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Determinants of Under-five Mortality Due to Pneumonia: A Negative Binomial Regression Analysis

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ABSTRACT

Pneumonia is one of the main causes of under-five mortality in Indonesia. In under-fives, pneumonia is the number one killer in the world. Meanwhile, in Indonesia, it ranks second after diarrhea. On average, the disease affects half a million children a year. This study aims to identify and analyze the risk of variables that affect the number of under-five mortality due to pneumonia in Indonesia in 2021. The novelty of this research focuses on the macro variables used, making it easier for policy makers to make decisions. The research method used is negative binomial regression. The results showed that the highest number of under-five mortality due to pneumonia was in Central Java Province. Meanwhile, the lowest was in Jambi Province, South Sumatra, Riau Islands, DKI Jakarta, North Kalimantan, Southeast Sulawesi, and Papua. The per capita income significantly reduces the number of under-five mortality due to pneumonia, while the number of under-fives with severe pneumonia significantly reduces the number of under-five mortality due to pneumonia in Indonesia. The government needs attention to reduce the death rate of children under five due to pneumonia by providing social protection in the fields of health and education for underprivileged communities.

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A. INTRODUCTION

The importance of health sector development to improve the quality of human resources in Indonesia is one of the health targets in the National Medium-Term Development Plan (RPJMN) 2020-2024, where one of the health developments focused on child health. One of the stages of child development is toddlerhood. This period is one of the most important, so it is not uncommon for it to be known as "the golden period" and a "window of opportunity" for children's growth and development, both physical and psychological, as well as their intelligence (Le Roux et al., 2015; Rahman et al., 2022; Singh and Stella, 2019). However, toddlerhood is also a vulnerable period because the under-fives' immune system is rudimentary, so it will be easy to be exposed to various types of diseases that can even cause death (Marangu and Zar, 2019; McAllister et al., 2019; Wang et al., 2019).

According to the Indonesia Demographic and Health Survey (SDKI), in 2017, the under-five mortality rate reached 97 deaths per 1000 births. However, this figure still does not meet the SDG target of 25 deaths per 1000 live births by 2030. One of the most common causes of under-five mortality is pneumonia. Pneumonia is an acute infectious disease that attacks the tissues of the lungs (alveoli) and is caused by various microorganisms such as fungi, viruses, and bacteria (He et al., 2015; Keddy et al., 2021). Currently, the control program is focused on preventing pneumonia in children under the age of five. In 2018, pneumonia was estimated to be the cause of nearly 20% of the world's total under-five mortality. Where the most cases of mortality due to pneumonia occur is on the African and Asian continents, which are included as developing countries (UNICEF et al., 2020). Pneumonia is the leading cause of death in children under the age of five (Bakare et al., 2020; He et al., 2015; Lamberti et al., 2013; Le Roux et al., 2015). Meanwhile, in Indonesia, it ranks second after diarrhea and has been dubbed "a forgotten killer" because pneumonia is the main cause of deaths for children under five, surpassing AIDS, measles, and malaria all at once (Bakare et al., 2020; Watkins and Sridhar, 2018). According to (UNICEF, 2021), pneumonia is one of the leading causes of death for under-fives in Indonesia. On average, the disease affects half a million children per year. In addition, the United Nations also revealed that deaths from pneumonia are declining, but slower than other leading causes of death and too slowly to achieve the Sustainable Development Goals ambition of "ending preventable child mortality" by 2030 (Jullien et al., 2020; Jullien et al., 2022).

One of the efforts of the Indonesian Ministry of Health to reduce the under-five mortality rate due to pneumonia is to increase the discovery of pneumonia in infants. One of the indicators used by the Ministry of Health of the Republic of Indonesia to measure the detection rate of pneumonia is the number of pneumonia cases detected in under-fives. Pneumonia coverage fluctuated from 2010-2016, but experienced an improvement trend in 2016 reaching 65.3%. After 2016, there was a downward trend in the discovery of pneumonia coverage in children under five. The presence of COVID-19 makes pneumonia more common in under-fives, reaching a coverage rate of 31.4% in 2021. According to the (Kementerian Kesehatan Republik Indonesia, 2021), the decrease in the number of visits to under-fives coughing and shortness of breath at public health center is more due to the impact of the COVID-19 pandemic than other factors. Several studies related to under-five mortality due to pneumonia have been carried out, such as research by (Noor et al. (2016); Ramandey et al. (2018); Vicasco and Handayani (2020)) whose research used a quantitative analytic approach with a case control study; Woldeamanuel and Aga (2021) used Hurdle Negative Binomial (HNB) regression analysis; Tadesse Zeleke (2022) used propensity score analysis and Poisson regression; Bitew et al. (2020) used machine learning models such as random forests, logistic regression, and K-nearest neighbors. As well as research by Yatnaningtyas et al. (2016) which uses Geographically Weighted Negative Binomial Regression (GWNBR).

Excess zeros with over-dispersion and heteroscedasticity were present in the under-five mortality data. The zero-inflated model and hurdle models are the most often used distributions for modeling such data. The over-dispersion has been attributed to heterogeneity that has not been taken into account in the unobserved population, which in this instance is a Poisson type population with several sub-populations. However, the membership of the sub-populations is not visible in the sample. This excess variation may have led to inaccurate inferences regarding parameter estimations, standard errors, tests, and confidence intervals. By incorporating a dispersion parameter to account for the unobserved variability in the count data, the Negative binomial model tackles the problem of over-dispersion (Argawu and Mekebo, 2022). However, from these studies there have been no studies using negative binomial analysis and factor analysis to determine the variables that are thought to have an effect on at a macro level. The novelty in this study is described in 2 contributions, namely, first, by concentrating on the macro variables used, this research helps policymakers make judgments. Second, utilizing the negative binomial model, where this model can resolve the issue of excessive dispersion in count data, such as the number of under-five mortality due to pneumonia data. Therefore, this study aims to identify and analyze the factors that influence the under-five mortality due to pneumonia in Indonesia in 2021 using negative binomial regression analysis. This study is anticipated to contribute to the body of knowledge on the number of under-five pneumonia mortality and give policymakers an overview so that effective initiatives can be developed to lower the mortality rate for children under five.

B. RESEARCH METHOD

1. Data

This study used unit analysis covering 34 provinces in Indonesia with data in 2021. The dependent variable used is the number of under-five mortality due to pneumonia in each province in Indonesia in the form of count/ discrete data. As well as 8 independent variables in this study, namely the percentage of infant who get exclusive breastfeeding, the number of under-fives with severe pneumonia, the average length of schooling for women, the percentage of poor people, the percentage of households with firewood main fuel, population density, the percentage of complete basic immunization in infants, and per capita income. The data used in this study used secondary data sourced from publications from the Indonesian Ministry of Health and the BPS-Statistics Indonesia.

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2. Analysis Methods

This study was conducted using STATA 15 and SPSS 24 software. The stages of inferential analysis in modeling follow the following steps:

1. Examination of non-multicollinearity assumptions
   The examination of non-multicollinearity assumptions aims to determine whether there is a strong relationship between variables independence. Detecting multicollinearity between independent variables with VIF. Multicollinearity occurs when a single variable has a VIF value greater than 10.
2. Formed a Poisson regression model with indepedent variables that do not contain multicollinearity, as shown in equation 1.

$$\ln(\mu) = \beta_0 + \beta_1\, bfeed + \beta_2\, pneu + \beta_3\, school + \beta_4\, poor + \beta_5\, firewd + \beta_6\, dens + \beta_7\, immun + \beta_8\, inc \qquad (1)$$

where
μ : The number of under-five mortality due to pneumonia
$bfeed$: The percentage of infant who get exclusive breastfeeding
$pneu$: The number of under-fives with severe pneumonia
$school$: The average length of schooling for women (year)
$poor$: The percentage of poor people
$firewd$: The percentage of households with firewood main fuel
$dens$: Population density $(soul/km^2)$
$immun$: The percentage of complete basic immunization in infants
inc : Per capita income (million rupiah)

3. Detects the presence or absence of overdispersion in the Poisson regression model by dividing the deviance value by its degree of freedom. If the result is more than one then over dispersion occurs. Perform the formation of a Negative Binomial regression model to overcome the over dispersion of the Poisson regression model.
4. Formed a Negative Binomial regression model using the same independent variables on Poisson regression, as illustrated in equation 2

$$\ln(\mu) = \beta_0 + \beta_1\, bfeed + \beta_2\, pneu + \beta_3\, school + \beta_4\, poor + \beta_5\, firewd + \beta_6\, dens + \beta_7\, immun + \beta_8\, inc \qquad (2)$$

5. Testing the goodness of fit, by comparing the Binomial Negative regression model and the Poisson regression model using the Likelihood Ratio Test.
6. Simultaneous and partial testing of regression model parameters.
7. Factor Analysis to address multicollinearity.
8. Conducting an analysis of the results obtained.

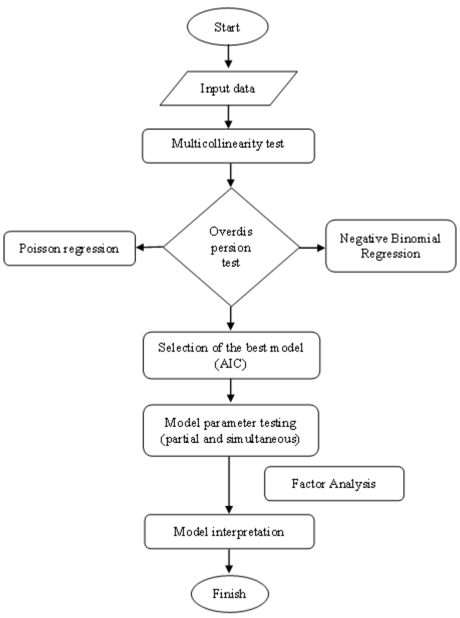

Figure 1. Research Flowchart

C. RESULTS AND DISCUSSION

1. Overview of Under-Five Mortality from Pneumonia in Indonesia 2021

The highest number of under-five mortality due to pneumonia was in Central Java Province with 90 deaths, followed by West Java Province with 41 deaths, and West Kalimantan with 38 deaths. In addition, there are also several provinces that do not have a number of under-five mortality due to pneumonia, namely Jambi Province, South Sumatra, Riau Islands, DKI Jakarta, North Kalimantan, Southeast Sulawesi, and Papua Province. The gap in the number of under-five mortality due to pneumonia that is quite large between provinces in Indonesia can be caused by several things such as significant differences in population, availability of health facilities, geographical conditions between provinces, and completeness of reports that are directly related to public awareness in the utilization of health facilities available.

2. Modeling with Poisson Regression

The dependent variable in this study is that the number of under-five mortality due to pneumonia is the data count. Therefore, for the simplest modeling using the Poisson regression model first. Before the Poisson regression model was formed, modeling was carried out with multiple linear regression to obtain variance inflation factor (VIF) values in order to examine the assumption of non-multicollinearity. Based on the analysis output, it was found that no independent variable had a VIF value of > 10. This means that there is no multicollinearity between independent variables. So, it can be concluded that all independent variables can be used to model under-five mortality due to pneumonia using Poisson regression as follows.

Table 1. Poisson regression parameter estimation and test results

Variable	$\hat{\beta}$	$se(\hat{\beta})$	W	95% Conf. Interval		p-value
bfeed	0,0099	0,0039	2,52	0,0022	0,0176	0,012*
pneu	0,0011	0,0001	9,45	0,0009	0,0013	0,000*
school	0,0617	0,8826	0,7	-0,1113	0,2347	0,485
poor	-0,0209	0,0146	-1,48	-0,0487	0,0069	0,139
firewood	-0,0026	0,0041	-0,62	-0,0107	0,0055	0,534
density	-0,0006	0,0002	-3,11	-0,0009	-0,0002	0,002*
immunization	-0,0170	0,0042	-4,02	-0,0252	-0,0087	0,000*
income	-0,0209	0,0032	-6,45	-0,0272	-0,0145	0,000*
constant	38,910	11,046	3,52	17,260	60,560	0,000

The modeling results with the Poisson regression in Table 1 show that the independent variable rejects H_0. This means that, with a significance level of 5%, the variable percentage of infant aged < 6 months given exclusive breastfeeding, the number of under-fives with severe pneumonia, population density, the percentage of complete basic immunity in infants, and per capita income have a significant effect on the number of under-five mortality due to pneumonia in a provincial area in Indonesia 2021. In the Poisson regression, there is an assumption that must be met, namely equidispersion. Therefore, further dispersion testing is carried out.

3. Dispersion Assumption Testing

Testing of equidispersion assumptions can be done by comparing the mean value and variance value on the dependent variable, namely the number of under-five mortality due to pneumonia. In addition, the examination of dispersion assumptions can also use the Pearson dispersion value.

Table 2. Equidispersion Test

Test	Test Value	Decision
Comparison of mean values and variance	$13,06 < 319,045$	Overdispersion
Pearson dispersion value	11,755	Overdispersion

According to the dispersion assumption test findings (see Table 2), the mean value is less than the variance value, and the Pearson dispersion value is also more than 1. This indicates that there is an overdispersion in the Poisson regression model. The occurrence of this overdispersion problem concludes that the Poisson regression model is not suitable for use in data on under-five mortality due to pneumonia in Indonesia 2021.

4. Modeling with Negative Binomial Regression

The results of the dispersion test provide the conclusion that over dispersion occurred which has implications for the Poisson regression model cannot be used. One solution that can be used is to use the Binomial Negative regression model. The estimation results of the Negative Binomial regression model yielded an AIC value of 238.3152. The regression formed can be seen in equation 3.

$$\ln(\hat{\mu}) = 1,7523 + 0,0099\,bfeed + 0,010\,pneu + 0,2739\,school - 0,0177\,poor + 0,0009\,firewd \\ - 0,0003\,dens - 0,0139\,immun - 0,0161\,inc \tag{3}$$

Table 3. Negative Binomial regression parameter estimation and test results

Variable	$\hat{\beta}$	$se(\hat{\beta})$	W	95% Conf. Interval		p-value
bfeed	0,0099	0,0119	0,82	-0,0135	0,0333	0,408
pneu	0,0010	0,0004	2,26	0,0001	0,0001	0,000*
school	0,2379	0,2713	0,88	-0,2939	-0,7697	0,381
poor	-0,0177	0,0424	-0,42	-0,1008	0,0653	0,676
firewood	0,0009	0,0140	0,06	-0,0266	0,0284	0,949
density	-0,0003	0,0001	-0,03	-0,0016	0,0010	0,663
immunization	-0,0139	0,0132	-1,06	-0,0398	0,0119	0,291
income	-0,0161	0,0072	-2,25	-0,0301	-0,0021	0,024*
contant	17,523	35,587	0,49	-52,227	87,272	0,622

Looking at the goodness of fit used AIC, the estimated value of Akaike's Information Criterion (AIC) for the Poisson and Negative Binomial models was 439.8983 and 238.3152, respectively. The AIC value of modeling using Negative Binomials is smaller compared to Poisson's model. This suggests that the Negative Binomial model is better used than the Poisson model.

After obtaining parameter estimates from the Binomial Negative regression model, simultaneous and partial testing of the alleged parameters was then carried out. Simultaneous testing to see if together all variables affect the dependent variables. Simultaneous testing yielded a Chi-square likelihood ratio value of 21.73, with a p-value of 0.0054. In conclusion, with a significance level of 5%, it can be proven that there is at least one independent variable that affects the dependent variable for the number of under-five mortality due to pneumonia.

Partial testing uses Wald test statistics. With a significance level of 5%, there is enough evidence to say that each variable number of under-fives with severe pneumonia and per capita income affects the number of under-five mortality due to pneumonia in a province in Indonesia 2021. Table 3 presents the results of estimates with Negative Binomial regression resulting in estimates with signs that differ from existing theories, namely the variable percentage of infants aged < 6 months given exclusive breastfeeding, the average length of schooling for women, the percentage of households with firewood main fuel, the percentage of poor people, and population density. The difference between the estimated coefficient sign and the theory indicates the presence of a collinearity problem in the data used (Kutner et al., 2005). The existence of this multicollinearity is overcome by factor analysis. Variables that have a high correlation value are reduced to one latent variable called a factor.

An important purpose of factor analysis is to illustrate the relationships among variables related to underlying random magnitudes, previously unobservable, called factors. Basically, the factor model is based on the presence of variables grouped by their correlation values. All variables in the group are highly correlated, but have a relatively low correlation with variables from different groups. Each group of variables represents a basic construct called a factor.

The result of reduction by factor analysis produces three factors. The first factor is characterized by the percentage of households with firewood main fuel and the percentage of the poor, this factor is called the poverty factor. The second factor is characterized by the average length of schooling for women and population density, this factor is called the population condition factor. The third factor formed is characterized by the percentage of infants who get exclusive breastfeeding, this factor is called the under-five nutritional factor. After that, these two factors were analyzed with a Binomial Negative regression model along with other variables. The Binomial Negative regression model can be written as equation 4.

$$\ln(\hat{\mu}) = 4,5670 + 0,0008\,pneu + 0,2739\,school + 0,0009\,firewd - 0,0003\,dens - 0,0167\,immun - 0,0181\,inc \\ - 0,2591\,poor + 0,1256\,population + 0,1057\,nutrition \tag{4}$$

Table 4. Negative Binomial regression parameter estimation and test results

Variable	$\hat{\beta}$	$se(\hat{\beta})$	W	95% Conf. Interval		p-value
pneu	0,0008	0,0000	3,70	0,0004	0,0012	0,0012*
immunization	-0,0167	0,0124	-1,35	-0,0411	0,0076	0,1780
income	-0,0181	0,0067	-2,70	-0,0313	-0,0049	0,0007*
poor	-0,2591	0,1899	-1,36	-0,6313	0,1131	0,1720
population	0,1256	0,4064	0,31	-0,6709	0,9222	0,7570
nutrition	0,1057	0,1791	0,59	-0,2454	0,4568	0,5550
constant	45,670	10,335	4,42	25,414	65,927	0,0000

5. Model Interpretation

The results of this study show that the number of toddlers suffering from severe pneumonia significantly increases the number of under-five deaths due to pneumonia. The parameter estimate value is 0,0008 which means that every increase in one

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case of variable number of under-fives with severe pneumonia, it will increase the average under-five mortality due to pneumonia by $(\exp(0,0008) - 1) \times 100\%) = 0,08\%$ assuming other variables are constant. Under-fives with severe pneumonia are at great risk of death and require prompt and appropriate hospitalization. This finding is in line with research by (Rigustia et al., 2019; Sari and Prasetyani, 2021) which states that severe pneumonia can increase the risk of under-five mortality due to pneumonia.

Table 4 explains that Per capita income significantly reduces the number of under-five deaths from pneumonia. The result of the parameter estimation for the per capita income variable is -0,0181. This means that every increase in per capita income in a province of Rp1,000,000 will reduce the average incidence of under-five mortality due to pneumonia by $(1 - \exp(-0,0181)) \times 100\% = 1,79\%$ assuming other variables are constant. This is because, in general, per capita income is a benchmark for a country's prosperity and welfare because the value of per capita income is derived from the average income of residents in the country. Per capita income can be used as a measure of prosperity for each region. The higher the per capita income, the higher the purchasing power of the population. This high purchasing power will have a positive impact on people's welfare. So that if the per capita income is high, people will be able to meet their basic needs and access existing health facilities easily. In line with Sari and Prasetyani (2021) which states that per capita income is negatively and significantly related to infant mortality.

Poverty affects the inability of the population to meet food and health needs (Aurellia et al., 2023; Belantika et al., 2023; Hardinata et al., 2023; Kartiasih and Pribadi, 2020). The poverty factor is suspected to increase under-five mortality, but in this study, poverty had no significant effect. In addition, there are several variables that do not significantly affect the number of under-five mortality due to pneumonia, namely, the variable percentage of complete basic immunization in infants, population condition factors, and under-five nutritional factors. The variable percentage of complete basic immunization negatively but not significantly affects the number of under-five mortality due to pneumonia in 2021. This is due to the many issues circulating during the Covid-19 pandemic which has made many mothers who do not carry out complete basic immunization of their children.

Under-five nutritional factors have a positive but not significant effect. Breastfeeding behavior during the pandemic is influenced by several factors including knowledge. Knowledge of exclusive breastfeeding as well as knowledge about Covid-19, understanding of this must be fulfilled by all lines in order to know how to protect yourself and others, including maternity and breastfeeding mothers. Understanding from breastfeeding mothers about how to take appropriate measures in preventing the transmission and protection of Covid-19. The anxiety caused by the fear that mothers can transmit the virus to infants during breastfeeding during the pandemic is quite high.

D. CONCLUSION AND SUGGESTION

A significant factor negatively affecting the number of under-five mortality from pneumonia is per capita income. Meanwhile, a significant factor that positively affects the number of under-five mortality due to pneumonia is the number of under-five with severe pneumonia. Provinces with low per capita incomes are at risk of having a high number of under-five mortality due to pneumonia. Provinces with a high number of under-five with severe pneumonia are at risk of having a high number of under-five mortality due to pneumonia.

For the government to increase per capita income through subsidizing poor families from various social programs, as well as providing relief on health and education costs for underprivileged people. In addition, there is also the need to socialize the importance of immunization, especially during a pandemic. For parents, especially mothers, it is hoped that they will be more aware of the importance of under-five health in order to protect children from dangerous diseases that can endanger lives. For subsequent researchers to add more relevant independent variables affecting the number of under-five mortality due to pneumonia.

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AUTHOR CONTIBUTION

All authors contributed to the writing of this article.

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COMPETING INTEREST

The authors declare no conflict of interest in this article.

REFERENCES

Argawu, A. S. and Mekebo, G. G. (2022). Risk factors of under-five mortality in ethiopia using count data regression models, 2021. *Annals of Medicine and Surgery*, page 104764. doi: https://doi.org/10.1016/j.amsu.2022.104764.

Aurellia, N. A., Ramadhani, A. A., Pamungkas, K. A., and Kartiasih, F. (2023). Determinan kejadian wasting pada balita. In *Seminar Nasional Official Statistics*, volume 2023, pages 167–178. doi: https://doi.org/10.34123/semnasoffstat.v2023i1.1901.

Bakare, A. A., Graham, H., Agwai, I. C., Shittu, F., King, C., Colbourn, T., Iuliano, A., Aranda, Z., McCollum, E. D., Isah, A., et al. (2020). Community and caregivers perceptions of pneumonia and care-seeking experiences in nigeria: A qualitative study. *Pediatric pulmonology*, 55:S104–S112. doi: https://doi.org/10.1002/ppul.24620.

Belantika, B. T., Rohmad, B., Arandita, H. D. N., Hutasoit, D. R., and Kartiasih, F. (2023). Factors affecting poverty using a geographically weighted regression approach (case study of java island, 2020). *Optimum: Jurnal Ekonomi dan Pembangunan*, 13(2):141–154. doi: https://doi.org/10.31849/jieb.v20i2.12259.

Bitew, F. H., Nyarko, S. H., Potter, L., and Sparks, C. S. (2020). Machine learning approach for predicting under-five mortality determinants in ethiopia: evidence from the 2016 ethiopian demographic and health survey. *Genus*, 76:1–16. doi: https://doi.org/10.1186/s41118-020-00106-2.

Hardinata, R., Oktaviana, L., Husain, F. F., Putri, S., and Kartiasih, F. (2023). Analisis faktor-faktor yang memengaruhi stunting di indonesia tahun 2021. In *Seminar Nasional Official Statistics*, volume 2023, pages 817–826. doi: https://doi.org/10.34123/semnasoffstat.v2023i1.1867.

He, C., Kang, L., Miao, L., Li, Q., Liang, J., Li, X., Wang, Y., and Zhu, J. (2015). Pneumonia mortality among children under 5 in china from 1996 to 2013: an analysis from national surveillance system. *PloS one*, 10(7):e0133620. doi: https://doi.org/10.1371/journal.pone.0133620.

Jullien, S., Pradhan, D., Tshering, T., Sharma, R., Dema, K., Garcia-Garcia, S., Ribó, J. L., Muñoz-Almagro, C., and Bassat, Q. (2020). Pneumonia in children admitted to the national referral hospital in bhutan: A prospective cohort study. *International Journal of Infectious Diseases*, 95:74–83. doi: https://doi.org/10.1016/j.ijid.2020.04.017.

Jullien, S., Richard-Greenblatt, M., Ngai, M., Lhadon, T., Sharma, R., Dema, K., Kain, K. C., and Bassat, Q. (2022). Performance of host-response biomarkers to risk-stratify children with pneumonia in bhutan. *Journal of Infection*, 85(6):634–643. doi: https://doi.org/10.1016/j.jinf.2022.10.010.

Kartiasih, F. and Pribadi, W. (2020). Environmental quality and poverty assessment in indonesia. *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal of Natural Resources and Environmental Management)*, 10(1):89–97. doi: https://doi.org/10.29244/jpsl.10.1.89-97.

Keddy, K. H., Saha, S., Okeke, I. N., Kalule, J. B., Qamar, F. N., and Kariuki, S. (2021). Big data, biomarkers and proteomics: informing childhood diarrhoeal disease management in low-and middle-income countries. *EBioMedicine*, 73. doi: https://doi.org/10.1016/j.ebiom.2021.103668.

Kementerian Kesehatan Republik Indonesia (2021). Profil Kesehatan Indonesia. *Kementerian Kesehatan Republik Indonesia*. Jakarta: UNICEF Indonesia.

Kutner, M. H., Nachtsheim, C. J., Neter, J., and Li, W. (2005). *Applied linear statistical models*. McGraw-hill.

Lamberti, L. M., Irena, Z.-G., Christa, L. F. W., Theodoratou, E., Nair, H., Harry, C., and Black, R. E. (2013). Pneumonia and cost. *http://www.biomedcentral.com/1471-2458/13/S3/S18*, 13(3):1–8. http://www.biomedcentral.com/1471-2458/13/S3/S18.

Le Roux, D. M., Myer, L., Nicol, M. P., and Zar, H. J. (2015). Incidence and severity of childhood pneumonia in the first year of life in a south african birth cohort: the drakenstein child health study. *The Lancet Global Health*, 3(2):e95–e103. doi: https://doi.org/10.1016/S2214-109X(14)70360-2.

Marangu, D. and Zar, H. J. (2019). Childhood pneumonia in low-and-middle-income countries: an update. *Paediatric respiratory reviews*, 32:3–9. doi: https://doi.org/10.1016/j.prrv.2019.06.001.

McAllister, D. A., Liu, L., Shi, T., Chu, Y., Reed, C., Burrows, J., Adeloye, D., Rudan, I., Black, R. E., Campbell, H., et al. (2019). Global, regional, and national estimates of pneumonia morbidity and mortality in children younger than 5 years between 2000 and 2015: a systematic analysis. *The Lancet Global Health*, 7(1):e47–e57. doi: https://doi.org/10.1016/S2214-109X(18)30408-X.

Noor, M., Riyanto, S., Wardani, M. K., Borneo, S. H., and Borneo, A. S. H. (2016). Faktor-faktor yang mempengaruhi kejadian pneumonia pada balita di wilayah kerja puskesmas guntung payung tahun 2013. *Jurnal Kesehatan Indonesia*, 4(2).

Rahman, A. E., Hossain, A. T., Nair, H., Chisti, M. J., Dockrell, D., El Arifeen, S., and Campbell, H. (2022). Prevalence of hypoxaemia in children with pneumonia in low-income and middle-income countries: a systematic review and meta-analysis. *The Lancet Global Health*, 10(3):e348–e359. doi: https://doi.org/10.1016/S2214-109X(21)00586-6.

Ramandey, D. E. M., Made, N., Kurniasari, D., and Widyanthini, D. (2018). Faktor-faktor yang mempengaruhi kejadian pneumonia pada balita di rumah sakit ibu anak permata hati kabupaten klungkung tahun 2015-2017. *Arc. Com. Health*, 5(2):11–17. doi: https://doi.org/10.24843/ach.2018.v05.i02.p02.

Rigustia, R., Zeffira, L., and Vani, A. T. (2019). Faktor risiko yang berhubungan dengan kejadian pneumonia pada balita di puskesmas ikur koto kota padang. *Health and Medical Journal*, 1(1):22–29. doi: https://doi.org/10.33854/heme.v1i1.215.

Sari, V. K. and Prasetyani, D. (2021). Socioeconomic determinants of infant mortality rate in asean: a panel data analysis. *JAS (Journal of ASEAN Studies)*, 9(1). doi: https://doi.org/10.21512/JAS.V9I1.7280.

Singh, G. K. and Stella, M. Y. (2019). Infant mortality in the united states, 1915-2017: large social inequalities have persisted for over a century. *International Journal of Maternal and Child Health and AIDS*, 8(1):19. doi: https://doi.org/10.21106/ijma.271.

Tadesse Zeleke, A. (2022). Effect of health extension service on under-five child mortality and determinants of under-five child mortality in derra district, oromia regional state, ethiopia: A cross-sectional study. *SAGE Open Medicine*, 10:20503121221100610. doi: https://doi.org/10.1177/20503121221100610.

UNICEF (2021). Laporan tahunan 2021. *Jakarta: United Nations Childrens Fund (UNICEF)*.

UNICEF et al. (2020). Nutrition, for every child: Unicef nutrition strategy 2020–2030. *UNICEF, New York: United Nations Childrens Fund*.

Vicasco, M. A. N. and Handayani, D. (2020). Literature review: Analisis faktor risiko pneumonia pada balita. In *PROSIDING NATIONAL CONFERENCE FOR UMMAH*, volume 1.

Wang, J., Cao, H., Sun, D., Qi, Z., Guo, C., Peng, W., Sun, Y., Xie, Y., Liu, X., Li, B., et al. (2019). Associations between ambient air pollution and mortality from all causes, pneumonia, and congenital heart diseases among children aged under 5 years in beijing, china: a population-based time series study. *Environmental research*, 176:108531. doi: https://doi.org/10.1016/j.envres.2019.108531.

Watkins, K. and Sridhar, D. (2018). Pneumonia: a global cause without champions. *The Lancet*, 392(10149):718–719. doi: https://doi.org/10.1016/S0140-6736(18)31666-0.

Woldeamanuel, B. T. and Aga, M. A. (2021). Count models analysis of factors associated with under-five mortality in ethiopia. *Global Pediatric Health*, 8:2333794X21989538. doi: https://doi.org/10.1177/2333794X21989538.

Yatnaningtyas, R., Latra, I. N., and Andari, S. (2016). Identifikasi faktor-faktor yang mempengaruhi pneumonia pada balita di surabaya menggunakan geographically weighted negative binomial regression. *Jurnal Sains dan Seni ITS*, 5(2). doi: https://doi.org/10.12962/j23373520.v5i2.16597.