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Does Food Inflation Affect Infant and Child Mortality? Evidence from Indonesia

(Adakah Inflasi Makanan Mempengaruhi Kematian Bayi dan Kanak-Kanak? Bukti dari Indonesia)

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ABSTRACT

This study investigates the impact of food inflation on infant and child mortality in Indonesia, employing panel estimation with provincial fixed effects. Data from the Indonesia Demographic Health Survey, Statistics Indonesia, and the Ministry of Finance, which has been underexplored in previous studies, is used. Mortality is measured using the infant mortality, under-five mortality, child mortality, neonatal mortality, and post-neonatal mortality rates. The study controls for provincial characteristics namely, political stability, crime rates, socio-cultural differences, and provincial governments' effectiveness in promoting infant and child health programs. The study found that food inflation and certain socioeconomic characteristics (literacy, per capita gross domestic product, and professions), have a significant influence on infant and child mortality in Indonesia. The study also found that the impact of food inflation is higher in vulnerable groups, specifically in the eastern provinces of Indonesia and those outside Java-Bali. The results contribute to policies related to food inflation and child health, particularly in developing countries with regional disparities similar to Indonesia.

Keywords: Food inflation; child mortality; provincial fixed effect; Indonesia; vulnerable groups regional disparities

ABSTRAK

Kajian ini menyiasat kesan inflasi makanan ke atas kematian bayi dan kanak-kanak di Indonesia, menggunakan anggaran panel dengan kesan tetap wilayah. Data daripada Tinjauan Kesihatan Demografi Indonesia, Statistik Indonesia, dan Kementerian Kewangan, yang kurang diterokai dalam kajian terdahulu, digunakan. Kematian diukur menggunakan kadar kematian bayi, kematian bawah lima tahun, kematian kanak-kanak, kematian neonatal dan kadar kematian selepas neonatal. Kajian ini mengawal ciri-ciri wilayah iaitu, kestabilan politik, kadar jenayah, perbezaan sosio-budaya, dan keberkesanan kerajaan wilayah dalam mempromosikan program kesihatan bayi dan kanak-kanak. Kajian mendapati bahawa inflasi makanan dan ciri sosioekonomi tertentu (celik huruf, keluaran dalam negara kasar per kapita, dan profesion), mempunyai pengaruh yang signifikan terhadap kematian bayi dan kanak-kanak di Indonesia. Kajian itu juga mendapati kesan inflasi makanan lebih tinggi dalam kumpulan yang terancam, khususnya di wilayah timur Indonesia dan di luar Jawa-Bali. Hasil kajian menyumbang kepada dasar yang berkaitan dengan inflasi makanan dan kesihatan kanak-kanak, khususnya di negara membangun yang mempunyai jurang perbezaan serantau yang serupa dengan Indonesia.

Kata kunci: Inflasi makanan; kematian kanak-kanak; kesan tetap wilayah; Indonesia; jurang perbezaan wilayah kumpulan terancam
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INTRODUCTION

Malnutrition is one of the factors that causes child mortality in developing countries. Malnutrition during pregnancy and early birth may influence the risk of disease prevalence, physical disability, and cognitive development in children. These factors, in turn, can affect an individual's health during adulthood, education performance, social behavior, and other impacts, including income (Sirag et al. 2022) during adulthood. Malnutrition has the worst impact on infant and child mortality.

Child survival remains the focus of the United Nations' sustainable development goals (SDGs), which

target a two-third reduction in the global under-five mortality rate. In 2015, approximately 16,000 children under five continued to die daily because of malnutrition (UN 2015). Malnutrition is often attributed to natural disasters and poverty. However, malnutrition caused by food inflation is rarely the focus of policymakers or society. Inflation, specifically food inflation, may cause deficiencies in micronutrition, which may lead to wasting, stunting, and underweight. These conditions significantly increase the risk of morbidity and mortality in infants and children.

Although infant and child mortality have decreased over the last few years, they remain high. Malnutrition contributes to approximately 35% of under-five deaths and 11% of morbidities (UNICEF 2019). In Indonesia, child mortality has generally decreased over the last few years; however, this decrease is insignificant. For instance, neonatal mortality decreased from 20 deaths per 1000 live births in 2002–2003 to 15 deaths per 1000 live births in 2017 (IDHS 2017). The infant mortality rate decreased from 35 deaths per 1000 live births in 2002–2003 to 24 deaths per 1000 live births in 2017. The under-five mortality rate decreased from 44 deaths per 1000 live births in 2007 to 32 deaths per 1000 live births in 2017 (IDHS 2017).

Furthermore, regional disparities in child mortality within the country remain high. For instance, there were significant differences in infant mortality rates between western and eastern Indonesia. In western Indonesia, the mortality rate was below 30 deaths per 1000 live births. However, in eastern Indonesia, the rate exceeded 30; in the Papua province, the rate exceeded 40 deaths per 1000 live births over the past decade (IDHS 2017). Meanwhile, the difference was even more significant for under-five mortality rates between western and eastern Indonesia. In 2017, there were 25 deaths per 1000 live births in Jakarta province (a western Indonesian province), compared to 45 deaths per 1000 live births in East Nusa Tenggara (an eastern Indonesian province), 39 deaths in North Kalimantan, 54 deaths in West Sulawesi, and 80 deaths in Papua province per 1000 live births.

Indonesia experienced historically high levels of food inflation from 2013 to 2017 (see figure 1), which may have affected child health through poverty (Faharuddin et al. 2023). While the country has maintained a controllable inflation rate, food inflation, along with administered prices, mainly contribute to the inflation rate. For example, in Indonesia, foodstuff increased from 1.26% in 2017 to 3.41% in 2018 and 4.3% in 2019 (Bank Indonesia 2013). Additionally, according to the Living Cost Survey conducted by Statistics Indonesia (2020), food significantly contributes to the country's inflation. For example, in 2018, food consumption was the second highest expense (18.02%) in Indonesia's cost of living, following housing, electricity, and household energy. As food constitutes a substantial portion of consumption in Indonesia, an increase in food prices will significantly affect the living conditions of its people and potentially contribute to poverty. Therefore, increasing food prices may increase poverty and, in turn, may reduce the quality and quantity of food consumption. This condition leads to malnutrition; if persistent, it may cause an increase in morbidity and mortality, including child mortality.

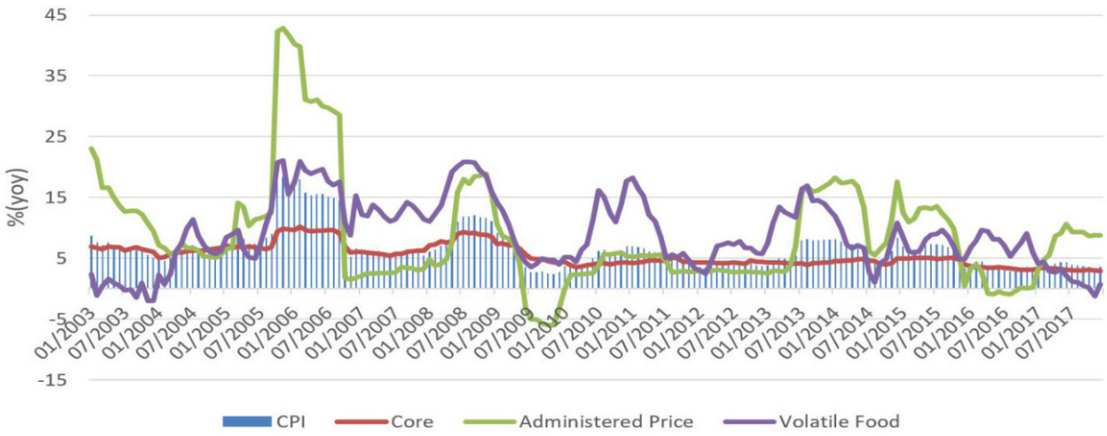

FIGURE 1. Indonesian inflation trend (2013–2017)
Source: Farandy 2020 (calculated from BPS, 2018, modified)

This study investigates the impact of food inflation on infant and child mortality in Indonesia, using data panel estimation. Data for 33 provinces in Indonesia from the 2012 and 2017 Indonesia Demographic Health Survey (IDHS) and Statistics Indonesia are used. Mortality was measured using the infant mortality, under-five mortality, child mortality, neonatal mortality, and post-neonatal mortality rates. Provincial characteristics, namely, political stability, crime rate, socio-cultural differences, and provincial governments' effectiveness in promoting infant and child health programs were controlled. The study found that food inflation, together with certain socioeconomic characteristics (literacy, per capita gross domestic product, and professions), have a significant influence on infant and child mortality in Indonesia. The study also found that the impact of food inflation is higher for more vulnerable groups, specifically in eastern Indonesia and outside the Java-Bali region. These results contribute to formulating policies related to food inflation and child health, particularly in developing countries with regional disparities similar to Indonesia.

This study contributes to the existing literature in several ways. The study is innovative as it uses provincial panel data and differentiates between the least developed (eastern Indonesian provinces) and the more developed regions (western Indonesian provinces). Previous studies (Arndt et al. 2016; Kidane & Woldemichael 2020; Akinlo & Odusanya 2016; Hoon Lee et al. 2016) have used African and developing country data to analyze the relationship between food inflation and mortality rates. Further, data from the IDHS and Statistics Indonesia are used as macroeconomic indicators of food inflation and real GDP per capita, which have been underexplored in previous studies. Previous studies of other countries (Arndt et al. 2016; Kidane & Woldemichael 2020; Akinlo & Odusanya 2016; Hoon Lee et al. 2016) have employed data from African countries from several databases. A method that includes a time-invariant provincial fixed effect to capture unobserved institutional factors was employed. Panel data estimation can be used to solve the omitted variable bias problem caused by these unobserved factors. Finally, research on the effect of food inflation on child mortality in Indonesia is lacking. The most recent studies on the impact of macroeconomic variables, including inflation, on mortality rates were conducted in Nigeria (Adeosun 2022), Mozambique (Arndt et al. 2016), Ethiopia (Kidane & Woldemichael 2020), sub-Saharan Africa (Akinlo & Odusanya 2016), and developing countries (Hoon Lee et al. 2016).

LITERATURE REVIEW

Previous studies have examined the relationship between global food crises, health, and nutritious food consumption (Brinkman et al. 2010; Christian 2010; Darnton-Hill & Cogill 2010). Specifically, commodity prices impact macroeconomic conditions (Cespedes & Velasco 2014), affecting infant mortality rates (Baird et al. 2011). Brinkman et al. (2010) identified a negative relationship between food prices and the consumption of a healthy diet in Haiti, Nepal, and Nigeria. They found that households in these countries attempt to reduce both food quality and quantity and face a high risk of malnutrition owing to global food crises.

Christian (2010) analyzed and elaborated on nutritional mechanisms to explain the impact of economic crises, in line with increasing food prices, on infant and child mortality. Darnton et al. (2010) focused on pregnant women and child nutrition. Moreover, Lee et al. (2016) also obtained similar results, particularly in developing and low developing countries, where increasing food prices impact nutritious food intake, which, in turn, contributes to an increase in infant and child mortality. The biological mechanisms underlying the impact of food crises have also been widely examined (Barker & Clark 1997; Wu et al. 2004; Kidane & Woldemichael 2020). Malnutrition in pregnant women before and during pregnancy may affect fetal programming and infant growth. Malnutrition during pregnancy can cause low birth weight, leading to higher infant health risks.

Research on Indonesia, a developing country with regional differences in socioeconomic and cultural backgrounds, still requires further study. These regional differences may influence differences in child health and, in this case, their mortality. Households from low socioeconomic backgrounds may suffer because of food inflation, leading to food distress and the consumption of less nutritious food owing to higher prices of nutritious food. Consequently, nutritional deficiency may occur and the risk of morbidity and mortality may increase. In Indonesia, this risk is substantial, particularly in provinces with low per-capita income and a high prevalence of malnutrition. Additionally, the focus on early life in this study has a twofold rationale. First, improving child survival is a critical concern in developing countries, including Indonesia, as recognized by the United Nations. Second, children face an increased risk of diseases and other health issues related to the quality of nutrition or life overall (Galiani et al. 2005). Both may be partially attributed to food commodity prices.

The theoretical framework in this study is adopted from Makhlouf et al. (2017), who analyzed the relationship between commodity price volatility and child mortality in developing countries. They focused on the role of the global commodity market. They explain three channels through which commodity prices affect child mortality. First, the cost channel, where an increase in the prices of goods, including food and energy, influences household living costs and, therefore, decisions regarding food consumption and healthcare expenditure. This channel explains how increasing food prices is often theorized to

correlate with rising malnutrition, thereby causing child mortality (Christian 2010; Darnton-Hill & Cogill 2010).

Second, Makhlaf et al. (2017) explain that most developing countries engage in the trade of main commodities that are sensitive to global commodity price changes. This trade could affect the countries' economy and government revenue, consequently affecting their healthcare budget. This would, in turn, influence child health. Makhlaf et al. (2017) called this mechanism a government channel.

Third, they state that child mortality can be explained through income channels. They argue that household income in developing countries depends on global commodity prices via employment in certain sectors. Therefore, changes in global commodity prices may influence child mortality through income channels.

Considering this study's focus on food inflation within Indonesia, it analyzes parts of Makhlouf et al.'s (2017) theoretical pathways that explore the relationship between domestic commodity price levels and child mortality through cost channels, which could influence household living costs. Based on this theoretical framework, the hypothesis that food prices—in this case, food inflation—influence infant and child mortality in Indonesia is proposed. Second, the effect of food inflation varies across provinces, particularly between western Indonesia (the region with higher per capita gross domestic product, other socioeconomic indicators, and healthcare facilities) and eastern Indonesia (the region with lesser economic and healthcare infrastructure than western Indonesia).

METHODOLOGY

METHODS

Data panel estimation is used in this study to analyze the impact of food prices on infant and child mortality in Indonesian provinces using data from 2012 and 2017. The outcome variables include infant mortality, under-five mortality, child mortality, neonatal mortality, and post-neonatal mortality rates.

The possibility that provincial characteristics could differ among provinces arises when analyzing the association between food inflation and child mortality. These characteristics include political stability, crime rates, socio-cultural differences, and provincial governments' effectiveness in promoting infant and child health programs. These institutional qualities determine the system's effectiveness in mitigating the effects of food price increases and the healthcare system's effectiveness in providing healthcare services. Atkinson and Hamilton (2003) and Van der Ploeg (2011) suggested that effective institutions play an important role in economies by positively impacting their resources. However, this study does not consider these factors owing to a lack of available data for these characteristics in Indonesia. Therefore, this study employs a provincial fixed effect method that is time-invariant to capture these unobserved institutional factors. Panel data estimation can be used to solve the omitted variable bias problem caused by unobserved factors. The model used in this study follows Lee et al. (2016) and Gerdtham and Ruhm (2006).

$$Mortality_{it} = \beta_0 + \beta_1 FP_{it} + \beta_2' CV_{it} + a_i + \delta_t + u_{it} \quad (1)$$

where $Mortality_{it}$ is the mortality rate, including the neonatal mortality, post-neonatal mortality, infant mortality, under-five mortality, child mortality, and post-neonatal mortality rates as dependent variables on the *i*th cross-sectional (provincial) unit at time *t*. Therefore, there are five separate estimations for each dependent variable. FP_{it} is the food inflation rate for each province for 2012 and 2017. Furthermore, CV_{it} comprises a vector of *control variables* encompassing provincial gross domestic product real per capita, percentage of the population with access to proper sanitation (to represent the living environment), percentage of the population with access to clean drinking water, provincial government healthcare expenditure, maternal literacy rates, maternal exposure to media, and the percentage of the population covered by health insurance within each province for 2012 and 2017. All variables are at the provincial level for 2012 and 2017. The provincial unobserved factors are represented by a_i (*provincial fixed effect*), δ_t is a time specific effect that captures infant and child mortality determinants that vary uniformly across provinces over time, and $_{it}$ includes all unobserved time-variant factors. The estimation is conducted for two areas in Indonesia with distinct socioeconomic characteristics—western and eastern Indonesia—to assess the varying impacts of food inflation.

Econometric issues have been raised in previous empirical studies. The first is the possibility of an association between excluded variables affecting the mortality rate and food inflation. To address these concerns, a fixed effect (provincial fixed effect) or the first difference method (Pritchett & Summers 1996; Ross 2006) can be employed. This study employs provincial fixed effects.

The second issue relates to the requirement for time-varying independent variables in model (1). Other panel studies that have considered this issue include Ruhm (2000), Gonzales and Quast (2011), and Makhlouf et al. (2017). The data for this study appears to satisfy this condition, as food inflation fluctuations suggest sufficient variation across provinces over time.

The final econometric issue relates to the downward trend of mortality in Indonesia over time owing to various factors, such as healthcare and health facility improvements. Specifically, if Indonesia improves its healthcare system, government health programs, and promotions that address health problems, it may lower infant and child mortality. An empirical study that

neglects this possibility will provide misleading results and misinterpretation of the impact of factors in the model; a reduction in infant and child mortality could be caused by the improvement of other factors related to the healthcare system and government programs. To address this possibility, we include a time-specific effect to test whether there has been a significant improvement in the healthcare system over time, potentially influencing infant and child mortality.

DATA

This study analyzes the relationship between food inflation and other factors influencing infant and child mortality in Indonesian provinces. The data used in this study were obtained from the IDHS for 2012 and 2017, and Statistics Indonesia for the same years. These two waves represent the most recent IDHS data, encompassing all provinces in Indonesia. The IDHS is conducted every five years; we use the two most recent data waves, which are for 2012 and 2017; the last IDHS was conducted in 2017. The IDHS data are combined with data from Statistics Indonesia and the Ministry of Finance of Indonesia (only for health expenditure data).

The IDHS has a very high response rate, encompassing 95% of all participants. For this study, we used the IDHS data as outcome indicators. They are *infant mortality*, *under-five mortality*, *child mortality*, *neonatal mortality*, and *post-neonatal mortality rates*. Additionally, the IDHS also collects information regarding the socioeconomic characteristics of mothers, such as their education, literacy, health insurance availability, employment in professional/technical/managerial fields, access to media (newspapers, television, and radio) at least once a week, and mothers aged 15–49 with the highest level of schooling beyond senior high school. These factors may influence children's early life.

The quality of infant and child mortality depends on the mother's ability to recall all pregnancies and their histories, including the birth dates and deaths of children. Therefore, there exists a potential for bias to arise when using these data, including *selection omission* involving child deaths, resulting in *an underestimation* in the calculation of child deaths. This problem may also cause *recall bias*. However, we believe that the possibility of bias is minimized and will not influence the estimation significantly, because the study used the most recent data from the IDHS and Statistics Indonesia survey.

The indicator for the key variable, food inflation, was collected from Statistics Indonesia (BPS). Other control variables from Statistics Indonesia are gross domestic product per capita per province and sanitation. Provincial governments' expenditure on healthcare was obtained from the Ministry of Finance of Indonesia. Table A1 in the Appendix provides the variable descriptions and sources.

RESULTS AND DISCUSSION

SUMMARY STATISTICS

Table 1 presents summary statistics of the mean values of each variable used in this study. There are five dependent variables: neonatal, infant, child, under-five, and post-neonatal mortality rates. The independent variables include food inflation, real per capita gross domestic product, health insurance availability, education beyond secondary school, employment in a professional job, access to mass media, access to clean drinking water, access to proper septic tanks, maternal literacy levels, and government healthcare expenditure. The mean value is divided into five categories, as depicted in Table 1: 1) the mean value of all samples comprising 33 provinces in Indonesia for two different years (2012 and 2017); 2) the mean value of the variables within the western provinces, comprising 44 observations; 3) the mean value of eastern Indonesian provinces, such as Papua Province and Maluku Province; 4) the mean value of provinces located on the islands of Java and Bali, comprising only 14 observations; and 5) the mean value of provinces located outside the islands of Java and Bali, comprising 51 observations.

Neonatal mortality has a mean value of 20.69 for the full sample, suggesting that, on average, 21 infants per 1000 live births do not survive the first 28 days of life in all provinces of Indonesia. Specifically, eastern Indonesia has the highest mean death rate at 24.29, and the lowest is in Java-Bali at 17.57. For the post-neonatal variable, the average mean is 13.51, indicating that, on average, there are 14 deaths of infants aged more than one month (post-neonatal) per 1000 live babies in every province of Indonesia. The highest mortality rates are observed in eastern Indonesia, while the lowest are on the islands of Java-Bali. For the infant mortality variable, on average, there are 34 deaths of infants aged less than one year per 1000 live births; the highest mortality rates are also found in eastern Indonesia.

Furthermore, the child mortality variable has the lowest mean value than other types of mortality; on average, there are ten deaths in children aged 1–5 years per 1000 living children. On the other hand, the under-five mortality rate has the highest average value than other types of mortality; on average, there are 44 deaths of children under five years of age per 1000 live births. The highest under-five mortality rate is also in eastern Indonesia and the lowest is in the Java-Bali region.

Food inflation is the primary independent variable in this study. Table 1 shows that on average, inflation was at 3.6 percent, with the highest average rate of inflation in the Java-Bali region. This study also includes maternal characteristics (women aged 15–49 years) by including the variables of insurance, education, employment, maternal exposure to mass media, and maternal literacy levels. Regarding insurance, on average, only 51 percent

of mothers have insurance; the highest mean is in eastern Indonesia. Furthermore, in terms of education, mothers whose highest level of education was tertiary education remained low, with a mean of only 15.84 percent. Regarding profession, those working in professional/technical/managerial fields are also relatively low; the mean value is only 12.36 percent.

This study differentiates the estimates between western and eastern Indonesia and between Java-Bali and outside the Java Bali region. It shows the differences in socioeconomic characteristics to determine the impact of food inflation on the outcome variables owing to regional differences in socioeconomic characteristics. The western and Java-Bali regions of Indonesia represent better socioeconomic conditions than eastern Indonesia and the outside Java-Bali region, as indicated in Table 1. For example, in terms of real GDP per capita, the western region has a higher figure at 41,023,031 rupiahs, than the eastern region's 30,001,972 rupiahs. The Java-Bali region has a higher percentage of individuals with education beyond the secondary level and a higher literacy rate. Moreover, a higher percentage of individuals have access to mass media in the western region (4.39%) than the eastern region (3.42%), and the Java-Bali region (5.65%) than the outside Java Bali region (3.65%). Finally, there is also a higher percentage of individuals with access to proper septic tanks in the western and Java-Bali regions than those outside the Java-Bali region and eastern Indonesia.

TABLE 1. Summary statistics

	Full Sample	West	East	Java-Bali	Outside Java-Bali
Dependent Variables					
Neonatal mortality rate	20.69	18.98	24.29	17.57	21.55
Post-neonatal mortality rate	13.51	10.11	20.62	8.50	14.88
Infant mortality rate	34.28	29.18	44.95	26.07	36.53
Child mortality rate	10.48	7.27	17.19	6.14	11.67
Under-five mortality rate	44.26	36.05	61.48	31.86	47.67
Independent Variables					
Food inflation (%)	3.59	3.53	3.70	3.98	3.48
Real GDP per capita (Rupiah)	37,462,381	41,023,031	30,001,972	34,439,571	38,292,172
Availability of health insurance (%)	51.00	48.99	55.20	50.52	51.13
Education beyond secondary level (%)	15.84	14.94	17.73	16.13	15.76
Professional jobs (%)	12.36	11.77	13.60	11.20	12.68
Access to mass media (%)	4.08	4.39	3.42	5.65	3.65
Access to clean drinking water (%)	38.60	36.93	42.10	39.69	38.30
Access to proper septic tanks (%)	70.05	70.28	69.58	79.24	67.53
Literacy (%)	93.14	94.44	90.42	95.44	92.51
Government healthcare expenditure (million Rupiah)	14,600,000	5,620,000	33,500,000	5,390,000	93,400,000
Number of Observations (N)	65	44	21	14	51

Source: author's calculation using IDHS, Statistics Indonesia, and Ministry of Finance of Indonesia dataset.

The mean value of maternal exposure to mass media is significantly low at 4.08 percent, suggesting that only 4.08 percent of mothers aged 15–49 years have access to mass media, such as TV, radio, and newspapers, at least once a week. However, maternal literacy levels are relatively high; on average, 93.14 percent of mothers are literate.

Furthermore, this study also considers sanitation in Indonesian households by examining variables related to access to clean drinking water and proper septic tanks. On average, 38.60 percent of Indonesian households use safe drinking water, which includes piped water and rainwater (artesian well/pump, protected well, and protected springs). The distance to the nearest final disposal site of feces is ≥ 10 m. Regarding the final disposal site for feces, the figure is relatively high; on average, 70.05 percent of households use proper septic tanks as the final disposal site for feces. This study also accommodates provincial factors such as real per capita GDP and local government health sector spending. In terms of GDP, each province's average GDP is 37,462,381 rupiah and healthcare expenditure is 14,600,000 (millions of rupiah).

FOOD INFLATION IN FULL SAMPLE ESTIMATION

Table 2 presents the results of the fixed-effects estimation for the full sample of 33 Indonesian provinces. The table shows the results for each outcome variable, including all control variables. The first column shows the key variable—food inflation—combined with all control variables.

In this estimation, the time fixed effects are not statistically significant for any outcome variable; therefore, the final estimation does not include time fixed effects. This implies that during the survey period, there was no significant improvement in Indonesia's healthcare system or in child

mortality programs. In general, the results demonstrate that food inflation statistically significantly influences the outcome variables, except for child mortality, in the full sample. As shown in column (1), for neonatal mortality, the coefficient of food inflation is 0.02723, which is statistically significant at the 10 percent level. This implies that a 10 percent increase in food inflation increases the neonatal mortality rate by 0.273 or approximately 27.3 percent, which is substantial considering the survival of newborns within the first four weeks of life.

Column (2) shows the estimated coefficient for food inflation and infant mortality, which represents infant deaths before their first birthday. The coefficient for food inflation is positively significant and statistically more significant than neonatal mortality at the 5% level, with an estimated coefficient of 0.0423. This indicates that rising food inflation decreases infants' survival rate more than that of neonates. In other words, a 10 percent increase in food inflation increases infant deaths during the first year after birth by 42.28 percent.

Column (3) presents the results for child mortality. The results show that the coefficient for food inflation is positive, but statistically insignificant. Further, its magnitude is lower than that of the infant mortality rate. This suggests that increasing food inflation does not significantly influence child mortality among those aged one to five years.

Column (4) shows the results for under-five mortality. The definition of the under-five mortality rate, as explained in the IDHS, is the probability of children dying between birth and the age of five years. The estimated coefficient for food inflation (0.0387), is positive and statistically significant at the 5% level, which is higher than that of neonatal mortality. This implies that a 10 percent increase in food inflation can increase the under-five mortality by 38.67 percent.

Finally, column (5) shows the results for post-neonatal mortality, which is the probability of children dying between one month and one year of age. The estimated coefficient for food inflation (0.0845), is positive and statistically significant at the 5% level, which is higher than that of neonatal mortality. This implies that a 10 percent increase in food inflation can increase the under-five mortality by 84.49 percent. This percentage is the highest among other child mortality measurements.

The results of the full-sample estimation indicate that early childhood is highly vulnerable to food inflation, particularly among children under the age of five. The magnitudes of post-neonatal and infant mortalities are significantly high. This suggests that the survival risk for children immediately after birth is higher than after their first birthday. These results align with those in the biomedical literature (Barker & Clark 1997; Wu et al. 2004), indicating that maternal nutrition before and during pregnancy significantly affects fetal growth and preterm birth. Fetal nutrition is determined by mothers' intake of nutrition and diet, delivered through the placenta and the placental transfer capabilities (Barker & Clark 1997; Owens et al. 1989). Therefore, fetal growth is vulnerable to maternal nutrition deficiencies. Consequently, mothers who experience malnutrition before and during pregnancy, including protein and micronutrient deficiencies, face a higher risk of giving birth to unhealthy infants. This condition is caused by fetal malnutrition, leading to various complications and diseases that cause low birth weight and preterm birth, ultimately decreasing early-life survival rates (Kidane & Woldemichael 2020).

TABLE 2. Fixed-effect estimation for the full sample: the impact of food inflation

	Neonatal Mortality	Infant Mortality	Child Mortality	Under-five Mortality	Post neonatal Mortality
	(1)	(2)	(3)	(4)	(5)
Food Inflation (%)	0.0273*	0.0423**	0.0378	0.0387**	0.0845**
	(0.0149)	(0.0177)	(0.0323)	(0.0154)	(0.0367)
Ln Per capita GDP (Rp)	-1.3896**	-0.9137	-3.5070**	-1.2135**	0.0331
	(0.4477)	(0.6028)	(1.1483)	(0.5882)	(1.2239)
Availability of health insurance (%)	-0.0043	-0.0051	-0.0075	-0.0031	-0.0053
	(0.0049)	(0.0043)	(0.0009)	(0.0039)	(0.0085)
Education beyond secondary level (%)	0.0318	0.0435*	0.0026	0.0299	0.0587
	(0.0237)	(0.0242)	(0.0386)	(0.0220)	(0.0709)
Professional jobs (%)	-0.0585**	-0.0774**	0.0561	-0.0604**	-0.1259**
	(0.0289)	(0.0259)	(0.0558)	(0.0254)	(0.0510)
Exposure to mass media (%)	-0.0141	-0.0058	-0.0362	-0.0088	0.0250
	(0.0216)	(0.0180)	(0.0444)	(0.0214)	(0.0428)
Access to clean drinking water (%)	-0.0415**	-0.0142	-0.0921**	-0.0217	0.0435
	(0.0130)	(0.0172)	(0.0351)	(0.0154)	(0.0332)
Access to proper septic tanks (%)	0.0008	-0.0050	-0.0000	-0.0044	-0.0151
	(0.0060)	(0.0051)	(0.0109)	(0.0053)	(0.0085)

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Ln Government Health expenditure (Rp)	0.0025	0.0218	0.0309	0.0241	0.0372
	(0.0176)	(0.0140)	(0.0328)	(0.0152)	(0.0408)
Literacy (%)	0.0283	0.0246	0.1091**	0.0321*	0.0155
	(0.0168)	(0.0210)	(0.0530)	(0.0174)	(0.0408)
Constant	26.1967***	17.6468*	54.7772**	22.4693**	-0.7318
	(7.4511)	(9.7415)	(18.3861)	(9.3667)	(20.2182)

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

OTHER CONTROL VARIABLES IN FULL-SAMPLE ESTIMATION

Generally, for the full-sample estimation, the per capita gross domestic product, percentage of mothers who work in professional jobs, and percentage of access to clean drinking water statistically significantly influence child mortality in Indonesia. The negative value for per capita GDP shows that an increase in per capita GDP reduces child mortality at the 5% significance level, except for infant and post-neonatal mortalities. This implies that an increase in the welfare of society may influence the decision to choose a better quality of life, including food nutrition intake and other healthy behaviors that, in turn, will reduce the probability of children dying at a young age. This supports previous studies that show the role of income in reducing child mortality in the developing world (Pritchett & Summers 1996; Cutler et al. 2002; Bhalotra 2010; Baird et al. 2011; Lee et al. 2016). Moreover, financial protection in terms of health insurance could also reduce child mortality rates; however, the coefficients are not statistically significant for all outcome variables.

Furthermore, mothers who work in professional jobs also have a positive impact on decreased child mortality. The negative value for the estimated coefficient implies that mothers with professional jobs may have two advantages in reducing child deaths. First, mothers with an income can increase their intake of more nutritious foods. Second, mothers earning their own income may have higher bargaining power in household decisions than those relying only on their husband's income, particularly regarding food provision. Therefore, they could provide nutritious food for themselves and their children.

Moreover, access to clean drinking water represents the use of appropriate sanitation practices in the household as an important complement to the availability of food to prevent child malnutrition. However, based on the results of the full-sample estimation, only neonatal and child mortalities are statistically significantly influenced by access to clean drinking water at the 5% level. The negative value for the estimated coefficient shows that an increase in the percentage of the population that can access clean drinking water in Indonesian provinces will reduce neonatal and child mortality. These findings are supported by previous studies such as Akinlo (2016), in sub-Saharan Africa. Finally, the coefficients that represent mothers' education—for instance, maternal exposure to mass media, mothers with higher education, and maternal literacy rates—are not statistically significant, although maternal exposure to mass media has an expected sign. Additionally, government healthcare expenditure did not statistically significantly influence child mortality.

FOOD INFLATION ESTIMATION FOR WESTERN AND EASTERN INDONESIA

Table 3 presents the estimation results for a differentiated sample, which includes western and eastern Indonesia. Generally, the estimated coefficients for food inflation are statistically significant for western Indonesia, except for neonatal mortality. The coefficient for infant mortality is 0.0439. This indicates that a 10 percent increase in food inflation increases infant deaths during the first year after birth by 43.9 percent, which is slightly higher than in the full sample and higher than the coefficient estimated for neonatal mortality in the full sample. When comparing it to eastern Indonesia, the coefficient for the eastern region is significantly higher than that for the western region, which is -0.1884. However, its negative value indicates a contrasting result.

For child mortality, the coefficients for estimated food inflation for western and eastern Indonesia are 0.0669 and 3.2159, which statistically significantly influence child mortality. The higher magnitude for eastern Indonesia suggests that child mortality risk is significantly higher than western Indonesia; this can be attributed to the lower socioeconomic conditions because of food inflation. Thus, an increase in food inflation is likely to affect people in eastern Indonesia.

TABLE 3. Fixed-effect estimation for western and eastern Indonesia

	Neonatal Mortality		Infant Mortality		Child Mortality		Under-five Mortality		Post-neonatal Mortality	
	(1)		(2)		(3)		(4)		(5)	
	West	East*	West	East*	West	East*	West	East*	West	East*
Food Inflation	0.02557	0.4277***	0.04439*	-0.1884***	0.0669**	3.2159***	0.04432*	0.3869***	-0.1020**	-0.8227***
	(0.0222)	(0.0000)	(0.02359)	(0.0000)	(0.0317)	(0.0000)	(0.0225)	(0.0000)	(0.0488)	(0.0000)
Ln Per capita GDP	-0.65583	-5.0509***	-0.79062	2.0032***	-6.0033***	-28.0886***	-1.7936**	-2.7426***	-1.16455	8.6191***
	(0.6148)	(0.0000)	(0.7893)	(0.0000)	(1.1402)	(0.0000)	(0.6912)	(0.0000)	(1.3515)	(0.0000)
Availability of health insurance	-0.0123**	-0.05429***	-0.00060	0.0426***	-0.00010	-0.5950***	-0.00149	-0.0620***	0.0093	0.1320***
	(0.0059)	(0.0000)	(0.0045)	(0.0000)	(0.0082)	(0.0000)	(0.00492)	(0.0000)	(0.0082)	(0.0000)
Education beyond secondary level	0.00009	0.4312***	0.03644	-0.0874***	0.06311	2.7127***	0.03985	0.3761***	0.07454	-0.6166***
	(0.0329)	(0.0000)	(0.0284)	(0.0000)	(0.0455)	(0.0000)	(0.03205)	(0.0000)	(0.0082)	(0.0000)
Professional jobs	-0.0679**	-0.1556***	-0.1048***	0.0002***	0.0163	-0.6846***	-0.08725**	-0.1243***	-0.1893***	0.1683***
	(0.0302)	(0.0000)	(0.0327)	(0.0000)	(0.0593)	(0.0000)	(0.03217)	(0.0000)	(0.0595)	(0.0000)
Exposure to mass media	-0.0450**	-0.0738***	-0.00012	0.0269***	0.00034	-0.0248***	0.00854	-0.0129***	0.0833	0.1301***
	(0.0211)	(0.0000)	(0.0246)	(0.0000)	(0.0485)	(0.0000)	(0.02527)	(0.0000)	(0.0523)	(0.0000)
Access to clean drinking water	-0.0503***	-0.0784***	-0.00254	0.0858***	-0.1180***	-0.6671***	-0.03545*	-0.0306***	0.0415	0.2450***
	(0.0166)	(0.0000)	(0.0190)	(0.0000)	(0.0282)	(0.0000)	(0.01716)	(0.0000)	(0.0338)	(0.0000)
Access to proper septic tanks	0.01106	-0.0520***	0.00024	0.0023***	-0.01197	-0.3199***	-0.00346	-0.0523***	-0.00235*	0.0657***
	(0.0091)	(0.0000)	(0.0067)	(0.0000)	(0.0128)	(0.0000)	(0.00679)	(0.0000)	(0.0125)	(0.0000)
Ln Government Health expenditure	0.0398**	0.0566***	0.01964	0.0562***	0.0729*	0.02097***	0.02411	0.0887***	-0.00293	0.0624***
	(0.0176)	(0.0000)	(0.0212)	(0.0000)	(0.0415)	(0.0000)	(0.02141)	(0.0000)	(0.0606)	(0.0000)
Literacy	0.00045	0.2037***	0.00018	-0.2037***	0.30365 ***	2.2778***	0.05498	0.2022***	0.0588	-0.5989***
	(0.0384)	(0.0000)	(0.0432)	(0.0000)	(0.07358)	(0.0000)	(0.03729)	(0.0000)	(0.0814)	(0.0000)
Constant	15.27449	72.4680***	17.93133	-17.4761***	79.6463***	303.6590***	30.6493**	32.1883***	17.68888	-102.6139***
	(9.2187)	(0.0000)	(12.2235)	(0.0000)	(18.8554)	(0.0000)	(10.95019)	(0.0000)	(22.4284)	(0.0000)

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Column (4) of Table 3 shows the results for the under-five mortality. The coefficient for estimated food inflation is positive and statistically significant at the 10 percent level for the western region and at the 1 percent level for the eastern region of Indonesia. Similar to child mortality, the food inflation coefficient is higher for eastern Indonesia than that for western Indonesia. These values are 0.0432 and 0.3869 for western and eastern Indonesia, respectively. This implies that food price fluctuations have a greater impact on more vulnerable groups from lower socioeconomic backgrounds.

These results align with those of Makhlouf et al. (2017), who suggested that a rise in commodity prices affects household living costs and, therefore, decisions regarding food consumption and healthcare expenditure. This explains how an increase in food prices is correlated with a rise in malnutrition, and thus causes child mortality (Christian 2010; Darnton-Hill & Cogill 2010), particularly in eastern Indonesia, which has lower socioeconomic conditions and higher child mortality. This demonstrates that one of the important factors influencing high malnutrition and child mortality in vulnerable regions (eastern Indonesia) is food prices.

Finally, column (5) shows the results for post-neonatal mortality in western and eastern Indonesia. Although the coefficient for food inflation in both regions is statistically significant, the signs of the coefficients are unexpected. A positive correlation was expected; however, the results show a negative relationship.

FOOD INFLATION IN THE JAVA-BALI REGION VERSUS OUTSIDE JAVA-BALI REGION

Table 4 presents the estimation results that differentiated between the Java-Bali region and those outside the Java-Bali region. The Java-Bali region represents provinces in Indonesia that have higher socioeconomic and infrastructure conditions than outside the Java-Bali region. Similar to the western and eastern region analysis, the estimation that differentiates between Java-Bali and outside Java-Bali analyzes the varying impacts of food inflation on child mortality. The literature suggests that regions with lower socioeconomic conditions may be more vulnerable to food inflation than regions with better welfare and infrastructure conditions.

The estimation results show that the estimated coefficient for food inflation for all outcome variables in both regions is statistically significant, except for child mortality outside Java-Bali. Notably, the results show a positive impact outside Java-Bali and a negative impact for the Java-Bali region. In the outside Java Bali region, an increase in food inflation increases child mortality. The magnitude is highest for post-neonatal mortality, which is the probability of death after the first month of life but before reaching the age of one.

TABLE 4. Fixed-effect estimation for Java-Bali and outside Java-Bali regions of Indonesia

	Neonatal Mortality		Infant Mortality		Child Mortality		Under-five Mortality		Post-neonatal Mortality	
	Java Bali*	Outside Java Bali	Java Bali*	Outside Java Bali	Java Bali*	Outside Java Bali	Java Bali*	Outside Java Bali	Java Bali*	Outside Java Bali
Food Inflation	-0.9035*** (0.0000)	0.0240* (0.0140)	-0.7422*** (0.0000)	0.0503** (0.0201)	-2.6086*** (0.0000)	0.0526 (0.0422)	-0.9553*** (0.0000)	0.0454*** (0.0145)	-1.9515*** (0.0000)	0.1102*** (0.0380)
Ln Per capita GDP	-23.9964*** (0.0000)	-1.1493** (0.5069)	-21.3244*** (0.0000)	-1.0436 (0.6453)	-70.0059*** (0.0000)	-3.2703** (1.3471)	-26.9545*** (0.0000)	-1.3018* (0.6356)	-58.4537*** (0.0000)	-0.4930 (1.1669)
Availability of health insurance	-0.0589*** (0.0000)	-0.0006 (0.00566)	-0.0379*** (0.0000)	-0.0048 (0.0069)	-0.1309*** (0.0000)	-0.0126 (0.0104)	-0.0446*** (0.0000)	-0.0026 (0.0053)	-0.0678*** (0.0000)	-0.01166 (0.01359)
Education beyond secondary level	1.0155*** (0.0000)	0.0249 (0.0260)	0.6088*** (0.0000)	0.0658** (0.0306)	2.4586*** (0.0000)	0.0237 (0.0104)	0.8099*** (0.0000)	0.0508** (0.0239)	0.9078*** (0.0000)	0.1237* (0.0713)
Professional jobs	-0.0811*** (0.0000)	-0.0569* (0.0289)	-0.6236*** (0.0000)	-0.0827** (0.0260)	-2.1521*** (0.0000)	0.0503 (0.0572)	-0.7827*** (0.0000)	-0.0652** (0.0262)	-1.5054*** (0.0000)	-0.1418*** (0.0452)
Exposure to mass media	0.2577*** (0.0000)	-0.0230 (0.0221)	0.2308*** (0.0000)	-0.0182 (0.0209)	0.6764*** (0.0000)	-0.0302 (0.0520)	0.3004*** (0.0000)	-0.0240 (0.0250)	0.5402*** (0.0000)	0.0152 (0.0507)
Access to clean drinking water	0.3161*** (0.0000)	-0.0385** (0.0116)	0.1153*** (0.0000)	-0.0095 (0.0177)	0.7921*** (0.0000)	-0.0892** (0.0335)	0.1879*** (0.0000)	-0.0174 (0.0165)	-0.0704*** (0.0000)	0.0529 (0.0370)
Access to proper septic tanks	-	-0.0036 (0.0065)	-	-0.0085 (0.0054)	-	-0.00448 (0.01139)	-	-0.0085 (0.0054)	-	-0.0161* (0.0079)
Ln Government Health expenditure	-	-0.0105 (0.0209)	-	0.0349* (0.0192)	-	0.01062 (0.04422)	-	0.0340 (0.0202)	-	0.0860* (0.0450)
Literacy	-	0.01809 (0.01903)	-	0.01542 (0.02904)	-	0.11811** (0.05311)	-	0.0225 (0.0226)	-	0.0078 (0.0624)
Constant	402.368*** (0.0000)	23.53147* (8.16909)	367.5156*** (0.0000)	20.23761 (10.1012)	1176.4010*** (0.0000)	50.6497** (21.3910)	461.3638*** (0.0000)	24.5546 (9.7977)	1024.263*** (0.0000)	7.0426 (18.8785)

Note: ***, **, and * denote significance at the 1% level, 5%, and 10% levels, respectively.
Sign - for access to proper septic tanks, ln government expenditure, and maternal literacy are omitted for the Java-Bali estimation.

CONCLUSIONS

Increasing food prices can immediately impact household food security, subsequently affecting public health, impeding human development, and reducing long-term labor productivity in the economy. Therefore, understanding the impact of nutritional food supply on health is critical for development. Particularly, accurate assessment is crucial to help policymakers monitor and evaluate social programs, specifically for vulnerable groups.

Using panel data for Indonesian provinces for 2012 and 2017, this study conducted a comprehensive analysis of the effect of food inflation on child health, measured using child mortality rates. By applying a provincial fixed-effects method, this study presents strong empirical evidence that rising food prices severely impact child mortality among provinces in Indonesia, thus supporting the findings of several previous studies.

For the sample including all provinces in Indonesia, the results indicate that early childhood, particularly children under five years of age, is highly vulnerable to food inflation. The magnitudes of post-neonatal and infant mortalities are significantly high. This implies that the survival risk for children immediately after birth is higher than those that have reached their first birthday.

We also found that the impact of food inflation is higher for more vulnerable groups in eastern Indonesia and outside the Java-Bali region. Thus, policies aimed at improving the health of infants and children are particularly important for vulnerable groups. These policies should aim to reduce the impact of food inflation. For example, safety net programs assist groups vulnerable to food insecurity, particularly during periods of high food prices. Further, these programs aid vulnerable groups suffering from malnutrition, particularly children, thus reducing child mortality. Although our focus is on Indonesia, this study may be relevant to other developing countries that have experienced food inflation over the past few years.

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APPENDIX A

Description of Variables

No.	Variable	Definition	Unit	Year	Source
1	Neonatal mortality	Neonatal mortality rate (number of neonatal deaths per 1000 live births).	Deaths per 1000 live births	2012, 2017	Indonesian Demographic Health Survey (IDHS)
2	Post-neonatal mortality	Post-neonatal mortality rate (number of post-neonatal deaths per 1000 live births).	Deaths per 1000 live births	2012, 2017	Indonesian Demographic Health Survey (IDHS)
3	Infant mortality	Infant mortality rate (the number of infant deaths for every 1000 live births).	Deaths per 1000 live births	2012, 2017	Indonesian Demographic Health Survey (IDHS)
4	Child mortality	Child mortality rate (number of child deaths per 1000 live births).	Deaths per 1000 live births	2012, 2017	Indonesian Demographic Health Survey (IDHS)
5	Under-five mortality	Under-five mortality rate (number of children under-five deaths per 1000 live births).	Deaths per 1000 live births	2012, 2017	Indonesian Demographic Health Survey (IDHS)
6	Availability of health insurance	Percentage of women aged 15–49 having health insurance.	Percentage (%)	2012, 2017	Indonesian Demographic Health Survey (IDHS)
7	Professional jobs	Women aged 15–49 who work in professional/technical/managerial fields.	Percentage (%)	2012, 2017	Indonesian Demographic Health Survey (IDHS)
8	Exposure to mass media	Percentage of women aged 15–49 who access all three media (newspaper, television, and radio) at least once a week.	Percentage (%)	2012, 2017	Indonesian Demographic Health Survey (IDHS)
9	Literacy	Percentage literacy in women aged 15–49.	Percentage (%)	2012, 2017	Indonesian Demographic Health Survey (IDHS)
10	Education beyond secondary level	Percentage of women aged 15–49 whose highest level of schooling is more secondary.	Percentage (%)	2012, 2017	Indonesian Demographic Health Survey (IDHS)
11	Food inflation	Food inflation rate. Base year: 2010 = 100.	Percentage (%)	2012, 2017	Central Bureau of Statistics. Accessed through CEIC Database.
12	Real per capita GDP	Real GDP per capita rate. Base year: 2010=100.	Million Rupiah	2012, 2017	Central Bureau of Statistics. Accessed through CEIC Database.
13	Access to proper septic tanks	Percentage of households in urban and rural areas that dispose feces in a septic tank.	Percentage (%)	2012, 2017	Welfare Statistics released by Central Bureau of Statistics
14	Access to clean drinking water	Percentage of households in rural and urban areas that use clean water.	Percentage (%)	2012, 2017	Welfare Statistics released by Central Bureau of Statistics
15	Government health expenditure	Expenditure realization in the health sector for each province.	Rupiah	2012, 2017	The Ministry of Finance, Indonesia (https://djpk.kemenkeu.go.id/)