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Article

# The Impact of Prematurity and Low Birth Weight among Food-Secure and Food-Insecure Households: A Comparative Study in Surabaya, Indonesia

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**Abstract: Background/Objectives:** Prematurity and low birth weight (LBW) drive infant morbidity and mortality, requiring nutritional interventions, especially in food-insecure settings. In Indonesia, regional disparities in food security hinder adequate nutrition for premature and LBW infants, exacerbating health challenges. The aim of study is to investigate and determine predictors of food insecurity that impact health outcomes in children born with prematurity and/or low birth weight.

**Methods:** A cross-sectional study with 657 mothers with children aged 36-59 months was conducted using random sampling. Data was collected via standardized questionnaires and analyzed using chi-square tests and logistic regression. **Results:** Children of food-insecure households had a higher risk of LBW (AOR=1.89; 95% CI: 1.02–3.48). Low maternal education was associated with an increased risk of preterm birth (AOR=2.95; 95% CI:1.66–5.25). The increase in prematurity may increase the risk of underweight status (AOR=2.19; 95% CI:1.27–3.82). Food insecurity correlated with maternal education and maternal employment status (AOR=2.46; 95% CI: 1.31–4.63 and AOR=1.46; 95% CI: 1.03–2.07, respectively). **Conclusion:** Food insecurity exacerbates risks for underweight children, particularly in the prevalence of prematurity. Initiative strategies to improve child health outcomes are essential, including enhancing maternal nutrition knowledge to improve child feeding practices, promoting gender equality in career development, and reducing food insecurity.

**Keywords:** prematurity; low birth weight; food security; maternal education; child nutrition

## 1. Introduction

Globally, neonatal and under-five mortality remains a critical health issue, especially regarding regional health inequalities. Approximately 13.4 million preterm births worldwide were recorded in 2020, leading to an estimated 900,000 deaths in 2019 [1]. Indonesia was in the top five countries for the prevalence of preterm births, recording 675,700 cases in 2018 [2]. In 2023, the national premature birth rate was estimated at 11.1%, with notable regional variations, such as 6.9% of preterm births in East Java [3]. Despite significant progress in reducing prematurity, as well as its impact on neonatal mortality, showing significant progress in decreasing cases from 23 per 1,000 live births in 2012 to 10.7 per 1,000 in 2022 [4], challenges persist. This country has achieved the Sustainable Development Goal (SDG) target of reducing neonatal mortality to fewer than 12 deaths per 1,000 live births in each country [5]. Furthermore, prematurity and low birth weight in 2023 were the leading causes of 27.9% neonatal mortality in East Java [6]. Concurrently, urban areas like Surabaya indicated

disproportionately high infant mortality rates, highlighting persistent inequalities in healthcare access and maternal health outcomes.

Low birth weight (LBW) is a significant contributor to neonatal mortality, accounting for 60-80% of neonatal deaths each year worldwide, with more than 20 million infants born with LBW annually [7]. LBW, often resulting from preterm birth, is a birth weight of less than 2,500 grams [8]. LBW may occur in both preterm and full-term birth due to growth retardation and is a major factor in neonatal mortality [9]. According to the World Health Organization (WHO), approximately 15% of babies worldwide experience LBW, with more than half of these cases occurring in Asia [8]. In Indonesia, the prevalence of LBW is recorded at 6.1% [10]. Previous research indicates that LBW is correlated with various factors, such as maternal education [11], socioeconomic status [12], nutritional deficiencies [13], anemia [13], and inadequate antenatal care [5,13,14]. In Indonesia, other factors associated with LBW include family size, nutritional status, maternal age, pregnancy complications, age at marriage, iron supplementation, and anemia status. Additionally, LBW also has a relationship with delayed breastfeeding, feeding refusal, impaired growth, and long-term developmental challenges [15].

The COVID-19 pandemic impacted household food security, indicating a concerning trend globally. The Food and Agriculture Organization (FAO) reported that around 828 million people faced hunger in 2021 [16]. Approximately 29.6% of the global population identified moderate to severe food insecurity by the end of 2022 [17]. The prevalence of food insecurity decreased from 35% in 2008 to 20.8% in 2015, which was attributed to rising household incomes and rapid economic growth in Indonesia. However, one in five Indonesians still faces severe food insecurity [18]. A significant finding from the National Socioeconomic Survey in Indonesia in 2021 was that 76% of children under five lived in food-insecure households. The breakdown of food insecurity levels showed that 17% experienced mild, 5% moderate, and 2% severe food insecurity [17]. This context underscores the urgent need for targeted interventions to address food insecurity, as it is closely linked to adverse health outcomes, including malnutrition among children [16].

Prior findings have revealed a significant correlation between food insecurity and adverse birth outcomes, such as prematurity and LBW. Studies indicated that food-insecure households are more susceptible to having infants with LBW and stunting, hence increasing the risk of chronic health problems, neurodevelopmental disorders, and higher mortality rates [19–21]. LBW infants face significantly higher mortality risks and long-term health complications, including cardiovascular diseases and cognitive impairments [20,22], with prevalence impacted by maternal factors, environmental factors, and socioeconomic status [23,24].

This study aims to examine these effects in food-secure and food-insecure households to explore further potential health inequalities. Despite these acknowledged risks, research is limited regarding how household food insecurity influences the impact of prematurity and LBW among children aged 36-59 months. Identifying these inequalities is important for developing specific approaches, as food-insecure households may endure more severe consequences, contributing to further long-term health inequalities.

## 2. Materials and Methods

### 2.1. Study Area and Period

The study area is Surabaya, the second-largest city in Indonesia, located approximately 800 kilometers east of Jakarta, the capital city of Indonesia. Surabaya serves as the capital of the East Java Province and is a major port city on the northern coast of Java Island. Surabaya is a highly urbanized city with a population of over 3 million people, according to the 2020 national census. The city is divided into 5 parts (east, west, center, north, and south), which are further subdivided into numerous neighborhoods, serving as the lowest administrative units. The study was conducted in April 2024. Twelve interviewers were involved in the data collection, who were college students in a Nutrition Program.

## 2.2. Study Design and Population

The study was conducted in Surabaya, Indonesia, focusing on children aged 36–59 months and their respective households. A cross-sectional study was carried out across five districts of the city—east, west, center, north, and south. The sampling process followed a multi-stage cluster random sampling approach, utilizing administrative divisions to ensure systematic selection. Initially, two sub-districts were randomly selected from each of the five regions, resulting in a total of 10 sub-districts. Within each selected district, respondents were recruited from public health centers (Posyandu), a community-based health program in Indonesia that plays a crucial role in providing basic health services, particularly for mothers and children. The source population for this research comprised all mothers or primary caregivers of children within the specified age range who were attending Posyandu in Surabaya. This approach ensured a geographically representative sample, allowing for a comprehensive analysis of the study variables across different geographic areas.

## 2.3. Sample Size Determination

Previous research recommended statistical methods that allow readers to verify results using the original data [25,26]. This principle should also apply to the description of sample size calculation or power analysis. Consequently, the subsequent considerations must be delineated when determining the sample size or statistical power.

GPower 3.1.9.4, a software used to calculate statistical power for various statistical tests, such as t-tests, F-tests,  $\chi^2$ -tests, z-tests, correlation tests, and other statistical analyses, was employed in this study. GPower can also be used to compute effect sizes and display the results graphically, making it suitable for conducting simulation studies and teaching processes. Cohen suggested that the effect sizes for correlations are 0.1 for “small,” 0.3 for “medium,” and 0.5 for “large” [25]. The author calculates the minimum sample for statistical tests in this research by setting the significance level ( $\alpha$ ) at 0.05, with an expected statistical power of 95%, and a medium effect size of 0.3. GPower software calculated that a minimum sample size is 134 mothers.

Women who were permanent residents or had spent the previous night in the designated households were qualified for interviews. The lists of mothers with children under five were obtained four weeks prior to data collection in each of the ten subdistricts, with a census conducted by the relevant local authority. A total of 657 mothers with at least one child aged between 36 to 59 months were randomly sampled from the public health center’s data. In cases where more than one child met this criterion, only one was selected. However, children with a diagnosed chronic illness, who were bedridden, or who had suffered a serious acute illness were excluded from the study. The same applied to any child with a physical deformity affecting the lower extremities or spine.

## 2.4. Data Management and Analysis

Data was collected using a structured, pretested questionnaire and analyzed through frequencies, percentages, means, and standard deviations. Univariate logistic regression was used to assess preterm birth and LBW as outcome variables. The study examined socioeconomic factors (income, food insecurity), maternal characteristics (age, education, employment), child demographics (gender, nutritional status), and infant and young child feeding (IYCF) practices (breastfeeding, complementary feeding). The analysis followed four steps: (a) descriptive analysis to evaluate relationships between variables; (b) variable selection prioritizing food insecurity, preterm birth, and LBW; (c) multivariable modeling to refine predictors; and (d) finalizing a model including key maternal and child factors.

Household food insecurity was measured using the Food Insecurity Experience Scale Survey Module (FIES-SM) from the Food and Agriculture Organization of the United Nations with 2 classifications: food-secure and food-insecure households. The FIES-SM measures food insecurity in the household by applying the Rasch model, determining the range of food insecurity as mild, moderate, or severe [27].

Anthropometric measurements, encompassing height and weight, were obtained from both children and caregivers. Body weight was recorded utilizing a portable electronic SECA 813 flat scale, and height was evaluated with a Shorr board. Sample size and power analysis were calculated from factors including effect size, significance level ( $\alpha$ ), statistical power ( $1-\beta$ ), and the chosen statistical analysis method [26].

The nutritional status of children measured based on nutritional indices, such as height-for-age (HAZ) for stunting status, weight-for-age (WAZ) for underweight status, and weight-for-height (WHZ) for wasting status, was computed using the WHO Anthro v3.2.2 software and classified by applying the WHO 2006 standards. Z-scores of height-for-age  $<-2$  SD indicated stunted, Z-scores of weight-for-age  $<-2$  SD indicated underweight, and Z-scores of weight-for-height  $<-2$  SD indicated wasted [28]. Chi-Square tests compared the nutritional status between food-secure and food-insecure households [29]. LBW ( $<2,500$ g) was identified through Posyandu records and linked to preterm birth ( $<37$  weeks) or intrauterine growth restriction (IUGR). IYCF variables included breastfeeding exclusivity, complementary feeding timing, and feeding frequency, which influenced child nutrition and development [30–32].

### 2.5. Data Quality Assurance

To ensure data integrity, the questionnaire underwent pretesting (5% of the sample), and weighing scales were calibrated using a standard weight. Enumerators received training in survey administration, response recording, and anthropometric measurements. Daily reviews by the primary investigator ensured accuracy and completeness, with feedback provided as needed.

### 2.6. Data Processing and Analysis

Data were administered in Microsoft Excel and analyzed using RStudio. Anthropometric data were analyzed using WHO Anthro Plus v3.2.2 to evaluate nutritional status. Descriptive statistics described socio-demographic and other data, whereas bivariate and multivariable logistic regression identified connections among household food insecurity, preterm birth, LBW, and related variables. Variables with p-values less than 0.2 in bivariate analysis were incorporated into multivariable regression to control for confounders. Adjusted odds ratios (AOR), accompanied by 95% confidence intervals, evaluated the strength of connections, with p-values  $< 0.05$  deemed statistically significant.

## 3. Results

### 3.1. Socio-Demographic and Economic Status of Respondents

A total of 657 mothers with children aged 36–59 years were randomly selected to participate in the study and included in the analysis. Among these, 38.51% of mothers were categorized as food-insecure, while 61.49% were classified as food-secure. Children from food-secure households showed better health outcomes, with 46.58% not stunted, 48.55% not underweight, and a majority having normal birth weight (54.79%). Furthermore, 50.99% of children without wastage were from food-secure households. Food insecurity was prevalent among 35.16% of low-income families. Households classified as food-insecure also had reduced access to safe drinking water, with 28.16% relying on mineral water and 0.46% on spring water (Table 1)

**Table 1.** Maternal factors, household characteristics, and child factors among food secure and insecure households in Indonesia (N=657).

Characteristics	Mean ( $\pm$ SD)	Food Insecure	Food Secure	Total	Chi-square (p-value)
		n (%)	n (%)	n (%)	
<b>Maternal and household factors</b>					
<b>Mother's age</b>					
Teen Mothers	32.79 ( $\pm$ 6.21)	0 (0.00)	1 (0.15)	1 (0.15)	0.51
Young Adult Mothers		87 (13.24)	133 (20.24)	220 (33.49)	
Mature Adult Mothers		123 (18.72)	213 (32.42)	336 (51.14)	

Advanced Age Mothers		43 (6.54)	57 (8.68)	100 (15.22)	
<b>Maternal education</b>					
Low Education		93 (14.16)	90 (13.70)	183 (27.85)	
Medium Education		141 (21.46)	235 (35.77)	376 (57.23)	0.00*
High Education		19 (2.89)	79 (12.02)	98 (14.92)	
<b>Mothers' employment status</b>					
Not employed		166 (25.27)	213 (32.42)	379 (57.69)	0.00*
Employed		87 (13.24)	191 (29.07)	278 (42.31)	
<b>Family size</b>					
Small Family		51 (7.76)	63 (9.59)	114 (17.35)	
Medium Family		170 (25.88)	279 (42.47)	449 (68.34)	0.25
Large Family		32 (4.87)	62 (9.44)	94 (14.31)	
<b>Monthly household income</b>					
Low income		231 (35.16)	319 (48.55)	550 (83.71)	<0.00*
Medium income		20 (3.04)	67 (10.20)	87 (13.24)	
High income		2 (0.30)	18 (2.74)	20 (3.04)	
<b>Drinking water</b>					
Tap water		54 (8.22)	69 (10.50)	123 (18.72)	
Mineral water (in glass/PET bottle)		185 (28.16)	316 (48.10)	501 (76.26)	0.52 f
Borehole		11 (1.67)	15 (2.28)	26 (3.95)	
Springwater		3 (0.46)	4 (0.61)	7 (1.07)	
<b>House Ownership</b>					
Yes		67 (10.20)	146 (22.22)	213 (32.42)	0.01**
No		186 (28.31)	258 (39.27)	444 (67.58)	
<b>Car Ownership</b>					
Yes		10 (1.52)	73 (11.11)	83 (12.63)	<0.00*
No		243 (36.99)	331 (50.38)	574 (87.37)	
<b>Wealth Status (self-assessment)</b>					
rather better off		74 (11.26)	128 (19.48)	202 (30.75)	
average		164 (24.96)	272 (41.40)	436 (66.36)	0.00*
rather worse off		15 (2.28)	4 (0.61)	19 (2.89)	
<b>Child factors</b>					
<b>Child gender</b>					
Boy		134 (20.40)	192 (29.22)	326 (49.62)	0.18
Girl		119 (18.11)	212 (32.27)	331 (50.38)	
<b>Prematurity</b>					
Preterm birth	37.33 (±2.40)	108 (16.44)	183 (27.85)	291 (44.29)	0.51
Normal birth		145 (22.07)	221 (33.64)	366 (55.71)	
<b>Birth weight</b>					
Low birth weight	3.05 (±0.48)	17 (2.59)	44 (6.70)	61 (9.28)	0.07
Normal birth weight		236 (35.92)	360 (54.79)	596 (90.72)	
<b>Birth length</b>					
Short birth length		42 (6.39)	64 (9.74)	106 (16.13)	
Normal birth length		207 (31.51)	331 (50.38)	538 (81.89)	0.83
Long birth length		4 (0.61)	9 (1.37)	13 (1.98)	
<b>Stunting</b>					
Stunted	-1.10 (±1.62)	68 (10.35)	98 (14.92)	166 (25.27)	0.45
Not stunted		185 (28.16)	306 (46.58)	491 (74.73)	
<b>Wasting</b>					
Wasted	-0.29 (±1.95)	37 (5.63)	69 (10.50)	106 (16.13)	0.41
Not wasted		216 (32.88)	335 (50.99)	551 (83.87)	
<b>Underweight</b>					
Underweight	-0.84 (±1.64)	63 (9.59)	85 (12.94)	148 (22.53)	0.25
Normal		190 (28.92)	319 (48.55)	509 (77.47)	
<b>Initiation of breastfeeding</b>					
Less than one hour		176 (26.79)	267 (40.64)	443 (67.43)	
Between 1 and 23 hours		44 (6.70)	80 (12.18)	124 (18.87)	0.64
More than 24 hours		33 (5.02)	57 (8.68)	90 (13.70)	
<b>Age at starting complementary feeding</b>					
Less than 6 months		28 (4.26)	39 (5.94)	67 (10.20)	
6 months		182 (27.70)	316 (48.10)	498 (75.80)	0.15
More than 6 months		43 (6.54)	49 (7.46)	92 (14.00)	
<b>Feeding frequency</b>					
2 times		42 (6.39)	67 (10.20)	109 (16.59)	
2–3 times		148 (22.53)	243 (36.99)	391 (59.51)	0.89

3–6 times and more	63 (9.59)	94 (14.31)	157 (23.90)	
<b>Exclusive breastfeeding</b>				
Yes	19 (2.89)	34 (5.18)	53 (8.07)	0.68
No	234 (35.62)	370 (56.32)	604 (91.93)	
<b>Ever breastfeeding</b>				
Yes	93 (14.16)	152 (23.14)	245 (37.29)	0.82
No	160 (24.35)	252 (38.36)	412 (62.71)	
<b>Baby weaning</b>				
less than 6 months	47 (7.15)	77 (11.72)	124 (18.87)	
Between 6 months–24 months	88 (13.39)	115 (17.50)	203 (30.90)	0.10
24 months or more	111 (16.89)	186 (28.31)	297 (45.21)	
Still breastfeeding	7 (1.07)	26 (3.96)	33 (5.02)	

\* $p < 0.001$ , \*\* $p < 0.01$ , \*\*\* $p < 0.05$ .

Children's prematurity prevalence was noted at 44.29% with a mean of 37.33 (SD±2.40), and LBW was reported at 9.28% with a mean of 3.05 (±0.48). The nutritional assessments in this study revealed that the mean (±SD) Z-scores for stunting, wasting, and underweight status were below zero, specifically -1.10 (±1.62), -0.29 (±1.95), and -0.84 (±1.64), respectively. These findings indicate deviations from standard growth benchmarks and highlight the prevalence of malnutrition within the study population. A negative standard deviation (SD) in weight-for-age Z-score is a critical indicator of children's malnutrition or suboptimal nutritional status. Household food insecurity was significantly associated with maternal education and employment status, as determined by the Chi-Square test. Additional factors influencing food insecurity included monthly household income, car and house ownership, and overall wealth status (Table 1).

### 3.2. Prevalence of Prematurity and Low Birth Weight and Other Characteristics

The majority of children who were not of LBW (68.49%) and did not experience preterm birth (42.01%) were not stunted. Children with normal birth weight (61.80%) and those born at term (38.36%) were more likely to initiate breastfeeding within one hour of birth. Most mothers were mature adults aged 30 to 39, with 46.60% delivering children of normal birth weight. These mothers were also more likely to introduce complementary feeding at six months (69.56%) for children with normal birth weight.

Furthermore, 52.82% of mothers who delivered children with normal birth weight had medium education levels (high school graduates). Among children with normal birth weight, 70.17% were not underweight, and 52.82% received meals two to three times daily, meeting recommended feeding frequency practices (Table 2).

**Table 2.** Prevalence of prematurity and low birth weight among children under five and other characteristics (N=657).

Characteristics	Prematurity		LBW	
	Normal n (%)	Preterm Birth n (%)	No LBW n (%)	LBW n (%)
<b>Child gender</b>				
Boy	184 (28.01)	142 (21.61)	294 (44.75)	32 (4.87)
Girl	182 (27.70)	149 (22.68)	302 (45.97)	29 (4.41)
<b>Stunting</b>				
Not stunted	276 (42.01)	215 (32.72)	450 (68.49)	41 (6.24)
Stunted	90 (13.70)	76 (11.57)	146 (22.22)	20 (3.04)
<b>Wasting</b>				
Wasted	60 (9.13)	46 (7.00)	98 (14.92)	8 (1.22)
Not wasted	306 (46.58)	245 (37.29)	498 (75.80)	53 (8.07)
<b>Underweight</b>				
Underweight	80 (12.18)	68 (10.35)	135 (20.55)	13 (1.98)
Normal	286 (43.53)	223 (33.94)	461 (70.17)	48 (7.31)
<b>Initiation of breastfeeding</b>				
Less than one hour	252 (38.36)	191 (29.07)	406 (61.80)	37 (5.63)
Between 1 and 23 hours	65 (9.89)	59 (8.98)	113 (17.20)	11 (1.67)

More than 24 hours	49 (7.46)	41 (6.24)	77 (11.72)	13 (1.98)
<b>Age at starting complementary feeding</b>				
Less than 6 months	38 (5.78)	29 (4.41)	60 (9.13)	7 (1.07)
6 months	284 (43.23)	214 (32.57)	457 (69.56)	41 (6.24)
More than 6 months	44 (6.70)	48 (7.31)	79 (12.02)	13 (1.98)
<b>Feeding frequency</b>				
2 times	58 (8.83)	51 (7.76)	103 (15.68)	6 (0.91)
2–3 times	220 (33.49)	171 (26.03)	347 (52.82)	44 (6.70)
3–6 times and more	88 (13.39)	69 (10.50)	146 (22.22)	11 (1.67)
<b>Ever breastfeeding</b>				
Yes	342 (52.05)	262 (39.88)	550 (83.71)	54 (8.22)
No	24 (3.65)	29 (4.41)	46 (7.00)	7 (1.07)
<b>Exclusive breastfeeding</b>				
Yes	129 (19.63)	116 (17.66)	224 (34.09)	21 (3.20)
No	237 (36.07)	175 (26.64)	372 (56.62)	40 (6.09)
<b>Baby weaning</b>				
less than 6 months	70 (10.65)	54 (8.22)	111 (16.89)	13 (1.98)
Between 6 months–24 months	115 (17.50)	88 (13.39)	183 (27.85)	20 (3.04)
24 months or more	164 (24.96)	133 (20.24)	275 (41.86)	22 (3.35)
still breastfeeding	17 (2.59)	16 (2.44)	27 (4.11)	6 (0.91)
<b>Household Food Insecurity</b>				
Food-secure	221 (33.64)	183 (27.85)	360 (54.79)	44 (6.70)
Food-insecure	108 (22.07)	253 (16.44)	236 (35.92)	17 (2.59)
<b>Mother's age</b>				
Teen Mothers	0 (0.00)	1 (0.20)	1 (0.20)	0 (0.00)
Young Adult Mothers	127 (19.30)	93 (14.20)	199 (30.30)	21 (3.20)
Mature Adult Mothers	182 (27.70)	154 (23.40)	306 (46.60)	30 (4.57)
Advanced Age Mothers	57 (8.68)	43 (6.50)	90 (13.70)	10 (1.52)
<b>Maternal education</b>				
Low Education	86 (13.09)	97 (14.76)	159 (24.20)	24 (3.65)
Medium Education	216 (32.88)	160 (24.35)	347 (52.82)	29 (4.41)
High Education	64 (9.74)	34 (5.18)	90 (13.70)	8 (1.22)
<b>Mothers' employment status</b>				
Not employed	210 (31.96)	169 (25.72)	350 (53.27)	29 (4.41)
Employed	156 (23.74)	122 (18.57)	246 (37.44)	32 (4.87)
<b>Family size</b>				
Small Family: 3 members	67 (10.20)	47 (7.15)	106 (16.13)	8 (1.22)
Medium Family: 4-6 members	248 (37.75)	201 (30.59)	405 (61.64)	44 (6.70)
Large Family: more than 6 members	51 (7.76)	43 (6.54)	85 (12.94)	9 (1.37)
<b>Monthly household income</b>				
Low income	315 (47.95)	235 (35.77)	498 (75.80)	52 (7.91)
Medium income	39 (5.94)	48 (7.31)	79 (12.02)	8 (1.22)
High income	12 (1.83)	8 (1.22)	19 (2.89)	1 (0.15)
<b>Drinking water</b>				
Tap water	63 (9.59)	60 (9.13)	113 (17.20)	10 (1.52)
Mineral water (in glass/PET bottle)	284 (43.23)	217 (33.03)	456 (69.41)	45 (6.85)
Borehole	17 (2.59)	9 (1.37)	21 (3.20)	5 (0.76)
Springwater	2 (0.30)	5 (0.76)	6 (0.91)	1 (0.15)
<b>House Ownership</b>				
Yes	119 (18.11)	94 (14.31)	196 (29.83)	17 (2.59)
No	247 (37.6)	197 (29.98)	400 (60.88)	44 (6.7)
<b>Car Ownership</b>				
Yes	42 (6.39)	41 (6.24)	79 (12.02)	4 (0.61)
No	324 (49.32)	250 (38.05)	517 (78.69)	57 (8.68)
<b>Wealth Status</b>				
rather better off	115 (17.50)	87 (13.24)	183 (27.85)	19 (2.89)
average	237 (36.07)	199 (30.29)	395 (60.12)	41 (6.24)
rather worse off	14 (2.13)	5 (0.76)	18 (2.74)	1 (0.15)

The majority of children who were not of LBW (68.49%) and did not experience preterm birth (42.01%) were not stunted. Children with normal birth weight (61.80%) and those born at term (38.36%) were more likely to initiate breastfeeding within one hour of birth. Most mothers were mature adults aged 30 to 39 years, with 46.60% delivering children of normal birth weight. These mothers were also more likely to introduce complementary feeding on time, with 69.56% starting at

six months for children with normal birth weight. Additionally, 52.82% of mothers with normal birth weight children had a medium level of education (high school graduates). Among children with normal birth weight, 70.17% were not underweight, and 52.82% adhered to the recommended feeding frequency of two to three meals daily. Regarding household wealth status, 41.40% of families resided in food-secure households (Table 2).

### 3.3. Factors Associated With Prematurity, Low Birth Weight, and Household Food Insecurity

This study revealed prematurity was significantly associated with maternal education, as mothers with lower education levels were nearly three times more likely to give birth neonate prematurely than mothers with higher educational levels (AOR = 2.95; 95% CI: 1.66–5.25;  $p < 0.001$ ). Children who were born to lower monthly household income are 1.66 times more likely to be born premature compared to children from households with a high monthly income (AOR=1.66; 95% CI:0.60–4.57;  $p < 0.01$ ). Furthermore, the analysis also indicated that prematurity significantly increased the likelihood of being underweight by 2.2 times (AOR = 2.19; 95% CI: 1.27–3.82;  $p < 0.01$ ). This association remained significant in the adjusted model, where the adjusted odds ratio (AOR) was 2.19, suggesting that, even after controlling for potential confounders, premature birth remained an independent risk factor for underweight status (Table 3).

In the present study, logistic regression analysis demonstrated a significant association between LBW and household food insecurity after adjusting for confounding factors (AOR=1.89; 95% CI: 1.02–3.48). This means that children from food-insecure households are approximately 1.89 times more likely to experience LBW compared to children from food-secure households. Neonates who were born prematurely had a 2.20 times greater probability of having LBW (AOR=2.20; 95% CI:1.25–3.86). This study revealed that children who had LBW were fed 2.5 times less a day compared to those who had normal birth weight (AOR = 2.50; 95% CI: 1.01–6.14;  $p < 0.05$ ) (Figure 1).

This study also found that low maternal education has a 2.46 times higher probability of being food-insecure (AOR=2.46; 95% CI:1.31-4.63). Accordingly, unemployed mothers had a 1.46 times higher probability of being food-insecure. Households with low monthly income were at a 3.36 times higher risk of being food-insecure (AOR=3.36; 95% CI: 0.71-15.83). Worse wealth was also 5 times more likely to be food-insecure (AOR=5.08; 95% CI: 1.59-16.28). While underweight children had significantly lower odds of experiencing food insecurity (AOR=0.53; 95% CI: 0.29-0.98), suggesting a potential inverse relationship between underweight status and food security (Figure 1).

**Table 3.** Determinant Analysis on Prematurity, Low Birth Weight, and Household Food Insecurity with Multivariable Logistic Regression.

Characteristics	Prematurity		Low Birth Weight (LBW)		Food Insecurity	
	COR (95%CI)	AOR (95%CI)	COR (95%CI)	AOR (95%CI)	COR (95%CI)	AOR (95%CI)
<b>Household Food Insecurity</b>						
Food secure	1		1			
Food insecure	1.11 (0.81–1.53)		1.70 (0.95–3.04)	1.89 (1.02–3.48)***		
<b>Maternal education</b>						
Low Education	2.12 (1.28–3.53)**	2.95 (1.66–5.25)*	1.70 (0.73–3.94)	1.51 (0.58–3.96)	4.30 (2.41–7.67)*	2.46 (1.31–4.63)**
Medium Education	1.39 (0.88–2.22)	1.82 (1.09–3.04)***	0.94 (0.42–2.13)	0.76 (0.31–1.85)	2.49 (1.45–4.29)*	1.59 (0.89–2.86)
High Education	1		1		1	
<b>Mothers' employment status</b>						
Unemployed	1.03 (0.75–1.41)		0.64 (0.38–1.08)	0.60 (0.34–1.05)	1.71 (1.24–2.37)*	1.46 (1.03–2.07)***
Employed	1		1		1	
<b>Monthly household income</b>						
Low income	1.12 (0.45–2.78)	0.86 (0.33–2.27)	1.98 (0.26–15.12)	1.78 (0.22–14.43)	6.52 (1.50–28.36)***	3.36 (0.71–15.83)**
Medium income	1.85 (0.69–4.97)	1.66 (0.60–4.57)**	1.92 (0.23–16.33)	1.87 (0.21–16.42)	2.69 (0.57–12.58)	2.41 (0.48–12.15)
High income	1		1		1	
<b>House Ownership</b>						
Yes	0.99 (0.71–1.38)		0.79 (0.44–1.42)		0.64 (0.45–0.90)**	0.84 (0.58–1.23)
No	1		1		1	
<b>Car Ownership</b>						
Yes	1.27 (0.80–2.00)	1.51 (0.89–2.54)	0.46 (0.16–1.30)	0.37 (0.12–1.16)	0.19 (0.09–0.37)*	0.31 (0.15–0.64)*

No	1	1	1	
<b>Wealth Status</b>				
rather better off	1	1	1	
average	1.11 (0.79–1.55)	0.99 (0.56–1.77)	1.04 (0.74–1.47)	0.96 (0.67–1.39)
rather worse off	0.47 (0.16–1.36)	0.54 (0.68–4.23)	6.49 (2.08–20.27)*	5.08 (1.59–16.28)**
<b>Prematurity</b>				
Preterm Birth		2.24 (1.30–3.85)**	2.20 (1.25–3.86)**	0.90 (0.66–1.23)
Normal		1	1	1
<b>Stunting</b>				
Stunted	1.08 (0.76–1.54)	1.50 (0.85–2.65)		1.15 (0.80–1.64)
Not stunted	1	1		1
<b>Wasting</b>				
Wasted	0.96 (0.63–1.46)	0.77 (0.35–1.66)		0.83 (0.54–1.28)
Not wasted	1	1		1
<b>Underweight</b>				
Underweight	2.24 (1.30–3.85)**	2.19 (1.27–3.82)**		0.59 (0.33–1.06)
Normal	1			1
<b>Feeding frequency</b>				
2 times	1	1		1
2–3 times	0.88 (0.58–1.35)	2.18 (0.90–5.25)	2.50 (1.01–6.14)***	0.97 (0.63–1.50)
3–6 times or more	0.89 (0.55–1.46)	1.29 (0.46–3.61)	1.45 (0.51–4.15)	1.07 (0.65–1.76)

\*P < 0.001, \*\*P < 0.01, \*\*\*p < 0.05.

## 4. Discussion

### 4.1. Low Birth Weight in Food-Secure and Food-Insecure Households

Our findings showed that food-insecure households were prevalent among children born with low birth weight (LBW) in Surabaya City, Indonesia. We found that food-insecure households have a 1.89 times higher risk of experiencing LBW compared to food-secure households. Consistent with previous findings, food insecurity was significantly associated with LBW [33,34]. Furthermore, previous findings indicated that food insecurity contributes to adverse health outcomes for mothers and children, reflecting maternal nutrition and health [34]. A previous study found that LBW not only denotes a singular health issue but also serves as a sentinel marker for long-term health trajectories. Children born with LBW exhibit increased vulnerability to a spectrum of developmental delays and chronic health conditions, including respiratory illnesses, cardiovascular complications, and higher rates of mortality in infancy and early childhood [35].

This study highlighted that premature infants are 2.2 times more likely to be born LBW. Likewise, premature infants who are delivered with LBW are more at risk of having infectious diseases because their immune systems are not completely developed, which may negatively impact child growth. This finding might also be consistent with previous findings showing the effect of urinary tract infection during pregnancy on adequate fetal growth and development, increasing the risk of preterm birth and LBW [36–38].

The present study revealed an interesting finding that infants with LBW were fed 2.5 times less than those born with normal birth weight. A previous study found that mothers with LBW infants are more likely to decide to give formula feeding instead of breastfeeding, due to concerns about adequate nutrition and growth [39]. This study indicated that formula feeding more effectively addresses their LBW infants' growth needs. Prior investigations highlighted that LBW infants frequently encounter feeding difficulties caused by medical conditions and/or immature promotor development [40]. Therefore, infants with less feeding frequency may have feeding problems due to LBW and often struggle with feeding intolerance related to their medical state. Consequently, enteral feeding practices are necessary to regain birth weight.

### 4.2. Prematurity in Food-Secure and Food-Insecure Households

The relationship between food insecurity and prematurity requires further examination. This finding is not consistent with earlier studies, which suggested that household food insecurity was

found as a predictive factor of prematurity [33,41]. However, the present study found that the risk of prematurity in food-insecure households was 1.1 times higher than in food-secure households, inviting a deeper inquiry into the multifaceted determinants of preterm birth. Following prior investigations, prematurity was associated with lower adulthood income [42,43]. Therefore, living in low-income households posed a significantly higher risk of experiencing food insecurity [43].

Our analysis showed that prematurity has a significant relationship with maternal education, that is, mothers with lower education levels were nearly 3 times more likely to give birth prematurely than mothers with higher education levels, after adjusting for confounding factors. In contrast to previous study, this study revealed that maternal education may support decreasing preterm birth [44]. Higher maternal education is related to better health literacy [45], increased knowledge of healthy diets [46], and greater access to healthcare services [47,48]. This finding analyzed the effect of maternal education on these factors, which may possibly affect the health outcomes of children.

In order to address unobserved heterogeneity, we controlled a variety of variables that may potentially affect maternal education as well as child health outcomes, such as nutritional status. Interestingly, this study revealed the impact of prematurity on child health outcomes, such as underweight status, and found a significant association of preterm birth and underweight, namely that children having a preterm birth history were 2.2 times more likely to be underweight. Previous research also revealed that preterm birth was a strong predictor of underweight status in early childhood [49]. However, prematurity does not appear to have an effect on stunting and wasting status. In contrast to the previous study, mothers who give birth with a short duration of pregnancy contribute significantly to child growth which cause stunting [50]. These findings highlight the need for longitudinal studies to explore the long-term impact of prematurity and LBW on child health outcomes.

#### 4.3. Comparison Findings in Food-Secure and Food-Insecure Households

The present study reported that lower maternal education corresponds to a heightened chance of food insecurity, indicating that less educated mothers face 2.46 times greater risk of being food-insecure. This aligns with two findings conducted in Southern Ethiopia, which reported that pregnant women with lower education had a higher risk of being food-insecure compared to the more educated [51,52]. Furthermore, the study revealed that educated pregnant women in food-secure households were more likely to have a higher dietary diversity score than those who were in food-insecure counterparts. The role of maternal education encourages household food insecurity with the knowledge and skills needed to improve food insecurity and manage resources effectively [53], for instance, by influencing their food choices and child meal plans to enhance adequate nutrition.

Based on the previous study, higher maternal education contributed to employment opportunities and reduced household food insecurity [54]. It indicates that maternal employment contributes to enhancing socioeconomic stability. Our study found that unemployed mothers are 1.46 times more likely to be food-insecure. Consistent with previous studies in Indonesia, our study indicated that employment status significantly impacts food insecurity, with unemployed mothers more vulnerable to being food-insecure [55]. These findings highlight the important role of mothers' employment status in enhancing household food security, emphasizing the need for policies that campaign for job opportunities for women to alleviate food insecurity.

As a result, our analysis highlighted that low household monthly income exhibited more than three times higher odds of being food-insecure. This aligns with previous findings, which revealed that family income conditions were severely affected by food insecurity during the COVID-19 pandemic [56]. Families with lower income levels and unstable employment status are more prone to food insecurity, amplifying the risks of adverse birth outcomes. Additionally, UNICEF reports pointed out that close to half of the children with severe food insecurity are from low-income households [57]. Childhood poverty in early life (in children under five years) could harm and damage child survival, cognitive development, and growth. Moreover, some studies demonstrated

that income support significantly reduces the experience of being food-insecure and increases food accessibility [58] particularly by enhancing food purchasing power.

Food insecurity is substantially associated with worse wealth status in a household, indicating elevated evidence among lower socioeconomic households. Our findings highlighted that households with worse wealth status experience significant food insecurity. Food-insecure households are up to five times more likely to experience food insecurity than their wealthier counterparts. This is consistent with findings from Zimbabwe, which demonstrated that worse wealth status is associated with socioeconomic inequalities. Wealth status was a main predictor of food insecurity and directly related to food accessibility and food purchasing power, affecting adequate nutrition for children [59]. Furthermore, when wealth status leads to food insecurity, it can further harm health outcomes, particularly in vulnerable risk groups, work capacity, and overall well-being, making it difficult for these food-insecure households to improve their wealth status. Likewise, previous research suggested that food insecurity can lead to increased weight and height growth among children [60,61]. This issue indicates that child malnutrition remains alarmingly high in poor households that experience severe food insecurity.

Our study revealed that underweight children exhibited significantly lower odds of being food secure, demonstrating an inverse relationship between underweight status and food security. This finding aligns with previous findings, which reported that household food insecurity was significantly predictive of malnutrition among children under five, having a particularly significant prediction on being underweight [62]. Similarly, children from food-insecure households have a considerably higher risk of being underweight than children who grew up in food-secure households. Additionally, a previous study found that children in food-insecure households may be nearly five times more likely to be underweight [63]. These findings underscore the urgent need for integrated strategies that aim to address food insecurity in order to improve child nutritional outcomes.

#### *4.4. Strengths and Limitations*

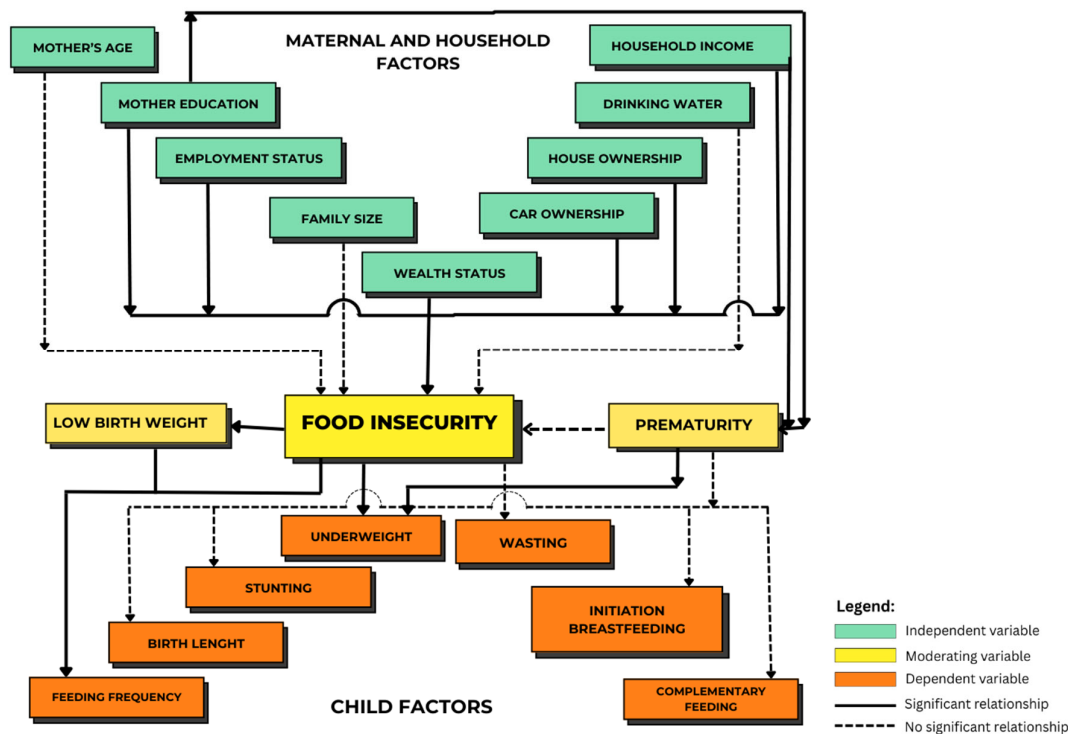
The study proved significant strengths by offering a comprehensive analysis of the relationship between food insecurity and its predictors, which have relationships with prematurity and LBW. The use of adjusted odds ratios (AOR) strengthens the findings by providing a more precise understanding of the likelihood of adverse health outcomes in food-insecure households after considering confounding factors. Moreover, this study's analysis identified variables directly associated with prematurity and LBW. Both may have been direct and indirect predictors of food insecurity, which may subsequently exacerbate food insecurity.

The challenge in obtaining representative respondents was one of the limitations found in this study. Even though efforts were made to attempt to make sample reflect the broader population, certain groups may have limited representation due to a lack of sampling methods, or non-response bias. Additionally, a quantitative method was employed in this study, which identified correlations statistically but may not have identified the experiences behind food insecurity and health issues in children effectively. A qualitative method is suggested to provide future research with more comprehensive results, more complex insights, and deeper connections.

## **5. Conclusions**

This study illustrates a complex connection between food insecurity, prematurity, and LBW that affects child health outcomes. Maternal education, monthly household income, and underweight are found as predictors directly associated with prematurity and food insecurity. However, these predictors, as well as other predictors such as mothers' employment status, underweight children, and wealth status (including house and car ownership), have direct relationships with food insecurity. While a significant correlation was found between food insecurity and LBW, the evidence of prematurity did not demonstrate a similar trend. Furthermore, prematurity prevalence is at elevated risk of LBW and being underweight, which emphasizes the urgency of targeted intervention

to diminish preterm birth and LBW. A comprehensive strategy should be implemented to mitigate food insecurity, prevent its adverse health consequences, and enhance mother and child health. Consequently, government policies must prioritize the empowerment of mothers through education, job opportunities for women, and the improvement of access to healthcare services.



**Figure 1.** Food Insecurity Pathway on The Impact of Prematurity and Low Birth Weight (LBW).

**Author Contributions:** AD participated in designing the study, developing the questionnaires, administering the data collection, analyzing and interpreting the data, and writing the manuscript. NM participated in the statistical analysis, AS contributed to finding the research gap, RD contributed to data collection/survey coordination, AZB reviewed and edited the text, and FHJ participated in designing the study, developing the questionnaires, reviewing, and finalizing the manuscript. All authors reviewed and approved the final manuscript.

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**Institutional Review Board Statement:** Ethical approval was secured from the Health Research Ethics Committee of the National Research and Innovation Agency (NRIA) Indonesia Number: 039/KE.03/SK/02/2024. The study's objectives, risks, advantages, confidentiality, and respondents' responsibilities were comprehensively conveyed to parents in the local language. Data collection commenced solely upon the obtaining of informed written consent from respondents.

**Informed Consent Statement:** Informed consent was obtained from all respondents involved in this research.

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**Conflicts of Interest:** The study was undertaken solely for academic purposes, and the authors declare no conflicts of interest.

## Abbreviations

The following abbreviations are used in this manuscript:

LBW	Low birth weight
CI	Confidence interval
AOR	Adjusted odds ratio
SDG	Sustainable development goal
FAO	Food and Agriculture Organization
WHO	World Health Organization
FIES-SM	Food insecurity experience scale survey module
IUGR	Intra-uterine growth restriction
IYCF	Infant and young child feeding
SD	Standard deviation
PET	polyethylene terephthalate

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