Ayres *et al. BMC Public Health* (2025) 25:430
https://doi.org/10.1186/s12889-025-21634-6

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of the underlying factors behind the rural–urban CIAF disparities, the result of this study is important in planning e□ective intervention measures aiming at reducing residence-based inequalities and the population health outcomes. Therefore, should be given for rural children to reduce CIAF by improving house hold wealth index, women education and attentions to older children, and female children.

Africa. e source population is children under 5 in in all study countries in the survey time. e study population is children under 5 who were living in the selected enumeration areas in the study countries [30–34]. Inner City Fund (ICF) provided technical support via the DHS program, which is funded by the USAID and o ers support and technical assistance for the implementation of population and health surveys in countries worldwide.

Sampling procedures and techniques

Community-based cross-sectional study design was employed among children under 5 in Ethiopia. Stratified by rural and urban two-stage cluster sampling was conducted in all countries. For Ethiopia, stratification was also done by regions. Based on the Probability proportional to Size (PPS) technique, clusters (EAs) were selected first and by applying systematic random sampling technique, equal numbers of households were selected in the second stage [30–34]. About 305, 1,691, and 608 clusters (EAs) were sampled in Ethiopia, Kenya, Rwanda, Uganda and Tanzania in the first stage respectively. About 30, 1,691, and 22 households per cluster (EA) were selected in Ethiopia, Kenya, Rwanda, Uganda and Tanzania in the second stage respectively. e pretest was performed for checking the reliability of the tools. Health professional field sta s were recruited and trained to serve as team supervisors, field editors, interviewers, secondary editors, and reserve interviewers. In addition, individuals were recruited and trained on how to collect biomarker data, including taking height and weight measurements, testing for anemia by measuring hemoglobin levels.

Measurement of the study variables

Dependent variable

Children composite index of anthropometric failure was the outcome of interest that was assessed using anthropometric like weight, height and age; and conventional anthropometric indices such as stunting, wasting and underweight. For the analysis, the dependent variable is dichotomous variable categorized as failure coded as 1 and normal coded as 0.

Equity strati er variable

Residence which was classified as rural (coded as 1) and urban (coded as 0).

Explanatory variables

Independent variables were extracted from the recent DHS in East African countries. Such as sex of child, age of child in months, birth order of the child, type of birth, birth interval, mother's age, mother's education, source of drinking water, toilet facility, family size, number of under 5 children in the household and household wealth index.

Operational de nitions

e Composite Index of Anthropometric Failure (CIAF) combines weight-for-age (WAZ), length/height-for-age (HAZ), and weight-for-length (WHZ) to assess the undernutritional status of children under-5. It categorizes children into "anthropometric failure" (coded as 1) or "normal" (coded as 0). e categories include: A) no

e Blinder-Oaxaca decomposition analysis was used to explain residence-based disparities in children's composite index of anthropometric failure (CIAF). is technique breaks down the di erences in CIAF between two groups into: 1) the endowment or explained component, which is due to di erences in the levels or distribution of determinants, and 2) the unexplained component, which is due to di erences in the impact of these determinants on the outcome, as well as the interaction of both factors [36, 37].

Yi represents the outcome variable (CIAF), and X is an independent variable. For two groups (rural and urban), the CIAF for children under 5 years old in each group is described as follows.

$$^{\text{rural}} = \beta^{\text{rural}} X_{+\varepsilon}{}^{\text{rural}} \quad (1)$$

$$Yi^{\text{urban}} = \beta^{\text{urban}} X_{i+\varepsilon}{}^{\text{urban}} \quad (2)$$

us, the gap in the average CIAF between rural and urban residences (Yi rural—Yi urban) is presented as [37].

Oaxaca decomposition

$$Y^{\text{rural}} - Y^{\text{urban}} = (X^{\text{rural}} - X^{\text{urban}})\beta^{\text{urban}} + (\beta^{\text{rural}} - \beta^{\text{urban}})X^{\text{rural}} + (X^{\text{urban}} - X^{\text{rural}})(\beta^{\text{urban}} - \beta^{\text{rural}}) \quad (3)$$

$$- \quad = \Delta \quad \beta \quad + \Delta\beta \quad (4)$$

where ΔX is the mean di erence explanatory variables (X^{rural}—X^{urban}) and the same to $\Delta\beta = (\beta^{\text{rural}} - \beta^{\text{urban}})$ [37].

Blinder decomposition

erefore, the disparity in average outcomes (CIAF) may arise from di erences in endowments (5), di erences in coe cients (3), and the interaction between endowments and coe cients (CE) [37].

e Oaxaca [36] decomposition analysis (4) uses rural children under 5 years old as the reference group, weighting di erences in attributes by their coe cients and di erences in coe cients by the covariates of urban children. Conversely, the Blinder decomposition analysis

CIAF between rural and urban residents was 25.49%, 11.38%, 27%, 22.15%, and 20.55% in Ethiopia, Kenya, Rwanda, Uganda and Tanzania respectively (Fig. 1). In

Table 2 Characteristics of children under-5 by place of residence in selected East African countries (2016–2022)

Characteristics	EDHS 2019		KDHS 2022		RDHS 2019		UDHS 2016		TDHS 2022	
Outcome variable (CIAF)%	**40.69**		**22.04**		**34.06**		**31.99**		**33.27**	
Residence	**Rural (%)**	**Urban (%)**	**Rural (%)**	**Urban (%)**	**Rural (%)**	**Urban (%)**	**Rural (%)**	**Urban (%)**	**Rural (%)**	**Urban (%)**
Proportion	74.96	25.04	64.06	35.94	83.32	16.68	79.62	20.38	73.22	26.78
Sex of child (%)	$Chi^2(1),0.6$		$Chi^2(1),1.2$		$Chi^2(1),0.1$		$Chi^2(1),0.6$		$Chi^2(1),0.12$	
Male	38.02	12.88	32.51	18.15	42.07	7.98	40.20	10.22	36.97	13.84
Female	36.94	12.16	31.55	17.79	41.24	8.70	39.42	10.16	36.25	12.94
Age of child (months) (%)	$Chi^2(2),11^{**}$		$Chi^2(2),1.8$		$Chi^2(2),3.1$		$Chi^2(2),6$		$Chi^2(2),1.1$	
< 6	8.14	2.38	6.96	3.78	8.70	1.33	8.64	1.53	8.28	2.76
6–23	21.26	8.40	20.40	11.31	26.48	5.28	25.22	7.17	23.67	8.83
24–59	45.56	14.26	36.69	20.85	48.13	10.07	45.77	11.67	41.27	15.20
Birth order (%)	$Chi^2(2),239^{***}$		$Chi^2(2),360^{***}$		$Chi^2(2),26^{***}$		$Chi^2(2),\ 55^{***}$		$Chi^2(2),89^{***}$	
1 child	14.03	7.38	16.49	11.66	18.77	4.87	14.50	4.61	15.15	7.21
2–3	21.93	10.36	24.73	17.29	34.84	7.25	25.68	8.68	26.48	11.99
≥ 4	39.01	7.29	22.84	7.00	29.70	4.57	39.45	7.08	31.59	7.58
Type of birth (%)	$Chi^2(1),1.4$		$Chi^2(1),0.01$		$Chi^2(1),8^{**}$		$Chi^2(1),0.02$		$Chi^2(1),4.5^{*}$	
Singleton	73.39	24.43	62.13	34.99	81.39	16.04	77.13	19.72	71.65	25.87
Multiple	1.57	0.61	1.92	0.95	1.93	0.65	2.50	0.66	1.57	0.91
Birth interval (%)	$Chi^2(1),2.4$		$Chi^2(1),1.2$		$Chi^2(1),2.3$		$Chi^2(1),0.1$		$Chi^2(1),13.5^{***}$	
< 24 months	16.55	4.32	11.45	5.23	11.43	12.59	19.26	4.29	13.32	2.93
≥ 24 months	61.12	18.01	54.82	28.50	73.21	2.78	61.38	15.07	61.54	22.21
Mother's age (years) (%)	$Chi^2(2),12^{**}$		$Chi^2(2),81^{***}$		$Chi^2(2),6.7^{*}$		$Chi^2(2),4.7$		$Chi^2(2),15^{**}$	
15–24	16.81	6.09	18.51	7.91	12.54	2.65	25.78	5.84	22.13	6.23
25–34	39.86	14.14	30.96	20.52	40.40	8.85	35.21	10.52	32.43	13.58
35–49	18.29	4.81	14.59	7.51	30.38	5.19	18.63	4.01	18.66	6.97
Mother's education (%)	$Chi^2(2),749^{***}$		$Chi^2(2),767^{***}$		$Chi^2(2),352^{***}$		$Chi^2(2),435^{***}$		$Chi^2(2),330^{***}$	
No formal education	45.63	7.96	8.34	2.17	11.14	0.90	10.18	0.90	20.04	1.86
Primary	25.10	10.29	28.29	9.51	57.48	7.38	53.71	7.96	42.60	14.98
Secondary and above	4.23	6.79	27.43	24.25	14.69	8.40	15.73	11.52	20.04	1.86
Source of drinking water (%)	$Chi^2(1),186^{***}$		$Chi^2(1),322^{***}$		$Chi^2(1),64^{***}$		$Chi^2(1),85^{***}$		$Chi^2(1),440.5^{***}$	
Unimproved	30.77	5.42	9.91	24.61	21.45	2.40	22.67	2.14	32.48	2.00
Improved	44.19	19.62	26.03	39.45	61.87	14.28	56.95	18.24	40.74	24.78
Toilet facilities (%)	$Chi^2(1),88^{***}$		$Chi^2(1),76^{***}$		$Chi^2(1),96^{***}$		$Chi^2(1),515^{***}$		$Chi^2(1),990^{***}$	
Unimproved	68.33	15.79	32.37	4.21	27.56	2.27	59.42	5.95	51.61	3.74
Improved	6.64	9.24	31.69	31.73	55.76	14.41	20.20	14.43	21.61	23.04

***

Table 3 Detailed decomposition of CIAF by residence for children under 5 in Ethiopia and Kenya

Country	**Ethiopia**			**Kenya**		
Decomposition	**Estimate**	**Standard error (se)**	**Percent**	**Estimate**	**Standard error (se)**	**Percent**
Explained (E)	0.11256***	0.03093	87.35	0.089***	0.01561	129.41
Unexplained (C)	0.01630	0.04241	12.65	−0.021	0.01885	−29.41
Raw di□erence (R)	0.12886***	0.02969	100	0.069***	0.01083	100
Endowment (Explained component) = Di□erence in characteristics (E)						
Mother's age						
15–24 years old	Ref			Ref		
25–34 years old	−0.00091	0.00275	−0.70	0.00033	0.00085	0.48
35–49 years old	−0.00198	0.00133	−1.54	−0.00046	0.00027	−0.67
Mother's education						
Higher	Ref			Refyears old		

Table 3 (continued)

Country	Ethiopia	Kenya
Decomposition		

Table 4 Detailed decomposition of CIAF by residence for children under 5 in Rwanda and Uganda

Table 5 Detailed decomposition of CIAF by residence for children under 5 in Tanzania

Country	**Tanzania**		
Decomposition	**Estimate**	**Standard error (se)**	**Percent**
Explained (E)	0.09831***	0.02143	80.62
Unexplained (C)	0.02363	0.02918	19.38
Raw di□erence (R)	0.12194***	0.02020	

anthropometric failure between the rural and urban categories was high.

Detailed decomposition estimates

Di erence in characteristics (covariate distribution)

From the output of the mvdcmp decomposition, the contribution of the individual characteristics for the composite index of anthropometric failure disparity by the residence. e results revealed in Ethiopia, Kenya, Rwanda, Uganda and Tanzania, a significant composite index of anthropometric failure disparity in rural and urban residencies (0.13, 0.10, 0.14, 0.06 and 0.12) respectively with all of the $P < 0.001$. In Ethiopia, Kenya, Rwanda, Uganda, and Tanzania about 87.35%, 129.41%, 87.60%, 168.25% and 80.62% of the composite index of anthropometric failure disparities were explained by the di erences in distributions of characteristics (endowments) between rural and urban residencies respectively.

In Ethiopia, the largest disparity of the composite index of anthropometric failure was explained by the household wealth index di erence between rural and urban children under 5; household with poorest wealth index (25.36%) contributed for narrowing this disparity and household with middle wealth index (16.85%) contributed for narrowing this disparity and mother's with primary education (−13.36%), and female sex (−1.56%) contributed for widening this disparity. e distribution of child age 24–59 months (2.74%), multiple births (0.47%), and mother's has no formal education (0.02%) were factors that help to achieve narrowing of the rural–urban composite index of anthropometric failure disparity if these characteristics distribution equalized to the level of rural children for urban children as well.

Di erence due to coe cients (the e ect of covariate di erences)

In this study, the coe cient e ect was not significant in all study countries. e rural–urban disparity in composite index of anthropometric failure in children under-5 was totally due to the endowment or the characteristic e ect.

Discussion

Literatures reported that the prevalence of composite index of anthropometric failure is higher in rural children under-5 as compared to the urban residents [9, 24]. Di erent factors are contributing to the higher burden of composite index of anthropometric failure of children under-5 in rural residence. is study thoroughly examined and determined the factors that contribute to the disparity in composite index of anthropometric failure between rural and urban residencies of selected East African Countries: Ethiopia, Kenya, Rwanda, Uganda and Tanzania. We employed a Blinder-Oaxaca and related decomposition techniques which have been underutilized in previous researches. To the best of our literature search, this is the initial study to provide explanations for the observed gap in composite index of anthropometric failure in children under-5 in rural and urban residencies with in East African countries. e findings of this study can inform and guide health policy development and program implementation targeted at reducing health and nutrition inequalities and enhancing overall population health in the study region.

In this study, significant disparities between rural and urban residents were identified in all countries included in the study. However, these disparities were not consistent across the region. e largest gap in composite index of anthropometric failure in children under-5 in rural–urban areas was observed in Rwanda, with a di erence of 27 percentage points (30.53% in rural and 3.35% in urban residence area) followed by Ethiopia with a di erence of 25.45 percentage points (33.09% in rural and 7.60% in urban residence area); Uganda with a di erence of 22.15 percentage points (27.07% in rural and 4.92% in urban residence area) and Tanzania 20.55 percentage points (26.91% in rural and 6.36% in urban residence area). e lowest gap in composite index of anthropometric failure in children under-5 in rural–urban areas was observed in Kenya, with a di erence of 11.38 percentage points (16.71% in rural and 5.33% in urban residence area). is variation could be attributed to several factors in Ethiopia including urban children belonging to high socioeconomic status, and high women literacy. e descriptive statistics support these -16.71TJ .0s(-1.o) .097 Tw 0 -1.224 Td [8 30

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