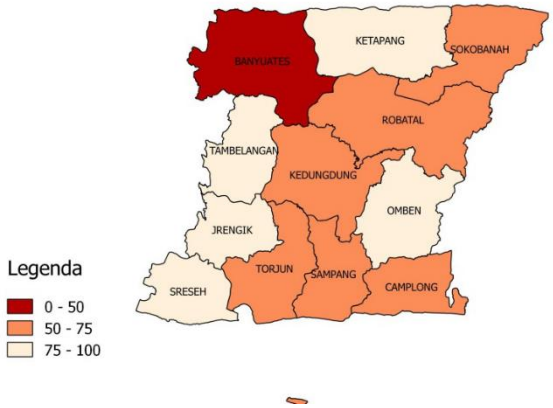

Fig 4. Percentage of Neonatal Complications Treated in Sampang Regency in 2017

The percentage of K4 visits in Sampang District according to Figure 5, there are only 2 areas that have a percentage below 70 - 80%, namely in Kedungdung and Jrengik Sub-districts. The percentage achievement of K4 visits/consultations with a percentage of 80 - 90% was in Banyuates, Ketapang, Tambelangan and Robatal, Omben, Sampang and Camplong sub-districts, while in Sokobanah, Sraseh and Torjun sub-districts the achievement reached 90 - 100%.

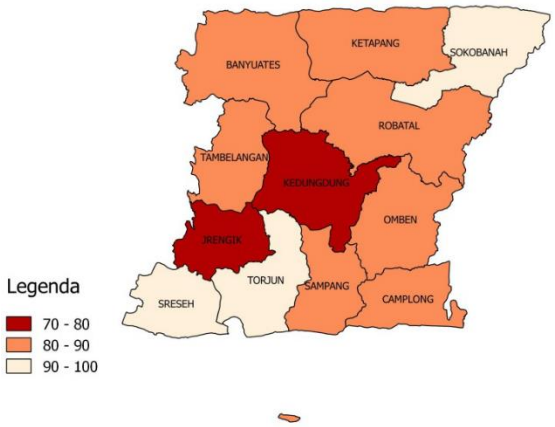

Fig 5. Percentage of K4 Visit Coverage in Sampang Regency in 2017

The percentage of babies with low birth weight (LBW) in Kabupaten Sampang is quite high where according to Figure 6 there is only 1 sub-district area that has an LBW rate of 1 - 3 per 1000 births, namely Kecamatan Ketapang. The sub-districts of Banyuates, Sokobanah, Robatal, Kedungdung, Torjun and Sraseh have LBW rates reaching 3 - 6 per 1000 births. Meanwhile, Kecamatan Tambelangan, Jrengik, Sampang, Omben and Camplong had LBW rates of 6-10 per 1000 births.

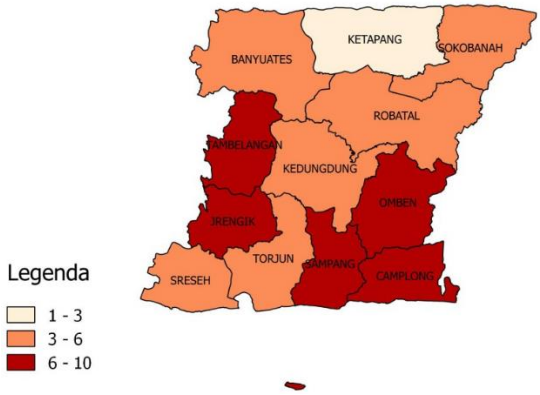

Fig 6. Percentage of LBW Infants in Sampang Regency in 2017

The ratio of midwives per 1000 female population in Kabupaten Sampang is not good. According to Figure 7, all sub-districts in Kabupaten Sampang have a ratio of midwives per 1,000 female residents <2, and some sub-districts even have a ratio of midwives <1 per 1,000 residents.

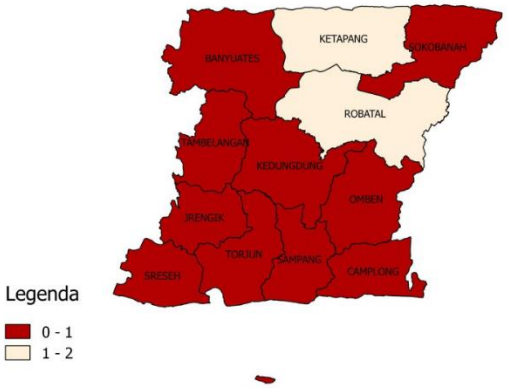

Fig 7. Ratio of Midwives to Population in Sampang Regency in 2017

The percentage of households practicing clean and healthy living behavior (PHBS) in Kabupaten Sampang is generally poor. According to Figure 8, there is only one sub-district that has a percentage of households with PHBS >75%, namely Omben sub-district.

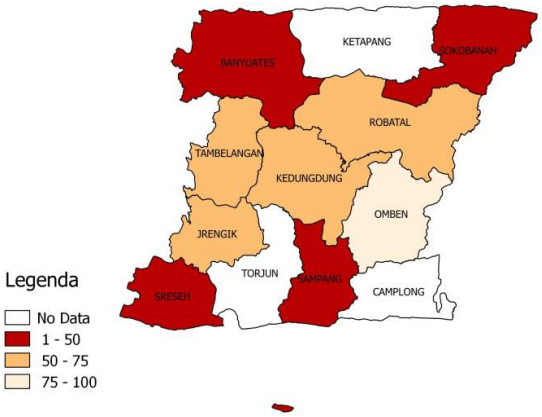

Fig 8. Percentage of Households Performing PHBS in Sampang Regency in 2017

To determine the appropriate spatial modeling, it is necessary to conduct a Lagrange multiplier (LM) test as an initial identification. If the data obtained produces lag dependencies, the data is modeled with the Spatial Autoregressive Model (SAR), but if the data produces error dependencies, the data is modeled with the Spatial Error Model (SEM).

Table 1. Lagrange Multiplier Test Results

Test	*Value*	*Probability*
Lagrange Multiplier (lag)	3,0140	0,0825*
Robust LM (lag)	11,6906	0,0006
Lagrange Multiplier (error)	0,1606	0,6885
Robust LM (error)	8,8373	0,0026

*α = 0,1

The Lagrange multiplier (LM) test conducted as can be seen in table 1 obtained significant Lagrange multiplier (lag) results (0.082 < 0.1) while for the Lagrange multiplier (error) test conducted is not significant (0.688 > 0.1). Thus the modeling carried out using the Spatial Autoregressive Model (SAR).

The results of the Spatial Autoregressive Model (SAR) analysis shown in table 2 obtained 4 significant variables (having a probability value <0.1), namely the variable of delivery childbirth assisted by health workers, neonatal complications handled by health workers, coverage of K4 visits and LBW babies.

Table 2. Result of Spatial Autoregresive Model (SAR)

Variable	B	SE	z	P
Constanta	-21,81	15,103	-1,444	0,148
Childbirth assisted by health workers	-0,611	0,221	-2,767	0,005*
Exclusive breastfeeding coverage	-0,033	0,096	-0,346	0,728
neonatal complications handled by health workers	0,105	0,038	2,732	0,006*
K4 Coverage	0,792	0,182	4,339	0,146

Percentage of LBW	1,891	0,687	2,753	0,005*
Midwife ratio	0,110	2,548	0,043	0,965
Percentage of household PHBS	0,045	0,036	1,234	0,216

$\alpha = 0{,}1; R^2 = 0{,}8731$

From the results of the analysis conducted, the Spatial Autoregressive Model (SAR) is obtained as follows:

$$\hat{y}_i = -21.82 + 0{,}706 \sum_{i=1, i \neq j}^{n} w_{ij} y_i - 0{,}61 * \text{Childbirth assisted by health workers} + 0{,}10 * \text{neonatal complications handled by health workers} + 1{,}89 * \text{Percentage of LBW}$$

The spatial model obtained can be explained as follows:

a. If the factor of delivery assisted by health workers increases by 10 units and other factors are constant, it can reduce the infant mortality rate by 6.1 cases.
b. If the factor of neonatal complications not handled by health workers increases by 10 units and other factors are constant, it can increase the infant mortality rate by 1 case.
c. If the LBW baby factor increases by 1 unit and other factors are constant, it can increase infant mortality cases by 1.89 cases or 2 cases.

Based on calculations using the Geoda application, R^2 = 83.7% is obtained, this indicates that the existing model is able to explain the variation in the incidence of infant mortality in sampang district by 83.7% and the rest is influenced by other variables outside the model.

3.2 Discussion

The research that has been conducted found that there are 4 statistically significant factors that can affect infant mortality rates in Sampang Regency, namely the factor of delivery assisted by health workers, the factor of neonatal complications handled, the factor of K4 visits by health workers and the LBW factor.

Birth assisted by a health worker (in this case a midwife or doctor) is one of the factors influencing the incidence of infant mortality in Sampang District. These results are in accordance with research conducted by Isnaeni, Jusuf and Dinan (2013) in the work area of the puskesmas in Banjarnegara Regency where childbirth assisted by health workers has a significant relationship with infant mortality that occurs with an odds ratio of 5.6 times, meaning that childbirth that is not assisted by trained health workers has a 5 times greater risk of death in infants compared to infants whose delivery process is assisted by health workers (Rofiqoch et al., 2018). The results of this study are also in line with research in Nigeria by Ezeh, et al (2015) where childbirth performed by health workers has a smaller percentage of infant mortality of 31.8% compared to childbirth by non-health workers who have infant mortality rates reaching 51.25 (Ezeh et al., 2015). The biggest cause of death in infants is due to neonatal complications that occur after childbirth. Most of the complications that occur are usually in the form of bleeding, infectious diseases, high blood pressure during pregnancy (Salam et al., 2014). Childbirth assistance performed by health workers will have less harmful impact on handling complications that may occur after childbirth, especially complications that occur to newborn babies including mothers who have gone through the childbirth process. This is due to the ability of health workers who are able to overcome various complications that arise compared to traditional birth attendants even though traditional birth attendants have received training related to the process of childbirth in accordance with standards. In addition to better skills, the delivery process carried out by health workers is also supported by better facilities and equipment, thus reducing the serious impact that may occur due to lack of adequate equipment during the labor process (Cheng, 2005).

Childbirth assisted by non-health personnel is vulnerable to labor complications that may occur to the baby during the delivery process, if not handled properly it can cause death to the baby in the future (Wiknjosastro, 2007). There are several factors that influence the selection of birth attendants, namely maternal knowledge, maternal trust in birth attendants, socio-cultural and economic conditions, geographical conditions, in addition to habitual factors and non-medical helpers (dukun) who provide postnatal services are also factors driving the selection of birth attendants (Abdhi, 2001; Kurniawan and Melaniani, 2019).

Neonatal complications that are not handled properly by health workers can increase the risk of infant mortality. The results of existing research are not in line with research conducted by Saptanto, Anggraheny, Umania (2012) at Tugurejo Hospital, this study states that complications not handled properly have a risk of death in infants by 4.9 times compared to infants with complications that are handled (Saptanto and Anggraheny, 2012). These results are also not in line with the results of Ramanda's (2016) research conducted in Pontianak where complications not handled can cause death in infants 15.7 times greater than with handled complications (Ramanda, 2016).

Complications are conditions that deviate from normal conditions that can cause pain or death in infants and mothers. Complications that often occur are infection, premature labor, LBW (Ramanda, 2016). There are several factors that cause infant mortality even though existing complications have been treated such as low coverage of exclusive breastfeeding, poor complementary feeding, other diseases that occur not due to complications.

Low birth weight (LBW) is one of the factors causing infant mortality in Sampang Regency. The results of existing research are in line with the results of research conducted by Rachmadiani, Shodikin, Komariah (2018) at RSD dr. Soebandi Jember which states that babies who have low birth weight (<2500 grams) have a risk of death of 9, 6 times greater than babies who have normal birth weight (≥2500 grams) (Rachmadiani et al., 2018). The results of this study are also in line with research by Gaiva, Fujimori, Sato (2016) conducted in Brazil, this study states that infants who have birth weight below normal are associated with infant mortality that occurs with a risk of 6.5 times (Gaiva et al., 2016).

Infants who have low birth weight are at risk for hypothermia caused by incomplete circulation, weak

respiration and have less food intake. In addition, low birth weight babies are also susceptible to nosocomial infections caused by low serum immunoglobulin levels. Low birth weight babies are also at risk of organ failure due to damage to existing organs, which can cause death in infants (Saptanto and Anggraheny, 2012).

4. Conclusion

The modeling that has been produced can be seen that there are 3 factors that spatially affect infant mortality that occurs in Sampang Regency, namely the factor of delivery assisted by health workers, neonatal complications that are handled and low birth weight (LBW). Of the three significant factors, further research needs to be done on the neonatal complication factor that is handled because the existing modeling has a positive value while other studies tend to show the opposite results. To solve the problem of high infant mortality rates, related parties such as the health department can make efforts by intervening in significant risk factors, especially in the factor of delivery assisted by health workers. By increasing the number of births assisted by health workers by 10 units, it can reduce the infant mortality rate by 6 cases, but other factors cannot be ignored for intervention.

5. Acknowledgements

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