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Gender Determines Pneumonia Risk Factor Patterns in Toddlers in South Kalimantan, Banjar Regency, Indonesia

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Abstract: Pneumonia remains one of the leading causes of mortality among children under five worldwide. Previous studies have reported inconsistent findings regarding sex differences in pneumonia susceptibility, suggesting that risk factors may differ between male and female toddlers. This study aimed to identify and compare sex-specific risk factors for pneumonia among toddlers in Banjar Regency, Indonesia. This case–control study included 300 toddlers: 169 male toddlers (61 cases and 108 controls) and 131 female toddlers (45 cases and 86 controls). We assessed 41 demographic, socioeconomic, behavioural, child-related, environmental, and housing indicators through interviews and direct household measurements. We analysed male and female datasets separately. Candidate variables with $p<0.25$ in simple logistic regression were entered into multivariable logistic regression using the backward stepwise method to identify independent predictors of pneumonia. Among male toddlers, four independent risk factors were identified: stunted child development (OR=7.022; 95% CI: 1.680–29.345), low family income (<minimum wage) (OR=3.305; 95% CI: 1.328–8.228), living within 15 m of the riverbank (OR=2.830; 95% CI: 1.336–5.994), and age 12–59 months (OR=2.236; 95% CI: 1.025–4.878). Among female toddlers, three independent predictors were identified: low family income (OR=3.211; 95% CI: 1.077–9.571), predominant infant formula feeding (OR=2.748; 95% CI: 1.040–7.261), and inadequate household occupancy density (OR=2.641; 95% CI: 1.187–5.876). The findings demonstrate distinct sex-specific risk factor patterns for pneumonia among toddlers. These results suggest that pneumonia prevention strategies should incorporate gender-specific approaches, with greater emphasis on improving child development and environmental conditions for boys, and promoting breastfeeding and adequate housing conditions for girls.
Keywords: Child development; family income; female toddler; male toddler; pneumonia; riverbank residence.

INTRODUCTION

Acute respiratory infections (pneumonia) caused 740,180 deaths in children under five globally in 2019[1]. Data on pneumonia in children under five in Banjar Regency, Indonesia, differed by gender: 280 (54.8%) in boys and 231 (45.2%) in girls, for a total of 511 children under five[2].

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Risk factors generally associated with acute respiratory infections include demographic, environmental, socioeconomic, and nutritional factors[3]. Research in various countries has identified several risk factors associated with acute respiratory infections (ARI), including population density, residential location, gender, parental smoking, maternal illiteracy, cooking fuel, indoor air pollution, malnutrition, poor nutrition, family history of acute respiratory infections, and HIV comorbidities[4]. Research in Nigeria indicates that risk factors for acute respiratory infections (ARI) in children under five include population density, residential density, air pollution, and poor environmental sanitation[5]. Research in India identified several factors that influence the incidence of ARI in toddlers, including children under one year of age, children aged 2–3 years, male gender, and low paternal educational background. Other significant risk factors found include a family history of respiratory disease, overcrowded living conditions, inadequate housing, the use of firewood for household fuel, delayed child development, and severe malnutrition[6].

The gender risk factor is a factor that greatly influences the occurrence of ARI in toddlers; male toddlers are three times more likely to experience ARI, with an Odds Ratio of 3.45 (2.49- 4.77)[7]. However, several other studies show that female toddlers tend to have a greater chance of experiencing ARI, with an OR of 1.059 (0.643–1.745)[8] and an OR of 1.02 (0.85–1.21)[9].

More in-depth research focusing on child gender differences regarding the relationship between solid fuels and father smoking in toddlers with ARI has been conducted in China. Research reveals that daughters have a higher risk of developing ARI when exposed to solid fuels (OR=3.28; 95% CI 1.34-8.03) and fathers who smoke (OR=2.27; 95% CI 1.08 -4.77), while for boys it does not have a significant effect[10].

Research has analyzed risk factors for ARI in toddlers in Indonesia and the Philippines, with a main review of child and household characteristics for male and female toddlers in both countries. The results showed differences in risk factors between males and females for child age under 1 year, dirty cooking fuel, and unavailability of toilet facilities. The percentage of toddlers with ARI symptoms in 2017 in the Philippines was 1.51%, while in Indonesia it was 4.22%. The variable age of children under 1 year significantly reduces the likelihood of ARI in males (Indonesian data), OR 0.54, 95% CI (0.36-0.82). The dirty cooking fuel variable significantly increases the likelihood of ARI in girls (Philippine data), OR 4.01, 95% CI (1.02-15.83). The variable that toilet facilities are not available has a significant effect on increasing the likelihood of ARI in males (Philippine data) OR 2.67, 95% CI (1.15-6.16)[11].

Previous studies have reported inconsistent findings regarding sex differences in childhood pneumonia, with some suggesting a higher susceptibility among boys and others reporting greater risk among girls. These inconsistent findings suggest that analyzing male and female toddlers separately may clarify sex-specific risk patterns that combined analyses could overlook. In addition, evidence from river basin communities in Indonesia remains limited, despite their distinctive environmental and socioeconomic characteristics, including densely populated riverside settlements, limited access to clean water, and frequent interaction with river environments.

Therefore, this study aimed to identify and compare pneumonia risk factors separately in male and female toddlers living in the Martapura River Basin, Banjar Regency, South Kalimantan. By integrating a broad range of child, household,

socioeconomic, behavioural, and environmental factors within a local socio-ecological context, this study sought to clarify whether pneumonia determinants differ by sex and to provide evidence for more targeted prevention strategies in vulnerable river basin communities.

MATERIALS AND METHODS

This was an analytical observational study with a case–control design, comparing toddlers with pneumonia (cases) with those without pneumonia (controls). The study was conducted in Banjar Regency, Indonesia, with a total sample of 300 toddlers: 169 male toddlers (61 cases and 108 controls) and 131 female toddlers (45 cases and 86 controls). The sample size was calculated based on the case–control formula according to Lwanga, Lemeshow, and Hosmer (1990), using parameters $\alpha = 0.05$ ($Z\alpha = 1.960$), 90% power ($Z\beta = 1.282$), and an odds ratio of 2.77 from previous literature on the risk of pneumonia due to wood fuel use. The calculation indicated a minimum requirement of 78 subjects per group. The researchers then set a case: control ratio of 1:2 based on the proportion of the real population, so the final sample size exceeded the minimum and met adequate test power.

The sample selection technique is simple random sampling. Primary data were collected retrospectively regarding risk factors associated with pneumonia in toddlers. The data collected were in the form of general data questionnaires, child characteristics, child psychomotor, child health, mother characteristics, mother behaviour, family economic status, contact between individuals, home air pollution, home sanitation, and physical condition of the home, which were filled in by enumerators from interviews with mothers/babysitter from November 2022 to January 2023. All measurements of the physical condition of the house, including temperature, humidity, airflow, lighting, and ventilation area of the toddler's bedroom, were carried out directly at the respondent's house. We used measuring meters to measure the bedroom area, lux meters to measure lighting, thermohygrometers to measure temperature and humidity, and anemometers to measure wind speed. In this study, we questioned and measured a total of 41 indicators.

This study's population consisted of all toddlers diagnosed with Acute Respiratory Tract Infection (ARI) by doctors at community health centres in Banjar Regency during the study period. The population was divided into two groups: cases and controls. The case population included toddlers diagnosed with pneumonia by doctors at community health centres. Pneumonia is defined as an ARI accompanied by clinical signs of coughing, rapid breathing appropriate for age, and/or lower chest wall indrawing (retractions), without other signs of serious illness such as seizures, decreased consciousness, or inability to drink. Doctors established the diagnosis of pneumonia based on applicable clinical guidelines. The inclusion criteria for the case population were toddlers diagnosed with pneumonia. Exclusion criteria were toddlers who refused or were unable to participate in some or all of the study procedures. The control population included toddlers diagnosed with non-pneumonia by doctors at community health centres. Non-pneumonia is defined as mild ARI with upper respiratory tract symptoms, such as coughing, runny nose, and fever, but without rapid breathing or chest indrawing. This condition is generally mild (self-limiting) and does not require antibiotic treatment. The inclusion criteria for the control population were toddlers diagnosed with non-pneumonia.

Exclusion criteria were toddlers initially diagnosed with non-pneumonia but later developing pneumonia.

The researchers first selected the case population from the list of toddlers with pneumonia recorded at the community health centre. The researchers used simple random sampling, ensuring each toddler on the list had an equal chance of being selected. The researchers then determined the control group. The control sample was drawn using simple random sampling from the list of toddlers without pneumonia at the community health centre, using the same method as the case group.

Child development indicators were measured using the Developmental Prescreening Questionnaire from the Republic of Indonesia Ministry of Health Team, which was translated and modified from the original Denver Prescreening Developmental Questionnaire (PDQ). This questionnaire is designed for preliminary screening of babies aged three months to six years old. Each age has ten questions related to the child's developmental abilities. If the answer "yes" is less than six points, the child's development is hampered.

The regional minimum wage for Banjar district is 2,906,473 rupiah, used to classify family income indicators (<minimum wage versus >minimum wage). Indicators of child growth and development (stunted versus normal); location of the house on the river bank (distance <15m from the river bank versus distance >15m from the river bank); child's age (12-59 months versus 1-11 months); breastfeeding (predominance of formula versus breast milk); residential density (1 person/4m2 (qualify) versus >1 person/4m2 (not eligible)[12].

Data were processed using SPSS version 26. We determined risk factors for pneumonia among toddlers using logistic regression analysis. First, we performed simple logistic regression to identify all potential risk factors with a p-value <0.25. Then, we performed multiple logistic regression analysis with the backward stepwise method, including all potential risk factors in the model. The significance level was set at p< 0.05. We also analyzed the results using the receiver operating characteristic (ROC) curve.

In this study, researchers did not strictly distinguish between primary variables and confounding factors from the outset. This was due to the exploratory nature of the approach used and its adherence to a socio-ecological framework, which views all determinants as part of an interacting system. Researchers considered all variables theoretically and empirically relevant to the incidence of pneumonia in toddlers for analysis in a multiple logistic regression model. The variable selection process was based on bivariate test results with a p-value <0.25, and supported by references from previous literature. This approach aimed to identify the most meaningful patterns of relationships in the local context and to allow for specific interpretations of risk differences between male and female toddlers.

Ethical approval

This research has obtained ethical approval from the Research Ethics Committee of the Faculty of Public Health, Airlangga University, with certificate number: 140/EA/KEPK/2022. Before data collection, the researcher explained the purpose, benefits, and procedures of the study to each participant (mother or caregiver of toddlers) in clear detail. The researcher then obtained written informed consent from all respondents who agreed to participate. Participation was voluntary and without coercion,

and respondents were free to refuse or discontinue participation at any time without consequence. To maintain data confidentiality and privacy, all personal information about respondents was encoded and stored securely. Respondents' identities were not disclosed in the publication of the research results. The data collected was used solely for this research and will not be disseminated without the respondents' written permission.

RESULTS AND DISCUSSION

Characteristics of Male and Female Toddlers

The characteristics of male and female toddlers differed somewhat between the pneumonia and control groups. Most toddlers with pneumonia were aged 12–59 months and were first- or second-born. Psychomotor development was generally normal, although delays were more common among males with pneumonia than females (16.4% vs 4.4%). High motor activity predominated in both sexes. Predominant breastfeeding was less common among toddlers with pneumonia than controls among both females (73.3% vs 86.0%) and males (77.0% vs 83.3%). Underweight/severe underweight was more frequent among males with pneumonia than controls (37.7% vs 26.9%). Immunization status was generally similar between groups (Table 1).

Table 1. Characteristics of Male and Female Toddlers According to Pneumonia Status

Characteristic	Female, n (%)		Male, n (%)	
	Control	Pneumonia	Control	Pneumonia
Age				
<12 months	25 (29.1)	10 (22.2)	40 (37.0)	15 (24.6)
12–59 months	61 (70.9)	35 (77.8)	68 (63.0)	46 (75.4)
Birth order				
1st–2nd	59 (68.6)	31 (68.9)	82 (75.9)	46 (75.4)
≥3rd	27 (31.4)	14 (31.1)	26 (24.1)	15 (24.6)
Psychomotor development				
Normal	84 (97.7)	43 (95.6)	105 (97.2)	51 (83.6)
Delayed	2 (2.3)	2 (4.4)	3 (2.8)	10 (16.4)
Motor activity				
Moderate/low	20 (23.3)	10 (22.2)	17 (15.7)	9 (14.8)
High	66 (76.7)	35 (77.8)	91 (84.3)	52 (85.2)
Breastfeeding				
Predominantly breast milk	74 (86.0)	33 (73.3)	90 (83.3)	47 (77.0)
Predominantly formula milk	12 (14.0)	12 (26.7)	18 (16.7)	14 (23.0)
Vitamin A supplementation				
Received	69 (80.2)	36 (80.0)	82 (75.9)	50 (82.0)
Not received	17 (19.8)	9 (20.0)	26 (24.1)	11 (18.0)
Nutritional status				
Normal/overweight	66 (76.7)	35 (77.8)	79 (73.1)	38 (62.3)
Underweight/severely underweight	20 (23.3)	10 (22.2)	29 (26.9)	23 (37.7)
Immunization status				
Complete	43 (50.0)	28 (62.2)	59 (54.6)	34 (55.7)
Incomplete/not received	43 (50.0)	17 (37.8)	49 (45.4)	27 (44.3)

Risk Factors of Pneumonia among Toddlers

Table 2. Indicators of Risk Factors for Toddlers with Pneumonia

No	Indicators	p-value	
		Male	Female
1	Child age	0.093*	0.396
3	Order of birth of children	0.940	0.973
4	Child development	0.002*	0.514
5	Motor activity	0.864	0.893
6	Breastfeeding	0.321	0.080*
7	Intake of vitamin A	0.357	0.975
8	Nutritional status	0.145*	0.893
9	Basic immunization	0.889	0.181*
10	Mother's age	0.496	0.599
11	Mother's job	0.217*	0.464
12	Mother's education	0.614	0.181*
13	Mother's knowledge	0.703	0.682
14	Mother's attitude	0.786	0.424
15	Mother's actions	0.495	0.916
16	Occupancy density	0.768	0.004*
17	History of close contact with sufferers of ARI before	0.119*	0.577
18	Family history of respiratory tract disease	0.133*	0.930
19	Family income	0.001*	0.022*
20	Home ownership status	0.609	0.777
21	Ownership of electronic goods	0.137*	0.124*
22	House electricity capacity	0.564	0.050*
23	Cooking fuel	0.439	0.290
24	Family members smoke in the house	0.303	0.339
25	Use of mosquito coils/electric	0.460	0.690
26	The distance between the house and the road	0.142*	0.577
27	Smoke burning garbage/household industry	0.854	0.464
28	Clean water source	0.531	0.743
29	Toilet facilities	0.004*	0.779
30	Waste water disposal facilities	0.785	0.388
31	Waste disposal	0.869	0.895
32	House floor	0.271	0.949
33	House wall	0.398	0.071*
34	Roof	0.202*	0.052*
35	House ceiling	0.022*	0.433
36	Ventilation	0.879	0.947
37	Temperature	0.562	0.663
38	Humidity	0.912	0.806
39	Lighting	0.440	0.910
40	Airflow	0.425	0.482
41	Location of the house from the river bank	0.005*	0.929

* = p-value <0.25; candidate for multiple logistic regression.

Table 2 shows the results of the regression analysis used to determine the risk factors of pneumonia among male and female toddlers. In the data for male toddlers, 13 indicators had p-values <0.25, so they can be used as candidates for inclusion in the multiple logistic regression test. These indicators are the child's age (p-value = 0.093), child development (p-value = 0.002), nutritional status (p-value = 0.145), mother's occupation (p-value = 0.217, history of close contact with previous non-pneumonic sufferers (p-value = 0.119), family history of respiratory disease (p-value = 0.133), family income (p-value = 0.001), ownership of electronic goods (p-value = 0.137), distance from house to main road (p-value = 0.142), toilet facilities (p-value = 0.004), roof of the house (p-value = 0.202), ceiling of the house (p-value = 0.022), location of the house on the river bank (p-value = 0.005).

The results show that, in the data on female toddlers, 9 indicators have a p-value <0.25 and can be used as candidates for inclusion in the multiple logistic regression test. These indicators are breastfeeding (p-value = 0.080), immunization (p-value = 0.181), mother's education (p-value = 0.181), occupancy density (p-value = 0.027), family income (p-value = 0.022), ownership of electronic goods (p-value = 0.124), house electrical capacity (p-value = 0.050), house walls (p-value = 0.071), house roof (p-value = 0.052).

Analysis Results with Multiple Logistic Regression Tests

Table 3 shows the final results of the multiple logistic regression test on male toddler data, which showed 4 significant indicators: child development (inhibited), OR (95% CI) 7.022 (1.680-29.345), p-value = 0.008. Family income (<wages minimum) OR (95%CI) 3.305 (1.328-8.228), p-value = 0.010. Location of the house on the river bank (distance <15m from the river bank) OR (95%CI) 2.830 (1.336-5.994), p-value = 0.007. Child age (12-59 months) OR (95%CI) 2.236 (1.025-4.878), p-value = 0.043. All indicators have a p-value <0.05.

Table 4 shows the final results of the multiple logistic regression test on female toddler data, which showed 3 significant indicators: family income (< minimum wage), OR (95% CI) 3.211 (1.077-9.571), p-value = 0.036. Breastfeeding (predominance of infant formula) OR 2.748 (1.040-7.261), p-value = 0.041. Occupancy density (not eligible) OR (95% CI) 2.641 (1.187-5.876), p-value = 0.017. All indicators have a p-value <0.05.

Table 3. Analysis Results with Multiple Logistic Regression Tests for Male Toddlers

Prediction Indicators	OR (95%CI)	P-Value	Beta coefficient (β)
Child development (stunted)	7.022 (1.680-29.345)	0.008	1.949
Family income (<wages minimum)	3.305 (1.328-8.228)	0.010	1.196
Location of the house on the river bank (distance <15m from the river bank)	2.830 (1.336-5.994)	0.007	1.040
Child age (12-59 months)	2.236 (1.025-4.878)	0.043	0.805
Constant	0.079	0.000	-2.535

Table 4. Analysis Results with Multiple Logistic Regression Tests for Female Toddlers

Prediction Indicators	OR (95%CI)	P-Value	Beta coefficient (β)
Family income (<wages minimum)	3.211 (1.077-9.571)	0.036	1.167
Breastfeeding (predominance of infant formula)	2.748 (1.040-7.261)	0.041	1.011
Occupancy density (not eligible)	2.641 (1.187-5.876)	0.017	0.971
Constant	0.093	0.000	-2.379

Sensitivity Specificity Multivariate Test Results for Toddler Pneumonia

The threshold value from the ROC curve results for male toddler data is 0.1954 with a constant of -2.535, to obtain a predictive index formula with a cutoff of '0', the constant is converted to a threshold value = -2.535 + 0.1954 = -2.3396 so that the predictive index formula pneumonia in male toddlers = -2.3396 + 1.949 x child development (stunted) + 1.196 x family income (<wages minimum) + 1.040 x location of the house on the river bank (distance <15m from the river bank) + 0.805 x child age (12-59 months). The threshold value of the ROC curve data for female toddlers is 0.2161 with a constant of -2.379, to obtain a predictive index formula with a cutoff of '0', the constant is converted to a threshold value = -2.379 + 0.2161 = -2.1629 so that the data predictive index formula for pneumonia female toddlers = -2.1629 + 1.167 x family income (<wages minimum) + 1.011 x breastfeeding (predominance of infant formula) + 0.971 x occupancy density (not eligible). ROC curve results are in Figures 1 and 2.

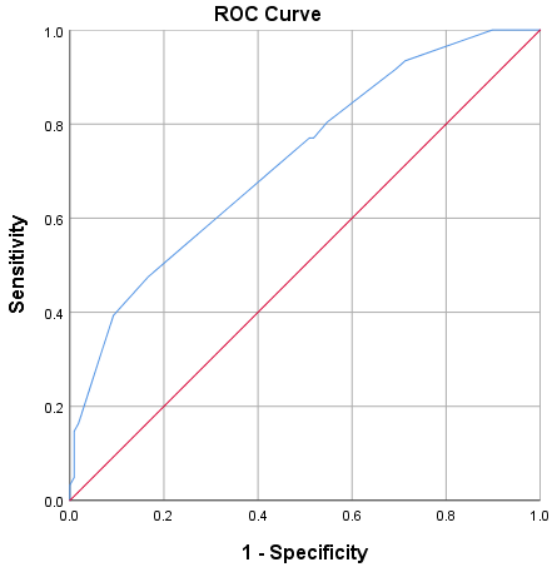

Figure 1. ROC Curve for Male Toddlers

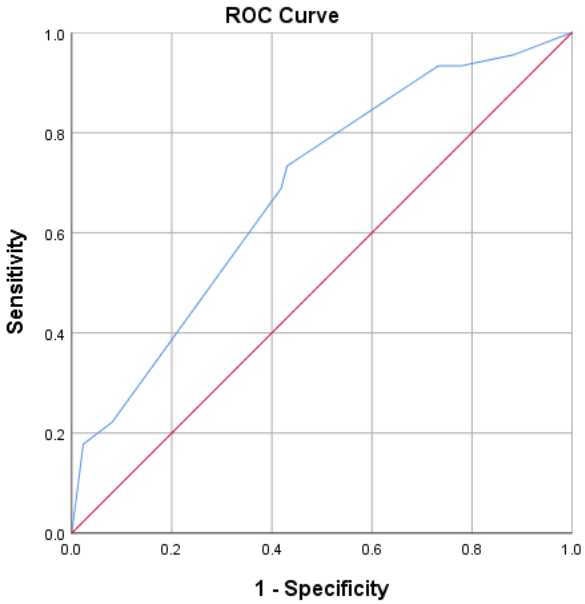

Figure 2. ROC Curve for Female Toddlers

Figure 1 shows the ROC curve for male toddlers, depicting the relationship between sensitivity and specificity at various threshold values. The graph shows that the ROC curve lies well above the random diagonal line, indicating that the model has adequate classification ability. Based on the analysis, the model yielded a sensitivity value of 91.8% and a specificity of 30.6%. Figure 2 presents the ROC curve for female toddlers, which also lies above the random diagonal line, although it is closer to the diagonal than that for male toddlers. The prediction model for this group had a sensitivity of 93.3% and a specificity of 26.7%.

Tabel 5. Area Under the Curve Results from the ROC Curve

Respondent Type	AUC (Area)	95% CI	Std. Error	p-value
Male Toddlers	0.723	0.644 – 0.802	0.040	0.000
Female Toddlers	0.683	0.589 – 0.778	0.048	0.001

Table 5 presents the Area Under the Curve (AUC) values and their significance tests. The results show that the AUC for male toddlers was 0.723 (95% CI: 0.644–0.802; $p < 0.001$), indicating acceptable discrimination. The AUC for female toddlers was 0.683 (95% CI: 0.589–0.778; $p = 0.001$), which falls into the category of poor to adequate discrimination ability. Table 1 summarises the complete results of the AUC analysis, confidence intervals, standard errors, and significance values for both groups. Both models demonstrated statistically significant predictive performance, as the p-value was <0.05.

Predictive Index for Pneumonia in Female Toddlers

The final results of the multiple logistic regression test on data on female toddlers showed 3 significant indicators: family income (< minimum wage), residential density (does not meet the requirements), and breastfeeding (predominance of infant formula) (Table 4). Residential density is a predictive indicator of pneumonia in female toddlers. Other research supports this, stating that residential density is a risk factor for ARI[13].

Female toddlers, according to interviews with mothers/caregivers, are more often at home, make friends, and play indoors, so residential density has a greater impact on female toddlers. Boys' play is more competitive and constructive, while girls' play is more cooperative and more indoors[14]. Indoor conditions in homes with high residential density are more likely to transmit respiratory viruses, according to Killingley B & Nguyen-Van-Tam J (2007). Respiratory viruses can be transmitted through respiratory secretions via direct contact, indirect contact, droplets, or aerosols[15].

Breastfeeding is a predictive indicator of pneumonia, specifically in female toddlers. Breastfeeding is beneficial not only because of the nutrition the mother provides to her child but also because of the touching and hugging during breastfeeding. Touching and hugging can increase the body's immunity. Scientists and developmental experts have come to understand the power of touch in managing disease and health, reducing stress, and shaping the brain[16].

A study showed that female babies were 30% more likely to have low birth weight compared to males[17]. Banjar Regency data for 2020 show that low birth weight is higher in female babies than in male babies, at 4.5% for females and 3.9% for males[2]. Although artificial infant formula can be formulated to contain higher amounts of macronutrients than breast milk, breast milk provides important immunonutrition benefits for premature or low birth weight babies[18]. Research in India shows that serious infections such as diarrhoea, pneumonia, or septicemia occur less frequently in low birth-weight babies who are given breast milk compared to infant formula[19]. So in this study, female toddlers who were more likely to have low birth weight and received breast milk were more likely to be prevented from pneumonia.

Predictive Index for Pneumonia in Male Toddlers

The final results of the multiple logistic regression test on male toddler data showed 4 significant indicators, namely child development (slowed), family income (< minimum wage), house location on the river bank (distance <15m from the river bank), and child age (12 -59 months) (Table 3). Developmental delays in children under five are a predictive indicator of pneumonia, particularly in male toddlers. High prenatal testosterone levels are a risk factor for language delay in boys but not in girls. Significantly more boys than girls experienced language delays at ages 1, 2, and 3 years. Boys were also more likely to be classified as delayed on fine motor and social development scales at age 3 years[20]. Boys with lower testosterone endorsed significantly higher levels of depressive symptoms[21]. Testosterone levels in male toddlers in the study may also play a role in causing depression, which can affect the toddler's immunity and ultimately have an impact on the incidence of pneumonia. Several studies show that neuroimmune disorders are associated with the incidence of depression[22].

The location of the house on the river bank is a predictive indicator of pneumonia in male toddlers. According to observations, boys in the river basin interact more often with the river; bathing, swimming, and jumping in the river seem to be done more often by boys. Around 70% of respondents with male toddlers and homes located on riverbanks also used river water as a source of clean water, making contact with river water more likely for boys. Respiratory viruses in river water can cause pneumonia in toddlers living in homes along riverbanks. The Martapura River is vulnerable to contamination from human faeces because latrines are still located along the river. Several respiratory

viruses, including Influenza viruses, Coronaviruses, and Rhinoviruses, can be recovered from faeces[23]. Viruses like coronaviruses can survive for a long time in water and waste[24].

The child's age is a predictive indicator of pneumonia in male toddlers. The results are supported by other research, which states that the variable age of children under 1 year has a significant influence in reducing the possibility of ARI in male toddlers, OR 0.54, 95% CI (0.36-0.82)[9]. The age of males under 1 year significantly influences the occurrence of ARI, which may be related to boys' immunity in early life. Various literature shows that the immune response elicited in male babies is higher than in female babies. Neonatal immunity has also been studied using umbilical cord blood samples; the number of monocytes and basophils in male babies is higher than in female babies up to 13 months of age[25].

The strength of the results of this study is that the predictive index for female toddlers has a sensitivity value of 93.3% and for male toddlers a sensitivity value of 91.8% (Figures 1 & 2), so the predictive index is a good tool for screening female or male toddlers with ARI that might develop into pneumonia. As a local, population-based study with an exploratory approach, this research focused on identifying patterns of pneumonia risk factors by gender in toddlers in the Martapura River basin. In the analysis, we considered all theoretically and empirically relevant indicators without pre-restricting the primary variables or confounding factors. While this approach allows broad mapping of relationships, we did not perform specific control or matching of baseline characteristics between groups. Furthermore, although the regression model used stepwise selection to filter out insignificant variables, we did not further analyze relationships among interrelated indicators such as income, housing conditions, and asset ownership using multicollinearity tests. This study was also retrospective, so some variables, such as breastfeeding, immunization/immunization status, and maternal attitudes and knowledge, may have limitations in timeliness and potential recall bias.

The number of indicators analyzed was quite large, following a broad socio-ecological framework. However, the indicator structure was not simplified through factor analysis. This can lead to complex interpretations and potential overlap between variables. In addition, testing many variables simultaneously increases the risk of Type I errors (false positives), and this study did not apply multiple-testing corrections such as Bonferroni, which are generally recommended to control inflation of significance values when multiple tests are performed. The resulting predictive model demonstrated high sensitivity but low specificity. This indicates that the model is more optimal as an initial screening tool than as a confirmatory diagnostic tool. Furthermore, the results are contextual and reflect the social and environmental conditions of riverside communities in Banjar Regency. Therefore, its application in other areas requires adaptation to local characteristics.

CONCLUSION

The present study demonstrates that pneumonia risk factors differ between male and female toddlers, indicating distinct sex-specific risk patterns. Among male toddlers, stunted child development, low family income, living within 15 m of the riverbank, and age 12–59 months were independently associated with pneumonia. Among female toddlers, low family income, predominant infant formula feeding, and inadequate household occupancy density were identified as significant risk factors. These findings suggest that

biological, socioeconomic, and environmental determinants may interact differently according to child sex. Therefore, pneumonia prevention strategies should incorporate sex-specific approaches that emphasize improved child development, living environments, breastfeeding practices, and household conditions in vulnerable communities.

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CONFLICT OF INTEREST

In this study there is no conflict of interest

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