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RESEARCH ARTICLE

Disaster Prone Areas and Stunting Prevalence in Indonesia: Ecological Study of 34 Provinces

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ABSTRACT

Indonesia has a high intensity of disaster events. The prevalence of under-five stunting in Indonesia is also high. One of the targets of the Ministry of Health's Medium-Term Development Plan for 2020-2024 is to reduce stunting in children by 14% in 2024. This study aims to look at the relationship between disaster risk and the prevalence of stunting in 34 provinces in Indonesia. The study design is an ecological study approach sourced from the 2021 Indonesian Disaster Risk Index (IRBI), the 2021 Indonesian Nutritional Status Survey (SSGI), the 2018 Basic Health Research and the 2021 National Socioeconomic Survey (Susenas). This study conducted a spatial analysis, scatter plots, pearson correlation test and multivariable linear regression. From the results, it found that the higher risk of disaster increased the tendency for the prevalence of under-five stunting. It was concluded that disaster risk has a positive relationship with the prevalence of under-five stunting in Indonesia. We suggest that a disaster management program can be considered to reduce stunting in Indonesia.

1. Introduction

The threat of disaster is still a problem throughout the world. During 2021, natural disasters accounted for 10,492 deaths, affected 101.8 million people, and caused economic losses of USD 252.1 billion. Asia is the region worst affected by disasters, 40% of world disasters occur in Asia, which accounts for 49% of deaths and 66% of people affected by disasters worldwide (EM-DAT, 2022).

Like other Asian countries, Indonesia is also one of the countries that has a high disaster intensity. Geographically, Indonesia is an archipelagic country located at the confluence of four tectonic plates and traversed by a line of active volcanoes, which makes Indonesia prone to disasters (Arnold, 1986). The National Disaster Management Agency said during 2021 there had been 5,402 disaster incidents which resulted in 728 deaths, 14 thousand injuries, and more than 7 million people being displaced (BNPB, 2022c).

Stunting is still a health problem worldwide. WHO records that 144 million under-five children in the world are stunted (World Health Organization, 2022). Based on data from Basic Health Research in 2018, the proportion of short and very short children was 30.8% (short children: 19.3%; very short children: 11.5%) (Kementerian Kesehatan RI, 2018).

Stunting is caused by many factors, but in general stunting is determined by household factors and community or country conditions. Household factors such as: inadequate breastfeeding, complementary feeding, living environment, food quality, clean water, infectious diseases, mother's condition, and parenting style. Community or Nation factors such as: education, political economy, agriculture and food, water, sanitation, and the environment (including natural and non-natural disasters), healthcare facilities, society, and culture (World Health Organization, 2017).

Research about the health effects of disasters

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mostly focused on immediate consequences, such as mortality and injury (Doocy *et al.,*, 2013). It has been reported that long-term negative effect of disasters on society are greater in low and middle-income countries than higher income countries. However, the prolonged effect are diffcult to measure and have not been well studied (Kahn, 2005; Ralte *et al.,*, 2011). One way to measure a long-term effect of disasters in one region is by monitor public health indicator such as still birth, maternal mortality, and stunting. Such indicators could describe socoeconomic status and living conditions thab can be affected by disasters (Rydberg *et al.,*, 2015). Under-five stunting is an important health indicator. Stunting could be affected by food insecurity, poverty and diseases, and could indicate long term effect on public health, which could be affected by disasters (Black *et al.,*, 2008; Waterlow, 1994).

In Indonesia, stunting has become a national public health problem, with the prevalence of under-five stunting is 24.4% (Kementerian Kesehatan RI, 2021). Reducing stunting has become one of the targets in MoH Medium-Term Development Plan for 2020-2024. Research on stunting has been done in many ways, but research on correlation of disasters and stunting has not much done yet. We hope this study can provide input for stakeholders to consider disaster management in developing policy plans related to stunting.

2. Materials and Methods

This study is an observational study with an ecological study design (aggregate study). We analysed the correlation between disaster risk and the prevalence of stunting in Indonesia. The unit of analysis used in this study is all provinces in Indonesia in 2021, with a total of 34 provinces.

The independent variable in this study is disaster risk, taken from the 2021 Indonesian Disaster Risk Index (IRBI) published by the National Disaster Management Agency (BNPB). IRBI contains disaster risk index values which are calculations of the hazard, vulnerability and capacity components in provincial and districts level in Indonesia. The calculation is done by scoring each component parameter (BNPB, 2022a) with the following formula:

$$\text{Risiko} = \text{Hazard} \times \frac{\text{Vurnerability}}{\text{Capacity}}$$

Hazard is calculated based on the spatial probability, frequency, and strength of a natural phenomenon that occurs in an area, such as volcanic eruptions, earthquakes, floods, and other natural disasters (BNPB, 2022a). Hazard is a phenomenon or human activity that can cause loss of life, injury or other health impacts, property damage, socio-economic disruption, or environmental damage, it can be natural, antropogenic or socionatural in origin (UNDRR, 2023). Vulnerability is a calculation obtained from economic, physical, and environmental parameters, as well as socio-culture (BNPB, 2022a). Vulnerability is a characteristic that is influenced by physical, socioeconomic, and environmental factors that can increase the vulnerability of a person, community, or system to the effects of hazards (UNDRR, 2023). Meanwhile, capacity is calculated based on the level of regional resilience based on seven priorities: public policy strengthening, risk assessment and integrated planning, developing of information systems, training and logistics, management of disaster-prone areas, increasing the effectiveness of disaster prevention and mitigation, strengthening disaster emergency preparedness, and developing disaster recovery systems (BNPB, 2022a). From the calculation of the three components, IRBI is expected to be able to describe the disaster risk at the provincial or district level. Disaster data used in this study is the calculation of the hazard and vulnerability components from IRBI 2021 data and the capacity component obtained from the regional resilience index 2021. We did not use the hazard and vulnerability components which refer to the baseline (IRBI 2013), because the most recent data is available already.

The dependent variable in this study is the prevalence of under-five stunting. We used the results of the 2021 Indonesian Nutrition Status Study (SSGI) conducted by the National Institute of Health Research and Development, Ministry of Health to describe the prevalence of under-five stunting in each province. Stunting is measured using the Z score by calculating body length or height (PB/TB) for age (U). A child is categorized to severely stunted if he has a Z score < -3 SD, stunted if Z score -3 SD to -2 SD, and normal if Z score ≥ -2 SD (Kementerian Kesehatan, 2020b). SSGI sampling uses stratified two-stage sampling of the Susenas census block with total sample of 153,228 under-five children from 514 districts/cities in 34 provinces, which was conducted in January-December 2021 (Kementerian Kesehatan RI, 2021).

We also included covariate variables such as family economic status and infectious diseases. The prevalence of poor is used to describe the socioeconomic level of society in general. The data is taken from the National Socioeconomic Survey (Susenas) conducted by the Central Bureau of Statistics (BPS) in 2021. The definition of poverty people used in Susenas is the percentage of the population that has an average expenditure per capita per month below the poverty line (Badan Pusat Statistik Provinsi Sulawesi Utara, 2023). Susenas sampling uses the Probability Proportional to Size Sampling (PPS) technique with a total sample

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of 75,000 households in 34 provinces, which was conducted in September 2021 (Badan Pusat Statistik, 2023).

Infectious disease data was taken from the 2018 Basic Health Research (Riskesdas) by the National Institute of Health Research and Development, Ministry of Health (Ethical approval No: LB.02.01/2/KE.024/2018). Riskesdas sampling used the Probability Proportional to Size Sampling (PPS) technique with a total sample of 300,000 households in 34 provinces (Kementerian Kesehatan, 2018). The definition of an infectious disease is an infectious disease that most often occurs in under-five children and the data is available in Riskesdas, such as Accute Respiratory Infection (ARI), pneumonia and diarrhea (Kementerian Kesehatan, 2018). The criteria for infectious diseases based on the diagnoses by health workers (doctors, nurses, or midwives).

This study used open data that can be accessed freely. SSGI, Riskesdas and Susenas are national-scale studies that have ethical approval, and IRBI is a calculation that does not involve humans as research subjects, so it does not require ethical approval. We conducted a spatial analysis to get an overview of disaster risk and the prevalence of stunting at the provincial level. Bivariate analysis was performed by conducting a correlation test to calculate the Pearson correlation coefficient (r) for each variable and depicting it in a scatter plot diagram. Multivariate analysis by performing multivariable linear regression to see the relationship of independent and dependent variables after controlled by covariate. Spatial analysis using QGIS 3.8 and statistical analysis using SPSS version 25.

3. Results

3.1. Descriptive analysis

Figure 1. Iilustrates the provinces with the highest prevalence of stunting are East Nusa Tenggara (37.8%),

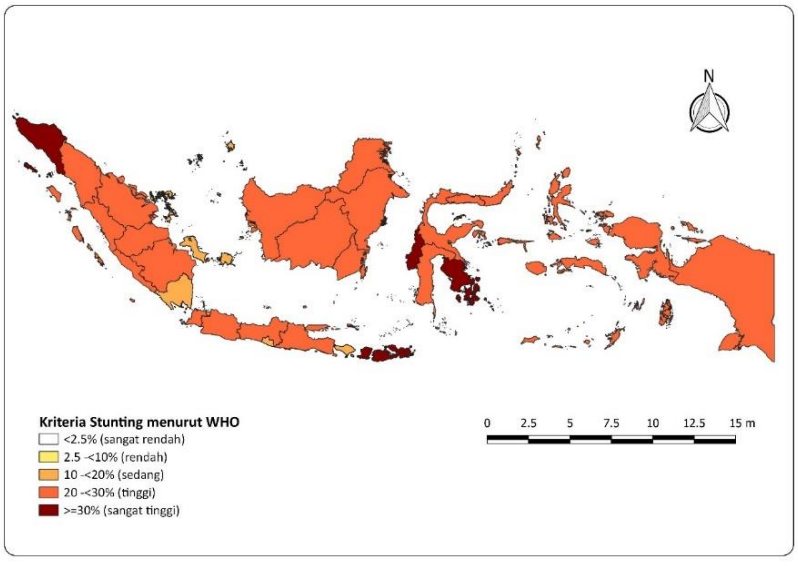

Figure 1. Under-five Stunting Prevalence in Indonesia

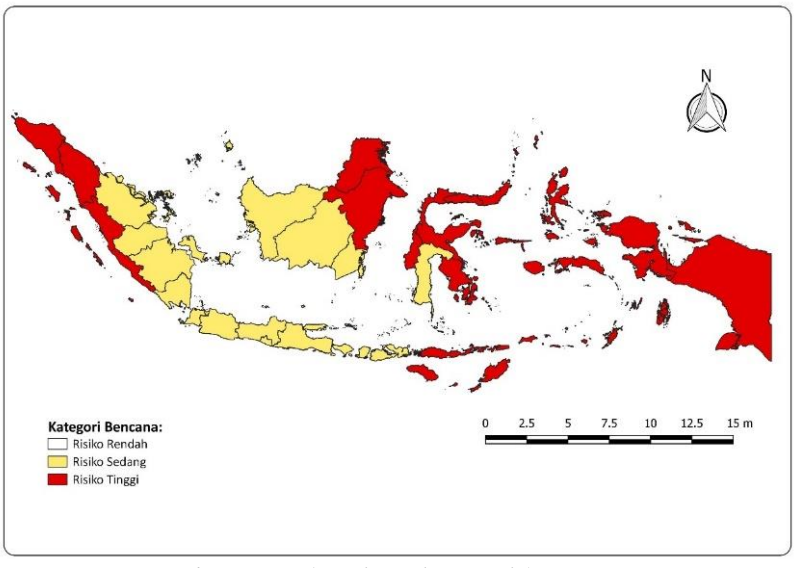

Figure 2. Indonesia's Disaster Risk 2021

Table 1. Stunting Correlation with Other Variables

Variabel	r	p-*value*
Disaster Risk	0.513	0.002
Prevalence of poor	0.180	0.309
Prevalence of Infectious Disease		
Accute Respiratory Infection	1.151	0.394
Pneumonia	0.145	0.413
Diarrhea	0.032	0.859

West Sulawesi (33.8%) and Aceh (33.2%) based on SSGI 2021. Meanwhile, the provinces with the lowest stunting prevalence were Bali (10.9%), DKI Jakarta (16.8%) and DI Yogyakarta (17.3%). The prevalence of stunting in Indonesia is 24.4% (Kementerian Kesehatan, 2021; WHO, 2017).

Based on the IRBI 2021, it is known that the provinces with the highest disaster risk are East Nusa Tenggara (197.48), West Papua (192.54) and Central Sulawesi (187.68), while the provinces with the lowest disaster risk is the DKI Jakarta (41.13), Central Java (91.58) and DI Yogyakarta (91.87). It seems that all provinces in Indonesia have moderate to high disaster risk (Figure 2).

3.2. Bivariate analysis

We conducted a correlation test to analyse the relationship between disaster risk and stunting prevalence in 34 provinces. From the results of the analysis, it was found that there was a significant relationship in a positive direction between disaster risk and the prevalence of under-five stunting with a correlation coefficient (r) = 0.513 (Tabel.1). Meanwhile, the variable prevalence of the poor and infectious diseases (ARI, pneumonia, and diarrhea) is not statistically related to the prevalence of under-five stunting. The scatter plot also shows that only the disaster risk variable has a linear line with a positive direction towards the prevalence of under-five stunting (Figure.3).

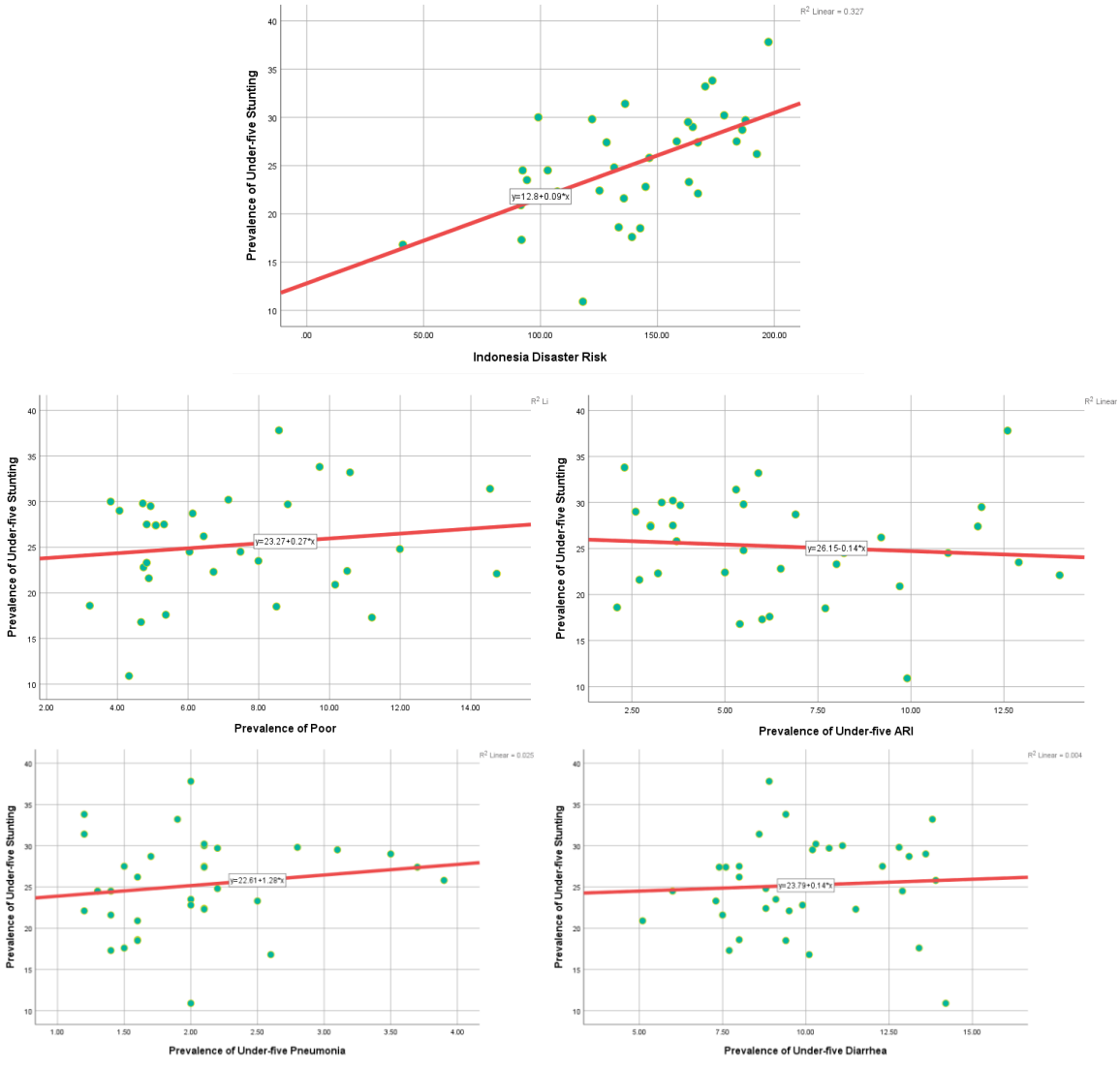

Figure 3. Scatter Plot

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Table 2. Linear Regression Test Result

Variabel	Coef β	p-*value*	R^2*
Disaster Risk	0.403	0.002	0.263

3.3. Multivariate Analysis

The results of bivariate tests show that the prevalence of poor people and infectious diseases was not statistically related to the prevalence of stunting, so they were not included in the multivariate analysis. After conducting a linear regression test, a significant relationship was found between disaster risk and the prevalence of stunting (p value = 0.002) with an R2 value = 0.263 (Tabel.2).

4. Disscussion

Based on the SSGI 2021 results, it was found that the prevalence of under-five stunting in Indonesia 24.4%, which is still high (20 - <30%) referring to the stunting criteria by WHO (World Health Organization, 2021). This achievement is still quite far from the target of reducing the prevalence of stunting in RPJMN and Strategic Plan for 2020 to 2024 by the Ministry of Health (stunting reduced to16% in 2023 and 14% in 2024) (Kementerian Kesehatan, 2020a). These data shows only 6 provinces have a moderate (10 - <20%) prevalence of stunting, and 28 others have category of high (20 - <30%) and very high (≥ 30%) stunting prevalence.

A correlation test on each variable, the disaster risk showed a statistically significant relationship (p value <0.05) with a correlation coefficient of 0.513, meaning there is a positive and strong relationship between disaster risk and the prevalence of under-five stunting (Hastono, 2016). The greater the risk of disaster in one province, the tendency for under-five stunting in that province is increasing. These result are in line with the longitudinal study conducted by Edwards, *et al.,* which stated that there is a relationship between natural disasters and stunting (Edwards, Gray, & Borja, 2020). While the variable prevalence of the poor and infectious diseases under five did not show a statistically significant relationship (p value > 0.05), this is not in line with research conducted by Tiwari, et al, which aims to determine the determinants of child stunting in Nepal. The risk factors that most influenced the incidence of stunting under five were poverty, Low Birth Weight (LBW) and breastfeeding for more than 12 months (Tiwari, Ausman, & Agho, 2014). The different results could be due to differences in the sociodemographic characteristics of the study population and the use of individual data from the Health Demographic Survei in Nepal, whereas in this study, we used aggregate data so it could not describe correlation at the individual level.

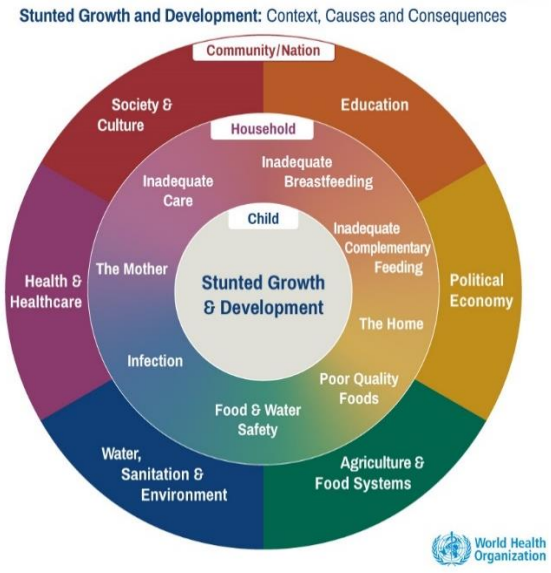

Figure 4. WHO Conceptual Framework of Stunting

The multivariable linear regression test showed the the disaster risk variable correlated with the prevalence of stunting with an R2 = 0.263. Disaster risk can explain the prevalence of under-five stunting by 26,3%, while the rest are explained by other variables (Hastono, 2016).

Stunting is a multi-factor health problem. Stunting is caused by the combined effects of poor nutrition, infectious diseases, and lack of psychosocial stimulation (WHO, 2022). Based on the WHO conceptual framework (Figure 4), stunting is caused by household factors and community or nation-wide conditions. Disaster is one of the external factors that can play a role in the occurrence of stunting in children. Natural and non-natural disasters can affect water, sanitation, and environmental conditions, which in the long run will have an impact on the nutritional status of children (WHO, 2017).

Disasters impact human life, causing injuries and fatalities, and potentially destroying lives and livelihoods (Murray, 2014). Disasters can have an impact on reducing the life quality of people (Tumenggung, 2017), causing injury, disease, displacement, poverty, hunger, death and have a major impact on children (Bartlett, 2008). The impact of disasters will be a higher burden for low-and middle-income country (Gaire, Delbiso, Pandey, & Guha-Sapir, 2016). Disasters can create poverty, affect family ability to fulfill of nutritional and child health needs which can affect children's growth and development and have an impact on their lives, affect cognitive intelligence, educational attainment, and productivity as adults (Skoufias, 2003). Several types of natural disasters such as floods can also affect agriculture and food production in an area which can have an impact on the food security of its

people (Atanga & Tankpa, 2021). Disasters in the short term can cause acute illnesses such as diarrhea, fever, and ARI in under-five children and in the long term can increase the risk of stunting in under-five children (Datar *et al.,*, 2013).

In this study, we use IRBI data to describe disaster risk where the risk is limited to hazards due to natural factors, which include nine types of threats such as earthquakes, tsunamis, volcanic eruptions, landslides, floods, extreme weather, drought, forest and land fires, as well as extreme waves and abrasion (BNPB, 2022b). One of the limitations in this study is the hazard components do not describe disasters due to non-natural and social factors. It is very possible to area which is vulnerable to non-natural disasters such as disease outbreaks or social conflicts which can threat food security and affect the health status of its people. Disaster is one of the many factors that cause stunting, so further research is needed to see a more valid relationship at the individual level and it is correlation with other factors that could not be included in this study due to data limitations. Another limitation of this study is that we used an ecological study design, which is the unit of analysis is aggregate data, so that the results of the study cannot be used to describe causal relationships at the individual level (Schwartz, 1994).

5. Conclusions

Disaster risk is related to the prevalence of stunting in under-five children. When the risk of disaster in one province is higher, the prevalence of stunting in under-five children will tend to be higher too. The results of the spatial analysis also show that Indonesia has a high risk of disaster, as well as a high prevalence of stunting. A disaster management program can be considered to reduce stunting in Indonesia.

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