



Comparative Analysis of Risk Factors for Wasting among Under-Five Children in Urban and Rural Areas of East Nusa Tenggara

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ABSTRACT

Introduction: Wasting, including wasted and severely wasted based on the weight-for-height index, remains a major public health concern in Indonesia. East Nusa Tenggara Province recorded the highest prevalence nationwide (15.9%) in 2024, highlighting persistent challenges in preventing child undernutrition. This study examined setting-specific factors associated with wasting among children aged 0–59 months in urban and rural areas of East Nusa Tenggara.

Methods: A cross-sectional study was conducted using secondary data from the 2024 Indonesian Nutrition Status Survey (INSS), including 11,372 children aged 0–59 months. Wasting was defined as a Weight-for-Height z-score (WHZ) < -2 SD based on World Health Organization standards. Independent variables included child characteristics, infant and young child feeding practices, health status and healthcare access, parental characteristics, and household factors. Modified Poisson regression was used to estimate adjusted prevalence ratios (aPRs) and 95% confidence intervals (CIs).

Results: Wasting prevalence was identical in urban and rural areas (15.5%). Low birth weight and short birth length were consistently associated with wasting in both settings. In urban areas, children aged 0–5 months had a lower prevalence of wasting (aPR= 0.43; 95% CI: 0.20–0.90), whereas low birth weight (aPR= 1.63; 95% CI: 1.15–2.30), short birth length (aPR= 1.35; 95% CI: 1.04–1.76), and low paternal education (aPR= 1.68; 95% CI: 1.20–2.35) increased the prevalence. In rural areas, wasting was associated with low birth weight (aPR= 1.64; 95% CI: 1.35–1.98), short birth length (aPR = 1.32; 95% CI: 1.11–1.57), male sex (aPR= 1.34; 95% CI: 1.18–1.53), and medium and low maternal education (aPR= 1.30 and 1.33, respectively).

Conclusion: Although wasting prevalence was similar across settings, associated factors differed between urban and rural areas. Strengthening interventions to prevent adverse birth outcomes, while addressing setting-specific educational and socioeconomic determinants, may improve strategies to reduce wasting in East Nusa Tenggara.

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INTRODUCTION

Wasting is a form of acute malnutrition associated with a substantially increased risk of child mortality. Despite declining from 8.8% in 2000 to 6.6% in 2024, wasting still affects an estimated 45 million children under five and severe wasting increases mortality risk up to 11-fold (UNICEF, 2022; WHO et al., 2025) (UNICEF, 2022; WHO et al., 2025). The burden remains concentrated in low- and middle-income countries, particularly in South and Southeast Asia (WHO et al., 2025). The Indonesian Nutrition Status Survey (INSS) 2024 reported a national wasting prevalence of 7.4%, although several provinces continued to report prevalence above the national average (Kementerian Kesehatan RI, 2024). These trends indicate persistent challenges in sustaining nutrition improvements. Among those provinces, East Nusa Tenggara Province (NTT) represents a high-burden setting, with a prevalence of 15.9% in 2024, the highest nationally (Kementerian Kesehatan RI, 2024).

Wasting is a multifactorial condition influenced by biological, maternal, behavioral, environmental, and socioeconomic determinants. In low-resource settings, poverty, inadequate sanitation, and limited access to health services further increase the risk of wasting (Motbainor et al., 2015; Tamir et al., 2025). However, evidence regarding urban–rural disparities in wasting remains inconsistent. Several studies have reported higher prevalence in rural areas due to limited resources and restricted access to services, whereas others have highlighted vulnerabilities among urban poor populations (Al Rahmad et al., 2020; Gebresilassie et al., 2024; Joseph & Sendhil, 2026; Murarkar et al., 2020; Qanita et al., 2025). These findings suggest that wasting disparities may be shaped more by the unequal distribution of underlying risk factors than by residential status itself.

Within the Indonesian context, particularly in East Nusa Tenggara, evidence on urban–rural differences in wasting remains limited. Existing evidence in East Nusa Tenggara indicates that wasting is influenced by multiple factors, including breastfeeding practices, household income, environmental conditions, and child health factors such as infection, immunization, and feeding practices (Miller et al., 2013; Shagti et al., 2025). However, most studies have focused on individual and household level determinants, with limited attention to urban–rural differences at the subnational level (Koritelu et al., 2024; Meilandayati et al., 2018; Purwadi et al., 2023; Qanita et al., 2025), constraining the development of context-specific interventions in heterogeneous settings such as East Nusa Tenggara. Therefore, this study aimed to identify setting-specific factors associated with wasting among children aged 0–59 months in urban and rural areas of East Nusa Tenggara Province.

METHODS

Study Design and Data Source

This study analyzed secondary data from the Indonesian Nutrition Status Survey (INSS) 2024, a nationally representative cross-sectional survey aiming to assess the nutritional status of children in Indonesia. The INSS collected data from October 2024 to February 2025 across 38 provinces and 510 districts/cities, covering 33,681 census blocks. In East Nusa Tenggara, 1,393 census blocks were visited, 11,488 households with children under five years of age were interviewed, and 12,350 children were successfully assessed. The survey used a two-stage stratified sampling design. However, district-level identifiers were not available in the secondary dataset used for this study; therefore, the analysis was limited to urban–rural comparisons at the provincial level.

Sampling Design and Study Population

The analysis was restricted to children aged 0–59 months residing in East Nusa Tenggara Province and living in households participated in the INSS 2024. From an initial 12,350 children meeting the inclusion criteria, 44 were excluded due to invalid anthropometric measurements and 95 due to implausible WHO Anthro z-scores. To minimize intra-household correlation, 839 children were excluded by retaining

only one child per household, prioritizing the youngest child, while one child was randomly selected in cases of multiple births. The final analytic sample consisted of 11,372 children (92% of the source population).

Variable Definitions

The outcome variable was wasting. Based on the WHO Child Growth Standards, children were classified as wasted (Weight-for-Height Z-score [WHZ] < -2 SD) or non-wasted (WHZ ≥ -2 SD) (Kemenkes RI, 2020; WHO, 2006). In the INSS 2024, anthropometric measurements were conducted by trained nutrition-related personnel using standardized and routinely calibrated equipment. Data quality was ensured through regular WHO-based quality-control procedures, including assessments of digit preference, z-score distributions, outliers, and measurement consistency (Kementerian Kesehatan RI, 2024). Child-related variables included age group, sex, exclusive breastfeeding, low birth weight, preterm birth, birth length, infectious morbidity, early initiation of breastfeeding, complementary feeding timing, minimum dietary diversity, animal-source food consumption, sugar-sweetened beverage consumption, immunization status, and utilization of Posyandu (*Pos Pelayanan Terpadu*, or Integrated Health Service Post – community-based health service program).

Exclusive breastfeeding was categorized as exclusive breastfeeding for the first six months of life, non-exclusive/mixed feeding (introduction of foods or liquids before six months or cessation of breastfeeding before six months), and never breastfed (WHO, 2021). Low birth weight was defined as birth weight $< 2,500$ g (WHO, n.d.-a), prematurity as gestational age at birth < 37 weeks (WHO, n.d.-b), and short birth length as birth length < 48 cm (Kementerian Kesehatan RI, 2024). Early initiation of breastfeeding among children aged 0–23 months was defined as the infant being placed on the mother's chest or abdomen within ≤ 1 hour after birth with skin-to-skin contact lasting ≥ 1 hour. Complementary feeding timing was categorized as untimely if complementary foods were introduced before 6 months of age among children aged 0–23 months (WHO, 2021).

Minimum dietary diversity among children aged 0–23 months was defined as adequate if the child consumed ≥ 5 out of 8 food groups in the previous 24 hours (WHO, 2021). Animal-source food consumption was defined as consuming at least one type of animal-source food in the previous 24 hours, while sugar-sweetened beverage consumption was defined as consuming at least one type of sugar-sweetened beverage in the previous 24 hours (WHO, 2021). Infectious morbidity was defined as the presence of at least one episode of ARI or diarrhea during the previous month, or a diagnosis of pneumonia or tuberculosis during the previous year (Kementerian Kesehatan RI, 2024). Complete basic immunization among children aged ≥ 12 months was categorized as complete or incomplete based on receipt of all recommended vaccines (HB-0, BCG, DPT-HB-Hib 1–3, OPV 1–4, ≥ 1 dose of IPV, and MR), using information from the Maternal and Child Health (MCH) Handbook, immunization cards, or maternal recall (Kemenkes RI, 2017; World Health Organization, 2023).

Maternal and paternal education were categorized according to the highest completed education level as low ($\leq$ junior high school), medium (senior high school/equivalent), and high (Diploma/Bachelor/Postgraduate) (Pemerintah Pusat Indonesia, 2003). Household size was categorized as ≤ 4 members, 5–6 members, and ≥ 7 members. Socioeconomic status was categorized into five quintiles, from poorest (Q1) to wealthiest (Q5), based on the Principal Component Analysis (PCA) scores of household asset ownership. Improved drinking water was defined as the use of a protected water source. Improved sanitation was defined as the use of a goose-neck toilet with fecal disposal to a septic tank, wastewater treatment system, or covered pit according to rural sanitation regulations. Place of residence was categorized as urban or rural based on the classification used in the INSS, which follows Statistics Indonesia (BPS) urban–rural classification (Kementerian Kesehatan RI, 2024).

Statistical Analysis

Wasting status was determined using WHO Anthro based on Weight-for-Height Z-score ($WHZ < -2$ SD). Survey-weighted descriptive analyses were conducted to describe the characteristics of the study population. Sampling weights provided in the INSS 2024 dataset were applied in all descriptive and regression analyses to account for the complex survey design and obtain population-representative estimates. Missing data were assessed before analysis. Variables with more than 10% missing values were further evaluated by examining the distribution of missing observations across selected sociodemographic characteristics and the outcome. As no meaningful differential pattern was identified, a complete-case approach was applied in both the bivariate and multivariable regression analyses (Dong & Peng, 2013).

Bivariate analyses were conducted separately for urban and rural subpopulations using modified Poisson regression with robust variance to estimate crude prevalence ratios (cPR) and 95% confidence intervals (CI). Variables with p-values < 0.25 in bivariate analyses were included in the multivariable model (Hosmer et al., 2013; Sperandei, 2014). Separate multivariable models for urban and rural subpopulations were subsequently developed using modified Poisson regression with robust variance to estimate adjusted prevalence ratios (aPR) and 95% confidence intervals (CI), considering the cross-sectional nature of the study and the relatively common outcome prevalence. Subpopulation analyses were performed without splitting the survey dataset in order to preserve the complex survey design structure. All analyses were conducted using Stata version 15.0.

Ethical Approval

This study received ethical approval from the Research and Community Engagement Ethical Committee, Faculty of Public Health, Universitas Indonesia (Ethical Approval No. Ket-344/UN2.F10.ETK/PPM.00.02/2026).

RESULTS

Characteristics of the Study Population

Based on Table 1, a total of 2,206 under-five children in urban areas and 9,166 under-five children in rural areas were included in the analysis. The prevalence of wasting was similar in both settings, accounting for 15.5% among under-five children in urban and rural areas. In both areas, the largest proportion of children were aged 36–59 months. Several differences in child, parental, and household characteristics were observed between urban and rural areas. Rural areas had a higher proportion of children with low parental educational attainment, particularly low maternal education (40.9%) and low paternal education (45.6%), compared with urban areas (15.6% and 19.3%, respectively). In contrast, higher parental education was more common among urban households.

Differences were also observed in feeding practices and healthcare access. Urban children had a higher proportion of minimum dietary diversity (45.0% vs. 24.6%) and animal-source food consumption (79.5% vs. 65.0%) compared with rural children. Likewise, complete basic immunization coverage was substantially higher in urban areas (57.6%) than in rural areas (36.2%). Rural households also had a higher proportion of unimproved drinking water sources (15.9% vs. 4.4%). However, Posyandu utilization remained high in both settings, exceeding 95%.

In terms of environmental conditions, improved sanitation was more common among rural households (71.9%) than urban households (44.1%). Despite these marked differences in socioeconomic, feeding, healthcare, and household characteristics, the prevalence of wasting remained similar between urban and rural children (15.5% in both settings).

Table 1. Characteristics of under-five children by urban-rural residence

Variables	Urban (N= 2,206)		Rural (N= 9,166)	
	n	% (95% CI)	n	% (95% CI)
Children's Nutritional Status and Characteristics				
Wasting				
Yes	344	15.5 (13.77-17.33)	1,421	15.5 (14.63-16.49)
No	1,862	84.5 (82.67-86.23)	7,745	84.5 (83.51-85.37)
Sex				
Female	1,067	48.6 (46.31-50.99)	4,485	49.5 (48.32-50.76)
Male	1,139	51.4 (49.01-53.69)	4,681	50.5 (49.24-51.68)
Age Group (months)				
0–5	105	5.0 (4.02-6.26)	368	3.9 (3.44-4.38)
6–11	179	7.3 (6.15-8.71)	765	8.1 (7.49-8.85)
12–23	464	21.0 (19.01-23.19)	1,633	17.8 (16.89-18.85)
24–35	472	21.4 (19.52-23.32)	1,968	21.9 (20.96-22.93)
36–47	509	22.8 (21.03-24.72)	2,235	24.1 (23.09-25.12)
48–59	477	22.4 (20.17-24.90)	2,197	24.1 (23.00-25.24)
Low Birth Weight				
No	1,957	88.4 (86.76-89.83)	7,554	81.5 (80.18-82.78)
Yes	186	9.1 (7.85-10.61)	648	7.1 (6.45-7.74)
Missing	63	2.5 (1.70-3.61)	964	11.4 (10.24-12.70)
Birth Length				
Normal	1,643	73.3 (70.57-75.79)	6,418	68.4 (66.50-70.23)
Short	421	20.4 (18.28-22.66)	1,135	12.7 (11.73-13.64)
Missing	142	6.4 (4.97-8.11)	1,613	19.0 (17.22-20.82)
Preterm Birth				
No	1,623	75.7 (71.28-79.71)	6,947	75.3 (73.23-77.19)
Yes	508	21.1 (17.24-25.61)	1,452	15.8 (14.08-17.68)
Missing	75	3.1 (2.30-4.26)	767	8.9 (7.86-10.16)
Infant and Young Child Feeding Practices				
Early Initiation of Breastfeeding				
Yes	155	21.1 (16.46-26.62)	509	19.5 (17.19-22.14)
No	576	76.8 (71.25-81.48)	2,145	76.0 (73.33-78.54)
Missing	17	2.1 (1.19-3.83)	112	4.4 (3.47-5.62)
Exclusive Breastfeeding History				
EBF	412	66.2 (61.50-70.60)	1,622	68.5 (65.67-71.14)
Mixed-fed	165	24.1 (20.07-28.67)	518	20.8 (18.42-23.33)
Never breastfed	56	8.2 (6.17-10.90)	202	8.3 (6.98-9.86)
Missing	10	1.5 (0.73-2.92)	56	2.5 (1.75-3.45)
Complementary Feeding				
Timely	370	59.3 (53.56-64.85)	1,476	62.6 (59.62-65.50)
Untimely	264	39.3 (34.10-44.72)	873	35.3 (32.48-38.31)
Missing	9	1.4 (0.67-2.86)	49	2.1 (1.41-2.98)

Variables	Urban (N= 2,206)		Rural (N= 9,166)	
	n	% (95% CI)	n	% (95% CI)
MDD				
Yes	338	45.0 (39.94-50.22)	725	24.6 (22.40-27.01)
No	402	53.8 (48.70-58.91)	1,987	73.0 (70.63-75.30)
Missing	8	1.1 (0.53-2.40)	54	2.3 (1.73-3.17)
ASF Consumption				
Yes	593	79.5 (75.66-82.89)	1,867	65.0 (62.43-67.49)
No	153	20.2 (16.85-24.02)	880	34.1 (31.66-36.65)
Missing	2	0.3 (0.06-1.34)	19	0.9 (0.54-1.46)
SSB Consumption				
No	563	75.5 (71.45-79.17)	1,975	73.0 (70.54-75.36)
Yes	180	23.9 (20.30-27.95)	779	26.5 (24.17-28.97)
Missing	5	0.6 (0.20-1.61)	12	0.5 (0.25-0.93)
Health Status and Access to Healthcare				
Infectious morbidity				
No	1,657	75.4 (72.32-78.17)	6,684	72.4 (70.45-74.25)
Yes	532	23.7 (20.88-26.73)	2,369	26.4 (24.49-28.30)
Missing	17	1.0 (0.58-1.58)	113	1.3 (0.98-1.62)
Complete Basic Immunization				
Yes	1,070	57.6 (53.62-61.55)	3,022	36.2 (33.97-38.40)
No	615	31.3 (27.64-35.25)	3,462	46.3 (44.01-48.55)
Missing	237	11.0 (8.79-13.80)	1,549	17.6 (15.98-19.30)
Posyandu Utilization				
Yes	2,096	95.1 (93.20-96.52)	8,926	97.1 (96.45-97.70)
No	96	4.3 (3.00-6.06)	171	2.0 (1.57-2.49)
Missing	14	0.6 (0.25-1.43)	69	0.9 (0.55-1.41)
Parental Characteristics				
Maternal Education				
High	594	26.3 (23.90-28.88)	1,184	12.3 (11.49-13.16)
Medium	1,193	55.3 (52.85-57.81)	4,085	43.1 (41.77-44.48)
Low	358	15.6 (13.66-17.83)	3,581	40.9 (39.46-42.38)
Missing	61	2.7 (1.96-3.74)	316	3.7 (3.10-4.32)
Paternal Education				
High	461	20.1 (17.98-22.32)	874	8.8 (8.15-9.55)
Medium	1,115	51.7 (49.31-54.14)	3,437	36.9 (35.68-38.24)
Low	439	19.3 (17.05-21.71)	4,094	45.6 (44.18-47.06)
Missing	191	8.9 (7.47-10.66)	761	8.6 (7.77-9.53)
Household Characteristics				
Improved Drinking Water				
Yes	2,012	92.3 (89.77-94.26)	7,386	82.3 (80.09-84.27)
No	113	4.4 (3.17-6.04)	1,612	15.9 (14.07-17.94)
Missing	81	3.3 (1.97-5.47)	168	1.8 (1.13-2.89)

Variables	Urban (N= 2,206)		Rural (N= 9,166)	
	n	% (95% CI)	n	% (95% CI)
Improved Sanitation				
Yes	1,044	44.1 (38.86-49.51)	6,746	71.9 (69.67-73.96)
No	1,162	55.9 (50.49-61.14)	2,420	28.1 (26.04-30.33)
Household Size (members)				
≤4	1,321	61.8 (58.65-64.93)	5,114	55.5 (53.83-57.15)
5–6	733	32.1 (29.30-35.00)	3,238	35.3 (33.91-36.76)
≥7	152	6.1 (4.92-7.50)	814	9.2 (8.33-10.11)
Socioeconomic Status				
Q1 — Poorest	110	4.3 (3.30-5.53)	2,168	25.7 (23.88-27.58)
Q2 — Poor	197	8.9 (7.50-10.52)	2,074	23.2 (21.87-24.54)
Q3 — Middle	337	14.8 (13.06-16.71)	1,933	20.7 (19.37-22.09)
Q4 — Wealthy	552	24.6 (22.26-27.14)	1,727	17.9 (16.73-19.04)
Q5 — Wealthiest	1,010	47.4 (44.05-50.80)	1,264	12.6 (11.55-13.68)

Source: INSS, 2024

Risk of Wasting

Results of the bivariate analysis of factors associated with wasting among under-five children in urban areas are presented in Table 2. Significant associations were observed for age group, low birth weight, birth length, complete basic immunization, paternal education, and household size. Children aged 12–23 months had a higher prevalence of wasting compared with those aged 48–59 months (cPR = 1.48; 95% CI: 1.07–2.05), whereas children aged 0–5 months had a lower prevalence (cPR = 0.47; 95% CI: 0.25–0.92). In addition, children with low birth weight had nearly twice the prevalence of wasting compared with those with normal birth weight (cPR = 1.93; 95% CI: 1.43–2.60). Short birth length was also significantly associated with wasting (cPR = 1.59; 95% CI: 1.25–2.01).

A higher prevalence of wasting was further observed among children who did not receive complete basic immunization (cPR = 1.41; 95% CI: 1.09–1.84), those whose fathers had low educational attainment (cPR = 1.57; 95% CI: 1.12–2.19), and those living in households with seven or more members (cPR = 1.52; 95% CI: 1.00–2.31). Other variables were not significantly associated with wasting ($p > 0.05$).

Table 2. Factors associated with wasting among under-five children in urban residence

Variables	N (unweighted)		N (weighted) [†]	<i>p-value</i>	Crude PR (95% CI)
	Wasting (N = 2,206)		Estimated weighted population (N=155,475)		
	Yes (n=344)	No (n=1,862)			
Children’s Nutritional Status and Characteristics					
Sex					
Female	153 (14.0%)	914 (86.0%)	75,634	-	1
Male	191 (16.8%)	948 (83.2%)	79,840	0.121	1.20 (0.95-1.52)
Age Group (months)					
48–59	71 (13.2%)	406 (86.8%)	34,899	-	1
36–47	81 (16.9%)	428 (83.1%)	35,481	0.134	1.28 (0.93-1.77)
24–35	71 (14.4%)	401 (85.6%)	33,205	0.576	1.10 (0.79-1.52)
12–23	82 (19.5%)	382 (80.5%)	32,691	0.018*	1.48 (1.07-2.05)
6–11	29 (16.0%)	150 (84.0%)	11,394	0.368	1.22 (0.79-1.88)
0–5	10 (6.2%)	95 (93.8%)	7,804	0.026*	0.47 (0.25-0.92)

Variables	N (unweighted)		N (weighted) [†]	p-value	Crude PR (95% CI)
	Wasting (N = 2,206)		Estimated weighted population (N=155,475)		
	Yes (n=344)	No (n=1,862)			
Low Birth Weight					
No	286 (14.3%)	1,671 (85.7%)	137,410	-	1
Yes	51 (27.6%)	135 (72.4%)	14,204	<0.001*	1.93 (1.43-2.60)
Birth Length					
Normal	229 (13.6%)	1,414 (86.4%)	113,897	-	1
Short	95 (21.6%)	326 (78.4%)	31,687	<0.001*	1.59 (1.25-2.01)
Preterm Birth					
No	252 (15.5%)	1,371 (84.5%)	117,763	-	1
Yes	80 (15.1%)	428 (84.9%)	32,840	0.873	0.98 (0.73-1.31)
Infant and Young Child Feeding Practices					
Early Initiation of Breastfeeding					
Yes	26 (14.9%)	129 (85.1%)	10,946	-	1
No	95 (17.7%)	481 (82.3%)	39,829	0.466	1.19 (0.75-1.89)
Exclusive Breastfeeding History					
EBF	74 (18.7%)	338 (81.3%)	29,185	-	1
Mixed-fed	29 (21.4%)	136 (78.6%)	10,628	0.473	1.14 (0.79-1.66)
Never breastfed	7 (11.2%)	49 (88.8%)	3,629	0.211	0.60 (0.26-1.34)
Complementary Feeding					
Timely	64 (17.1%)	306 (82.9%)	26,153	-	1
Untimely	46 (21.2%)	218 (78.8%)	17,318	0.280	1.23 (0.84-1.81)
MDD					
Yes	55 (17.0%)	283 (83.0%)	23,364	-	1
No	64 (16.4%)	338 (83.6%)	27,939	0.855	0.97 (0.66-1.40)
ASF Consumption					
Yes	101 (18.0%)	492 (82.0%)	41,257	-	1
No	20 (12.0%)	133 (88.0%)	10,481	0.153	0.67 (0.38-1.16)
SSB Consumption					
No	95 (17.1%)	468 (82.9%)	39,185	-	1
Yes	26 (16.0%)	154 (84.0%)	12,410	0.773	0.94 (0.60-1.46)
Health Status and Access to Healthcare					
Infectious morbidity					
No	248 (14.7%)	1,409 (85.3%)	117,170	-	1
Yes	91 (17.5%)	441 (82.5%)	36,819	0.187	1.19 (0.92-1.55)
Complete Basic Immunization					
Yes	159 (13.8%)	911 (86.2%)	78,540	-	1
No	108 (19.5%)	507 (80.5%)	42,681	0.010*	1.41 (1.09-1.84)
Posyandu Utilization					
Yes	327 (15.5%)	1,769 (84.5%)	147,891	-	1
No	14 (14.8%)	82 (85.2%)	6,652	0.836	0.95 (0.59-1.54)
Parental Characteristics					

Variables	N (unweighted)		N (weighted) [†]	<i>p</i> -value	Crude PR (95% CI)
	Wasting (N = 2,206)		Estimated weighted population (N=155,475)		
	Yes (n=344)	No (n=1,862)			
Maternal Education					
High	83 (13.8%)	511 (86.2%)	40,911	-	1
Medium	191 (15.6%)	1,002 (84.4%)	86,044	0.399	1.13 (0.85-1.52)
Low	60 (16.4%)	298 (83.6%)	24,302	0.302	1.19 (0.85-1.67)
Paternal Education					
High	55 (12.6%)	406 (87.4%)	31,196	-	1
Medium	176 (14.5%)	939 (85.5%)	80,419	0.363	1.16 (0.84-1.58)
Low	83 (19.7%)	356 (80.3%)	29,965	0.008*	1.57 (1.12-2.19)
Household Characteristics					
Improved Drinking Water					
Yes	315 (15.7%)	1,697 (84.3%)	143,518	-	1
No	21 (16.2%)	92 (83.8%)	6,825	0.910	1.03 (0.64-1.65)
Improved Sanitation					
Yes	176 (16.8%)	868 (83.2%)	68,591	-	1
No	168 (14.4%)	994 (85.6%)	86,884	0.172	0.85 (0.68-1.07)
Household Size (members)					
≤4	205 (14.9%)	1,116 (85.1%)	96,143	-	1
5–6	111 (15.1%)	622 (84.9%)	49,877	0.907	1.01 (0.80-1.28)
≥7	28 (22.7%)	124 (77.3%)	9,455	0.048*	1.52 (1.00-2.31)
Socioeconomic Status					
Q5	145 (14.4%)	865 (85.6%)	73,715	-	1
Q4	84 (14.9%)	468 (85.1%)	38,274	0.829	1.03 (0.76-1.40)
Q3	59 (19.0%)	278 (81.0%)	22,999	0.091	1.32 (0.96-1.81)
Q2	38 (16.5%)	159 (83.5%)	13,828	0.519	1.14 (0.76-1.72)
Q1	18 (15.7%)	92 (84.3%)	6,659	0.751	1.09 (0.65-1.82)

*Statistically significant ($p < 0.05$) based on modified Poisson regression

Source: INSS, 2024

Results of the bivariate analysis of factors associated with wasting among under-five children in rural areas are presented in Table 3. Significant associations were observed for sex, age group, low birth weight, birth length, exclusive breastfeeding history, maternal education, paternal education, and socioeconomic status. Male children had a higher prevalence of wasting compared with female children (cPR = 1.26; 95% CI: 1.12–1.42). Children aged 0–5 months had a lower prevalence of wasting compared with those aged 48–59 months (cPR = 0.66; 95% CI: 0.46–0.96). In addition, children with low birth weight had a significantly higher prevalence of wasting (cPR = 1.74; 95% CI: 1.47–2.06), and short birth length was also associated with wasting (cPR = 1.49; 95% CI: 1.28–1.74).

Children who were never breastfed had a higher prevalence of wasting compared with exclusively breastfed children (cPR = 1.53; 95% CI: 1.11–2.11). Higher prevalence of wasting was also observed among children whose mothers had medium (cPR = 1.37; 95% CI: 1.12–1.66) and low educational attainment (cPR = 1.41; 95% CI: 1.17–1.72), as well as those whose fathers had medium (cPR = 1.28; 95% CI: 1.03–1.59) and low educational attainment (cPR = 1.28; 95% CI: 1.02–1.59). Furthermore, children from households in the fourth (Q4) (cPR = 1.30; 95% CI: 1.05–1.62), third (Q3) (cPR = 1.29; 95% CI: 1.05–1.58), and second

(Q2) wealth quintiles (cPR = 1.47; 95% CI: 1.21–1.77) had a higher prevalence of wasting compared with those in the highest wealth quintile (Q5). Other variables were not significantly associated with wasting ($p > 0.05$).

Table 3. Factors associated with wasting among under-five children in rural residence

Variables	N (unweighted)		N (weighted) [†] Estimated weighted population (N=376,760)	<i>p-value</i>	<i>Crude PR</i> (95% CI)
	Wasting (N = 9,166)				
	Yes (n=1,421)	No (n=7,745)			
Sex					
Female	613 (13.7%)	3,872 (86.3%)	186,653	-	1
Male	808 (17.3%)	3,873 (82.7%)	190,107	<0.001*	1.26 (1.12-1.42)
Age Group (months)					
48–59	335 (15.0%)	1,862 (85.0%)	90,817	-	1
36–47	326 (14.3%)	1,909 (85.7%)	90,777	0.590	0.96 (0.81-1.13)
24–35	314 (16.7%)	1,654 (83.3%)	82,627	0.218	1.11 (0.94-1.31)
12–23	292 (17.8%)	1,341 (82.2%)	67,243	0.055*	1.18 (1.00-1.41)
6–11	114 (15.5%)	651 (84.5%)	30,669	0.797	1.03 (0.82-1.29)
0–5	40 (10.0%)	328 (90.0%)	14,627	0.027*	0.66 (0.46-0.96)
Low Birth Weight					
No	1,081 (14.7%)	6,473 (85.3%)	307,124	-	1
Yes	175 (25.5%)	473 (74.5%)	26,624	<0.001*	1.74 (1.47-2.06)
Birth Length					
Normal	923 (14.4%)	5,495 (85.6%)	257,687	-	1
Short	238 (21.5%)	897 (78.5%)	47,671	<0.001*	1.49 (1.28-1.74)
Preterm Birth					
No	1,044 (15.4%)	5,903 (84.6%)	283,550	-	1
Yes	256 (17.8%)	1,196 (82.2%)	59,512	0.057	1.16 (1.00-1.35)
Early Initiation of Breastfeeding					
Yes	93 (17.5%)	416 (82.5%)	21,996	-	1
No	334 (15.7%)	1,811 (84.3%)	85,564	0.389	0.90 (0.70-1.15)
Exclusive Breastfeeding History					
EBF	264 (16.1%)	1,358 (83.9%)	67,037	-	1
Mixed-fed	97 (18.7%)	421 (81.3%)	20,335	0.219	1.16 (0.92-1.47)
Never BF	42 (24.7%)	160 (75.3%)	8,131	0.009*	1.53 (1.11-2.11)
Complementary Feeding					
Timely	242 (16.7%)	1,234 (83.3%)	61,297	-	1
Untimely	162 (18.5%)	711 (81.5%)	34,604	0.350	1.11 (0.89-1.37)
MDD					
Yes	127 (18.0%)	598 (82.0%)	27,720	-	1
No	315 (15.7%)	1,672 (84.3%)	82,184	0.204	0.87 (0.70-1.08)
ASF Consumption					
Yes	310 (16.6%)	1,557 (83.4%)	73,155	-	1
No	133 (15.1%)	747 (84.9%)	38,389	0.421	0.91 (0.72-1.15)

Variables	N (unweighted)		N (weighted) [†]	<i>p-value</i>	Crude PR (95% CI)
	Wasting (N = 9,166)		Estimated weighted population (N=376,760)		
	Yes (n=1,421)	No (n=7,745)			
SSB Consumption					
No	299 (15.2%)	1,676 (84.8%)	82,172	-	1
Yes	145 (18.7%)	634 (81.3%)	29,820	0.061*	1.23 (0.99-1.52)
Infectious morbidity					
No	1,016 (15.0%)	5,668 (85.0%)	272,733	-	1
Yes	384 (16.9%)	1,985 (83.1%)	99,283	0.079	1.12 (0.99-1.28)
Complete Basic Immunization					
Yes	462 (15.8%)	2,560 (84.2%)	119,832	-	1
No	554 (15.9%)	2,908 (84.1%)	153,364	0.949	1.00 (0.87-1.16)
Posyandu Utilization					
Yes	1,375 (15.5%)	7,551 (84.5%)	365,984	-	1
No	36 (19.6%)	135 (80.4%)	7,462	0.226	1.26 (0.87-1.83)
Maternal Education					
High	147 (11.7%)	1,037 (88.3%)	46,353	-	1
Medium	640 (15.9%)	3,445 (84.1%)	162,467	0.002*	1.37 (1.12-1.66)
Low	589 (16.5%)	2,992 (83.5%)	154,145	<0.001*	1.41 (1.17-1.72)
Paternal Education					
High	111 (12.3%)	763 (87.7%)	33,238	-	1
Medium	535 (15.7%)	2,902 (84.3%)	139,203	0.026*	1.28 (1.03-1.59)
Low	641 (15.7%)	3,453 (84.3%)	171,870	0.030*	1.28 (1.02-1.59)
Improved Drinking Water					
Yes	1,140 (15.5%)	6,246 (84.5%)	309,996	-	1
No	255 (15.5%)	1,357 (84.5%)	59,942	0.983	1.00 (0.85-1.17)
Improved Sanitation					
Yes	1,024 (15.2%)	5,722 (84.8%)	270,765	-	1
No	397 (16.4%)	2,023 (83.6%)	105,995	0.282	1.08 (0.94-1.23)
Household Size (members)					
≤4	808 (15.7%)	4,306 (84.3%)	209,094	-	1
5–6	495 (15.3%)	2,743 (84.7%)	133,077	0.652	0.97 (0.86-1.10)
≥7	118 (15.3%)	696 (84.7%)	34,589	0.831	0.98 (0.78-1.22)
Socioeconomic Status					
Q5	159 (12.3%)	1,105 (87.7%)	47,388	-	1
Q4	270 (16.0%)	1,457 (84.0%)	67,280	0.018*	1.30 (1.05-1.62)
Q3	310 (15.8%)	1,623 (84.2%)	77,979	0.015*	1.29 (1.05-1.58)
Q2	355 (18.0%)	1,719 (82.0%)	87,337	<0.001*	1.47 (1.21-1.77)
Q1	327 (14.4%)	1,841 (85.6%)	96,775	0.096	1.18 (0.97-1.43)

*Statistically significant ($p < 0.05$) based on modified Poisson regression

Source: INSS, 2024

Multivariable Analysis

The multivariable analysis showed that low birth weight and short birth length were consistently associated with wasting among children aged 0–59 months in both urban and rural areas, as presented in Table 4. Children with low birth weight had a higher prevalence of wasting in urban areas (aPR = 1.63; 95% CI: 1.15–2.30; $p = 0.006$) and rural areas (aPR = 1.64; 95% CI: 1.35–1.98; $p < 0.001$) compared with those with normal birth weight. Similarly, children with short birth length had a higher prevalence of wasting in urban (aPR = 1.35; 95% CI: 1.04–1.76; $p = 0.027$) and rural areas (aPR = 1.32; 95% CI: 1.11–1.57; $p = 0.002$) compared with those with normal birth length.

Differences in associated factors were also observed between urban and rural settings. In urban areas, paternal education remained significantly associated with wasting. Children whose fathers had low educational attainment had a 1.68 times higher prevalence of wasting compared with those whose fathers had high educational attainment (aPR = 1.68; 95% CI: 1.20–2.35; $p = 0.003$). In addition, children aged 0–5 months had a lower prevalence of wasting compared with children aged 48–59 months (aPR = 0.43; 95% CI: 0.20–0.90; $p = 0.026$).

In contrast, rural areas showed a broader range of associated factors. Male children had a higher prevalence of wasting than female children (aPR = 1.34; 95% CI: 1.18–1.53; $p < 0.001$). Maternal education was also significantly associated with wasting, as children whose mothers had medium (aPR = 1.30; 95% CI: 1.06–1.60; $p = 0.012$) and low educational attainment (aPR = 1.33; 95% CI: 1.09–1.63; $p = 0.006$) had a higher prevalence of wasting compared with children whose mothers had high educational attainment.

Table 4. Final Multivariable Model of Factors Associated with Wasting Among Children Aged 0–59 Months in Urban and Rural Residence

Variables	Urban (N=1,890)		Variables	Rural (N=7,366)	
	Adjusted PR (95% CI)	<i>p</i> -value		Adjusted PR (95% CI)	<i>p</i> -value
Low birth weight			Low birth weight		
No	1	-	No	1	-
Yes	1.63 (1.15-2.30)	0.006*	Yes	1.64 (1.35-1.98)	<0.001*
Birth length			Birth length		
Normal	1	-	Normal	1	-
Short	1.35 (1.04-1.76)	0.027*	Short	1.32 (1.11-1.57)	0.002*
Paternal education			Maternal education		
High	1	-	High	1	-
Medium	1.19 (0.87-1.64)	0.280	Medium	1.30 (1.06-1.60)	0.012*
Low	1.68 (1.20-2.35)	0.003*	Low	1.33 (1.09-1.63)	0.006*
Age Group (months)			Sex		
48–59	1	-	Female	1	-
36–47	1.27 (0.90-1.79)	0.166	Male	1.34 (1.18-1.53)	< 0.001*
24–35	1.03 (0.72-1.47)	0.878			
12–23	1.38 (0.96-2.00)	0.083			
6–11	1.13 (0.71-1.81)	0.610			
0–5	0.43 (0.20-0.90)	0.026*			

*Statistically significant ($p < 0.05$) based on modified Poisson regression

Source: INSS, 2024

Subset Analysis

A subgroup multivariable analysis of factors associated with wasting among children aged 6–23 months is presented in Table 5. Different patterns of associated factors were observed between urban and rural areas. In urban areas, short birth length remained the only significant factor associated with wasting. Children with short birth length had a 1.92 times higher prevalence of wasting compared with those with normal birth length (aPR = 1.92; 95% CI: 1.35–2.72; $p < 0.001$). Meanwhile, rural areas demonstrated more complex associated factors. Low birth weight remained significantly associated with wasting, with children having a 1.91 times higher prevalence of wasting compared with those with normal birth weight (aPR = 1.91; 95% CI: 1.45–2.52; $p < 0.001$). Male children had a higher prevalence of wasting than female children (aPR = 1.29; 95% CI: 1.02–1.63; $p = 0.033$). Children who were never breastfed had a 1.54 times higher prevalence of wasting compared with exclusively breastfed children (aPR = 1.54; 95% CI: 1.10–2.15; $p = 0.012$).

Table 5. Final Multivariable Model of Factors Associated with Wasting Among Children Aged 6-23 Months in Urban and Rural Residence

Variables	Urban (N= 2,181)		Variables	Rural (N=8,908)	
	Adjusted PR (95% CI)	<i>p</i> -value		Adjusted PR (95% CI)	<i>p</i> -value
Birth Length			Low birth weight		
Normal	1	-	No	1	-
Short	1.92 (1.35-2.72)	<0.001*	Yes	1.91 (1.45-2.52)	<0.001*
			Sex		
			Female	1	-
			Male	1.29 (1.02-1.63)	0.033*
			Exclusive breast feeding		
			EBF	1	-
			Mixed-fed	1.15 (0.90-1.47)	0.270
			Never BF	1.54 (1.10-2.15)	0.012*
			Maternal education		
			High	1	-
			Medium	1.66 (1.07-2.57)	0.022*
			Low	1.72 (1.10-2.71)	0.018*
			Socioeconomic status		
			Q5	1	-
			Q4	1.22 (0.76-1.97)	0.417
			Q3	1.68 (1.08-2.63)	0.022*
			Q2	1.85 (1.24-2.75)	0.002*
			Q1	1.24 (0.79-1.94)	0.343

*Statistically significant ($p < 0.05$) based on modified Poisson regression

Source: INSS, 2024

Maternal education also remained significantly associated with wasting, as children whose mothers had medium (aPR = 1.66; 95% CI: 1.07–2.57; $p = 0.022$) and low educational attainment (aPR = 1.72; 95% CI: 1.10–2.71; $p = 0.018$) had a higher prevalence of wasting compared with children whose mothers had high educational attainment. In addition, socioeconomic status was significantly associated with wasting,

with children from households in the third (Q3) (aPR = 1.68; 95% CI: 1.08–2.63; $p = 0.022$) and second wealth quintiles (Q2) (aPR = 1.85; 95% CI: 1.24–2.75; $p = 0.002$) having a higher prevalence of wasting compared with those in the highest wealth quintile (Q5).

DISCUSSION

The present study found an identical prevalence of wasting in urban and rural areas of East Nusa Tenggara (15.5% in both settings). However, separate multivariable models identified different setting-specific factors associated with wasting in each residential setting. These findings contribute to the inconsistent evidence regarding urban–rural patterns of wasting reported in previous studies, where some studies have reported a higher prevalence of wasting in rural areas due to limited access to health services and economic resources, whereas others have shown that urban residence does not necessarily confer protection, particularly among socioeconomically disadvantaged populations. The findings of this study indicate that similar wasting prevalence may coexist with different sets of associated factors identified in urban and rural settings. Nevertheless, the comparable burden observed across both populations highlights that child undernutrition in East Nusa Tenggara is not confined to rural communities but remains a persistent public health challenge throughout the province (Atok et al., 2023).

In both urban and rural settings, low birth weight and short birth length were consistently identified as independent predictors of wasting, with relatively similar magnitudes of association. Children with LBW had approximately 60% higher prevalence of wasting, whereas those with short birth length had approximately 30% higher prevalence. These findings are consistent with previous evidence indicating that LBW and short birth length reflect suboptimal fetal growth and adverse intrauterine conditions, which may compromise postnatal growth and increase susceptibility to undernutrition during early childhood (Malhotra et al., 2019; Okwaraji et al., 2024). Paternal education was identified as an independent predictor of wasting in urban areas but not in rural areas. Fathers in urban settings often play a central role in household income generation, and higher educational attainment may facilitate better employment opportunities and greater access to food and health services (Vaezghasemi et al., 2020). This finding is consistent with evidence from 180 Demographic and Health Surveys across 62 countries, which reported that paternal education contributes to reducing childhood undernutrition to a similar extent as maternal education (Vollmer et al., 2016).

In rural areas, the final multivariable model additionally identified male sex and maternal education as factors associated with wasting. One possible explanation is that maternal education may influence childcare practices and health-related decision-making, particularly in rural households. Previous studies have suggested that higher maternal education is associated with improved feeding practices, health service utilization, and caregiving behaviors, which may contribute to better child nutritional outcomes (Makoka & Masibo, 2015). The relatively small difference in adjusted prevalence ratios between low and medium maternal education observed in this study suggests that the benefits of maternal education may become more apparent at higher educational levels. These findings indicate that improving maternal education may be considered as one component of broader nutrition strategies in rural East Nusa Tenggara (Rezaeizadeh et al., 2024).

The emergence of male sex as a significant factor associated with wasting only in the rural model is consistent with previous evidence showing that boys are generally at greater risk of wasting than girls. A meta-analysis of 44 studies reported higher odds of wasting among boys, particularly in socioeconomically disadvantaged settings (Thurstans et al., 2020, 2022). The absence of this association in the urban model may reflect contextual differences between residential settings; however, the mechanisms underlying this finding cannot be evaluated using the present data. The similar magnitude of association between low birth weight and wasting across the urban and rural models is consistent with the Developmental Origins of Health and Disease (DOHaD) framework, which proposes that adverse intrauterine conditions may influence physiological development and increase susceptibility to adverse health outcomes later in life (Lacagnina,

2020). Previous studies have suggested that undernutrition during gestation may lead to fetal programming that affects growth, metabolism, and physiological function beyond the neonatal period, thereby increasing vulnerability to undernutrition during childhood. The consistent association observed across both residential settings underscores the importance of early-life conditions as factors associated with wasting. Although household food security was not examined in the present study, previous studies have reported that seasonal food insecurity related to rain-fed agriculture remains an important challenge in rural East Nusa Tenggara and may contribute to child undernutrition (Kirk et al., 2017; Roba et al., 2019).

The present study also included a subgroup analysis among rural children aged 6–23 months (Table 5), allowing the inclusion of age-specific feeding practice variables that did not apply to the full sample of children aged 0–59 months. These variables included exclusive breastfeeding history, complementary feeding practices, minimum dietary diversity, animal-source food consumption, and sugar-sweetened beverage consumption. The findings suggest additional determinants not captured in the main model, namely exclusive breastfeeding history and socioeconomic status, highlighting the nutritional vulnerability of children during this critical period. Children who were never breastfed had a significantly higher prevalence of wasting than those who received exclusive breastfeeding, whereas mixed feeding was not significantly associated with wasting. Breast milk provides essential nutrients and immunological protection during infancy, which may help reduce susceptibility to acute undernutrition, particularly where complementary feeding practices are suboptimal (Mertens et al., 2023). Consistent with this finding, previous studies have also reported that non-exclusive breastfeeding and delayed initiation of breastfeeding are associated with a higher risk of wasting among young children (Mertens et al., 2023).

Among children aged 6–23 months, the association between LBW and wasting appeared stronger than that observed in the overall population. Children with LBW had nearly twice the prevalence of wasting (aPR = 1.93; 95% CI: 1.47–2.53), compared with a 63% higher prevalence in urban areas (aPR = 1.63; 95% CI: 1.15–2.30) and a 64% higher prevalence in rural areas (aPR = 1.64; 95% CI: 1.35–1.98). This finding may suggest that the effect of adverse birth conditions on nutritional status is more pronounced during early childhood, when children remain more biologically vulnerable and have had less time to compensate for early growth deficits. As children grow older, other factors such as feeding practices, infection, caregiving, and environmental conditions may play a greater role in shaping nutritional outcomes. The association between socioeconomic status and wasting should be interpreted cautiously. Only children in the second wealth quintile showed a significantly higher prevalence of wasting, whereas the poorest wealth quintile was not significantly associated with wasting. The reasons for this pattern cannot be determined from the present study and may reflect unmeasured contextual factors. Previous studies have shown that the relationship between socioeconomic status and wasting is complex and may operate through multiple pathways, including water, sanitation, hygiene, food access, and household living conditions (Ijaiya et al., 2024).

Taken together, these findings indicate that different setting-specific factors associated with wasting were identified in the urban and rural multivariable models. In urban areas of East Nusa Tenggara, the final model identified birth-related factors and paternal education as factors associated with wasting, whereas the rural model additionally identified biological, maternal, and socioeconomic factors. These findings are consistent with previous evidence suggesting that wasting may originate during fetal development and early infancy, highlighting the potential importance of improving maternal nutrition and birth outcomes. The identification of additional maternal and socioeconomic factors in the rural model also suggests that broader nutrition strategies addressing social determinants may be considered alongside interventions targeting early-life conditions. Furthermore, these findings support previous evidence highlighting substantial geographic and socioeconomic disparities in child undernutrition across Papua, Maluku, and Nusa Tenggara, suggesting that nutrition strategies may benefit from considering the contextual characteristics of these regions rather than relying on a uniform national approach (Ayuningtyas et al., 2022).

This study has several strengths, including the use of a large population-based dataset and separate

urban and rural analyses, which enabled the identification of setting-specific factors associated with wasting. However, several limitations should be acknowledged. First, the cross-sectional design precludes establishing temporal relationships or causal inferences, and reverse causality cannot be ruled out. Second, information on birth-related characteristics, breastfeeding history, and immunization status was obtained from child health records when available or caregiver recall otherwise, which may have introduced recall bias for some exposure variables. However, wasting status was determined using anthropometric measurements collected during the survey, making outcome misclassification unlikely. Third, this study adopted a predictive rather than a causal modeling approach; therefore, variable selection was not intended to explicitly control for confounding.

Although the models incorporated a range of child, parental, and household characteristics, several potentially relevant maternal factors, including maternal nutritional status, maternal height, maternal anemia, antenatal care utilization or quality, and household food security, were beyond the scope of the present analysis. The inclusion of these factors may improve future predictive models of wasting. Finally, although missing data patterns were assessed and complete-case analysis was considered appropriate, some degree of selection bias cannot be entirely excluded. Despite these limitations, the findings provide useful evidence on setting-specific factors associated with wasting and may help inform context-specific nutrition strategies in East Nusa Tenggara. Future longitudinal studies with more comprehensive maternal and household information are warranted to confirm these findings and further examine the observed associations.

CONCLUSION

The prevalence of wasting among children under five in East Nusa Tenggara was similar between urban and rural areas. However, setting-specific factors associated with wasting were identified in the urban and rural multivariable models. In urban areas, wasting was associated with child age, biological and perinatal conditions, particularly low birth weight, short birth length, and low paternal education. In rural areas, the final model additionally identified male sex, maternal education, exclusive breastfeeding history, and socioeconomic status among children aged 6–23 months as factors associated with wasting. These findings suggest that, despite similar wasting prevalence, the factors associated with wasting identified within each residential setting may differ in their relative importance.

Given the observational nature of this study, the findings should be interpreted as associations rather than causal relationships. Nevertheless, they may provide useful evidence for developing context-specific nutrition strategies in East Nusa Tenggara. Across both urban and rural areas, efforts could consider strengthening maternal nutrition and antenatal care to reduce the occurrence of low birth weight and short birth length. Additional strategies may also be tailored to local contexts, such as promoting paternal involvement in maternal and child nutrition in urban areas and strengthening maternal education, optimal infant feeding practices, access to health services, and socioeconomic conditions among vulnerable households in rural areas. Future longitudinal studies are needed to confirm these associations and inform targeted interventions.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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ARTIFICIAL INTELLIGENCE (AI) STATEMENT

No generative artificial intelligence (AI) tools were used in the preparation of this manuscript.

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