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Decomposing the rural–urban gap in factors associated with childhood immunisation in sub-Saharan Africa: evidence from surveys in 23 countries

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ABSTRACT

Background About 31 million children in sub-Saharan Africa (SSA) suffer from immunisation preventable diseases yearly and more than half a million children die because of lack of access to immunisation. Immunisation coverage has stagnated at 72% in SSA over the past 6 years. Due to evidence that full immunisation of children may be determined by place of residence, this study aimed at investigating the rural–urban differential in full childhood immunisation in SSA.

Methods The data used for this study consisted of 26 241 children pooled from 23 Demographic and Health Surveys conducted between 2010 and 2018 in SSA. We performed a Poisson regression analysis with robust Standard Errors (SEs) to determine the factors associated with full immunisation status for rural and urban children. Likewise, a multivariate decomposition analysis for non-linear response model was used to examine the contribution of the covariates to the observed rural and urban differential in full childhood immunisation. All analyses were performed using Stata software V.15.0 and associations with a p<0.05 were considered statistically significant.

Results More than half of children in urban settings were fully immunised (52.8%) while 59.3% of rural residents were not fully immunised. In all, 76.5% of rural–urban variation in full immunisation was attributable to differences in child and maternal characteristics. Household wealth was an important component contributing to the rural–urban gap. Specifically, richest wealth status substantially accounted for immunisation disparity (35.7%). First and sixth birth orders contributed 7.3% and 14.9%, respectively, towards the disparity while 7.9% of the disparity was attributable to distance to health facility.

Conclusion This study has emphasised the rural–urban disparity in childhood immunisation, with children in the urban settings more likely to complete immunisation. Subregional, national and community-level interventions to obviate this disparity should target children in rural settings, those from poor households and women who have difficulties in accessing healthcare facilities due to distance.

Key questions

What is already known?

- Immunisation coverage in sub-Saharan Africa has stagnated at 72% over the past 6 years.
- Approximately 31 million children in sub-Saharan Africa are at risk of immunisation preventable diseases each year.

What are the new findings?

- 76.5% rural–urban variation in full immunisation in sub-Saharan Africa is attributable to differences in child and maternal characteristics.
- No child aged 11–23 months from Zimbabwe was fully immunised.

What do the new findings imply?

- Subregional, national and community-level interventions to obviate rural–urban disparity in immunisation should target rural children as well as those in poor households and women who have difficulties in accessing healthcare facilities due to distance. Factors mediating the large gap need to be considered by immunisation interventions.

BACKGROUND

Globally, significant decline in under-5 mortality has occurred especially between 1970 and 2016 and this has been partly attributed to childhood immunisation.[1–3] Childhood immunisation constitutes one of the most impactful and cost-effective public health interventions.[4] It is efficacious in attenuating infectious disease-related ill health and deaths among children.[4] Childhood immunisation has been acknowledged as a prerequisite for achieving target 3.2 of the Sustainable Development Goals (SDGs), thus achieving neonatal mortality of 12 per 1000 live births and under-5 mortality of 25 per 1000 live births by 2030.[5] Yet, as of 2016, estimates revealed that one in five African children went unimmunised.[6] About 31 million

children in sub-Saharan Africa (SSA) suffer from immunisation preventable diseases yearly and more than half a million die as a result of lack of access to immunisation.[7] Immunisation coverage has stagnated at 72% in SSA over the past 6 years.[7] In spite of these, the benefits of immunisation to the well-being of children are enormous. Moreover, several countries in Africa are unable to reach and immunise most vulnerable children in rural and remote locations.[8]

In recent times, studies have explored the predictors and barriers to immunisation or full immunisation while series of reviews have been conducted on this subject. Some of these recent studies have reported that lack of knowledge of immunisation, lack of partner support, financial deprivation and distrust in immunisation programmes account for incomplete or non-immunisation.[9–11] Further evidence indicate rural–urban variation in childhood immunisation in some parts of SSA[12] while another study examined rural–urban variations in missed opportunities of immunisation in SSA,[13] and showed an emerging trend in the disparity in favour of urban residents. It is, therefore, not unanticipated that under-5 mortality is higher among rural children compared with urban children in SSA.[14]

A greater segment of health workforce in SSA are also concentrated in urban settings[15] and this could increase the prospects of urban children to receive full immunisation at the expense of those in rural locations. This situation incontestably hampers the prospects of achieving Universal Health Coverage of full childhood immunisation and increase chances of childhood mortalities. Populations in difficult terrains and rural settings are highly disadvantaged, encounter setbacks in healthcare access as well as participating in preventive interventions and may have less prospects of achieving full immunisation coverage.[15]

In spite of the foregoing, there is limited scholarly research that collate data from several countries on the magnitude of rural–urban disparity in full immunisation in SSA. There is, therefore, the need to decompose immunisation by rural–urban variations in order to deepen the depth of knowledge on childhood immunisation in SSA. As a result, we investigated the rural–urban differences in childhood immunisation among children 12–23 months in SSA. The findings from this study are anticipated to enhance current knowledge and guide the development of result-oriented interventions for childhood immunisation within the subregion.

METHODS

Data source

We sourced data from the most recent Demographic and Health Surveys (DHS) of 23 countries conducted between 2010 and 2018. These 23 countries were included based on two principal reasons: countries having DHS data within the study period (ie, from 2010 to 2018) and comparability of data due to availability of required variables within the datasets. These surveys were executed by the DHS Programme. DHS is executed in low-income and middle-income countries in partnership with local organisations in the respective countries. It is usually conducted at 5-year interval and follows a common execution procedure. The survey focuses on crucial maternal and child health factors such as immunisation, maternal healthcare utilisation, malaria and other essential indicators.[16] A two-stage stratified sampling procedure is adopted in selecting research participants. In the first phase, clusters/enumeration areas (EAs) are selected guided by a sample frame developed during the preceding census of the respective countries, while in the second stage, a sample of households is drawn from each selected EAs. The full sampling procedure has been documented elsewhere.[16] A total of 26 241 children who had complete information on all the variables considered were eligible for this study. We relied on the Strengthening the Reporting of Observational Studies in Epidemiology statement in conducting this study and writing the manuscript (online supplemental file 1).

Measurement of variables

Outcome variable

Full immunisation coverage of children 12–23 months was the outcome of interest. Children within 12–23 months are expected to receive the rudimentary immunisation dosages. Following the WHO recommendations, a child was considered to be fully immunised if the child has received Bacille Calmette-Guerin against tuberculosis; at least three doses of polio vaccine; three doses of diptheria, tetanus toxoids and pertussis vaccine and one dose measles vaccine[17] as illustrated in table 1. Subsequently, a child between 12 and 23 months who had received all nine doses was classified as fully immunised (coded 1), while any child without all the dosages was categorised as non-fully immunised (coded 0).

Independent variables

The key independent variable was residential status, that is, rural or urban area. Based on some immunisation literature,[9 11 13] we selected and controlled for nine (9) covariates grouped into child factors: sex of child, and birth order as well as maternal factors: maternal age, education, wealth quintile, occupation, sex of household head, health insurance subscription status and distance

Table 1 Recommended immunisation for SSA children

At birth	BCG; Polio 0
6 weeks period	Polio 1; DPT 1
10 weeks period	Polio 2; DPT 2
14 weeks period	Polio 3; DPT 3
9 months period	Measles

Source: modified from WHO.[17]
BCG, Bacille Calmette-Guerin; DPT, Diphtheria-Pertussis-Tetanus; SSA, sub-Saharan Africa.

Table 2 Details and summaries of countries' immunisation status by residence

Countries	Year of survey	Sample size	Prevalence of full Immunisation		P value
			Urban prev. (95% CI)	Rural prev. (95% CI)	
Benin	2017/2018	2382	60.2 (56.1 to 64.1)	53.1 (49.7 to 56.4)	0.008
Burundi	2016	1236	78.7 (67.3 to 87.0)	77.8 (74.8 to 80.5)	0.862
Democratic Republic of Congo	2013/2014	1661	42.3 (36.4 to 48.5)	22.8 (18.7 to 27.6)	<0.001
Ethiopia	2016	1813	49.0 (36.4 to 61.7)	12.8 (10.2 to 16.1)	<0.001
Gabon	2012	726	3.9 (2.2 to 6.6)	9.0 (5.9 to 13.6)	0.013
Ghana	2014	562	67.5 (60.1 to 74.1)	55.6 (48.1 to 62.9)	0.024
Gambia	2013	715	65.5 (56.1 to 73.9)	84.9 (81.0 to 88.2)	<0.001
Guinea	2018	717	25.5 (18.7 to 33.6)	17.2 (13.6 to 21.5)	0.041
Kenya	2014	1815	69.3 (62.1 to 75.7)	54.9 (51.3 to 58.5)	<0.001
Liberia	2013	665	49.2 (37.3 to 61.2)	43.3 (37.2 to 49.5)	0.394
Lesotho	2014	109	87.8 (70.2 to 95.7)	65.9 (52.3 to 77.4)	0.033
Mali	2018	1803	44.5 (37.7 to 51.6)	31.4 (27.7 to 35.4)	0.001
Malawi	2015/2016	1073	56.0 (43.8 to 67.5)	55.7 (51.6 to 60.0)	0.961
Nigeria	2018	1278	45.7 (39.8 to 51.7)	23.0 (19.5 to 26.9)	<0.001
Niger	2012	970	71.0 (64.4 to 76.7)	37.5 (33.1 to 42.0)	<0.001
Namibia	2013	404	75.5 (66.7 to 82.6)	84.6 (79.6 to 88.5)	0.038
Sierra Leone	2013	943	63.2 (54.5 to 71.2)	67.5 (62.6 to 72.1)	0.380
Togo	2013/2014	689	67.4 (59.5 to 74.4)	56.5 (49.4 to 63.3)	0.040
Tanzania	2015/2016	2006	75.9 (71.7 to 79.6)	47.6 (43.4 to 51.8)	<0.000
Uganda	2016	882	54.8 (46.4 to 62.9)	44.3 (40.4 to 48.3)	0.026
South Africa	2016	289	66.9 (56.4 to 75.9)	68.9 (58.9 to 77.5)	0.769
Zambia	2013/2014	2439	56.8 (52.2 to 61.3)	25.6 (22.9 to 28.6)	<0.001
Zimbabwe	2015	1064	0.0	0.0	n/a
Total	2010–2018	26241	52.8 (51.1 to 54.4)	40.7 (39.7 to 41.7)	<0.001

n/a, not applicable.

to health facilities. Sex of child was either male or female while birth order ranged from one (1) to six (6) or more. Maternal age was measured in completed years categorised into 5-year interval (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49); education was captured as no education, primary, secondary and higher; wealth quintile was grouped as poorest, poorer, poor, richer and richest; occupation was measured as not working or working; distance to health facility was either not a big problem/no problem or a big problem; and finally health insurance subscription status was either yes (ie, subscribed) or no (ie, not subscribed).

Analytical procedure

The descriptive summaries of countries by year of survey, sample size and the prevalence of full immunisation by place of residence were presented in table 2. Similarly, a pooled analysis of the proportion of children who were fully immunised by residential status with respect to each of the covariates were presented in table 3. A χ^2 test of association was conducted to investigate if there exist a difference between the maternal and child characteristics by place of residence (table 4). The proportion of children aged 12–23 months with full immunisation status across the 23 countries was presented in figure 1. For the inferential analysis, we fitted a Poisson regression with robust standard errors to explore the predictors and direction of full immunisation status with respect to the covariates (table 5). In the final analysis, a multivariate non-linear decomposition model,[18] which is similar to the Fairlie and Blinder-Oaxaca was employed to decompose the disparity in immunisation status due to residential status (table 6). This technique was used to evaluate the variation in full immunisation status between rural and urban children and to identify the contribution of each covariates to the explained immunisation variation between rural and urban children. The multivariate decomposition analysis was weighted, and other analyses were conducted using Stata software V.15.0 and adjusted for the complex survey design. The variance inflation factor (VIF) was used to check for the presence of multicollinearity which showed no evidence of multicollinearity (mean VIF=2.98, maximum=3.40, minimum=1.04).

Table 3 Weighted full immunisation coverage by explanatory variables (n=26 241)

Variables	Level	Full immunisation coverage		P value*
		No	Yes	
		n (%)	n (%)	
Residence	Urban	3814 (47.2)	4263 (52.8)	<0.001
	Rural	10 764 (59.3)	7399 (40.7)	
Child factors				
Sex	Male	7300 (55.2)	5936 (44.8)	0.780
	Female	7278 (56.0)	5727 (44.0)	
Birth order	1	2842 (50.8)	2757 (49.2)	<0.001
	2	2556 (51.7)	2388 (48.3)	
	3	2350 (55.2)	1905 (44.8)	
	4	1941 (55.9)	1533 (44.1)	
	5	1525 (58.2)	1095 (41.8)	
	6+	3363 (62.9)	1985 (37.1)	
Maternal factors				
Age	15–19	1189 (61.1)	757 (38.9)	<0.001
	20–24	3418 (54.2)	2887 (45.8)	
	25–29	3952 (54.6)	3285 (45.4)	
	30–34	2979 (54.8)	2457 (45.2)	
	35–39	1980 (55.6)	1580 (44.4)	
	40–44	843 (60.1)	559 (39.9)	
	45–49	217 (61.2)	137 (38.8)	
Education	No education	5768 (60.3)	3796 (39.7)	<0.001
	Primary	5067 (55.4)	4082 (44.6)	
	Secondary	3369 (51.1)	3226 (48.9)	
	Higher	374 (40.2)	558 (59.8)	
Wealth quintile	Poorest	3801 (65.0)	2046 (35.0)	<0.001
	Poorer	3375 (60.7)	2184 (39.3)	
	Poor	2943 (55.5)	2363 (44.5)	
	Richer	2639 (52.2)	2418 (47.8)	
	Richest	1821 (40.7)	2652 (59.3)	
Occupation	Not working	4969 (60.4)	3252 (39.6)	<0.001
	Working	9609 (53.3)	8411 (46.7)	
Distance to health facility	Not a big problem/no problem	8015 (50.9)	7731 (49.1)	<0.001
	A big problem	6564 (62.5)	3931 (37.5)	
Sex of household head	Male	11 516 (55.8)	9128 (44.2)	0.717
	Female	3063 (54.7)	2534 (45.3)	
Health insurance	No	13 742 (56.5)	10 598 (43.5)	<0.001
	Yes	836 (44.0)	1064 (56.0)	

* $p < 0.05$.

The Inner-City Fund International further ensures that the procedures of DHS are consistent with the regulations for the respect of human subjects as recommended by the US Department of Health and Human Services. Comprehensive information about the ethical protocols is accessible through http://goo.gl/ny8T6X. Authors sought and obtained permission to use the data from the Measure DHS Programme after our intent for the data was accessed.

Patient and public involvement

Patients and the public were not involved in the design and conduct of this research.

Table 4 Weighted frequencies of explanatory variables by residence (n=26 241)

Variables	Level	Residence		P value*
		Urban	Rural	
		n (%)	n (%)	
Child's sex	Male	4172 (51.6)	9063 (49.9)	0.245
	Female	3905 (48.4)	9100 (50.1)	
Birth order	1	2156 (26.7)	3443 (19.0)	<0.001
	2	1857 (23.0)	3087 (17.0)	
	3	1470 (18.2)	2785 (15.3)	
	4	1022 (12.6)	2453 (13.5)	
	5	659 (8.2)	1961 (10.8)	
	6+	914 (11.3)	4434 (24.4)	
Age	15–19	549 (6.8)	1397 (7.7)	<0.001
	20–24	1929 (23.9)	4376 (24.1)	
	25–29	2353 (29.1)	4884 (26.9)	
	30–34	1755 (21.7)	3681 (20.3)	
	35–39	1083 (13.4)	2477 (13.6)	
	40–44	351 (4.3)	1051 (5.8)	
	45–49	58.2 (0.7)	296 (1.63)	
Education	No education	1597 (19.8)	7967 (43.9)	<0.001
	Primary	2178 (27.0)	6971 (38.4)	
	Secondary	3540 (43.8)	3055 (16.8)	
	Higher	763 (9.4)	169 (0.9)	
Wealth quintile	Poorest	441 (5.5)	5406 (29.8)	<0.001
	Poorer	500 (6.2)	5058 (27.8)	
	Poor	949 (11.8)	4357 (24.0)	
	Richer	2440 (30.2)	2616 (14.4)	
	Richest	3747 (46.4)	726 (4.0)	
Occupation	Not working	2781 (34.4)	5440 (30.0)	<0.001
	Working	5297 (65.6)	12 723 (70.0)	
Distance to health facility	Not a big problem/No problem	6236 (77.2)	9510 (52.4)	<0.001
	A big problem	1842 (22.8)	8653 (47.6)	
Sex of household head	Male	6142 (76.0)	14 501 (79.8)	<0.001
	Female	1935 (24.0)	3662 (20.2)	
Health insurance	No	13 742 (94.3)	10 598 (90.9)	<0.001
	Yes	836 (5.7)	1064 (9.1)	

* $p < 0.05$.

RESULTS

Descriptive results

The sample size ranged between 109 children in Lesotho to 2439 children in Zambia (table 2). More than half of children in urban settings were fully immunised (52.8%) while nearly 6 out of 10 children were not fully immunised in rural locations (59.3%) as shown in table 3.

There was no significant difference in the proportion of males with full immunisation compared with females with full immunisation (44.8% vs 44.0%; p=0.780). Full immunisation was prevalent among children of first birth order (49.2%) and lowest among those having sixth or higher birth order (37.1%). A significant proportion of children born to women aged 20–24 were fully immunised (45.8%) as well as those born to women with higher education (59.8%). As regard wealth quintile, 59.3% of children that belonged to the richest household were fully immunised while 46.7% of children whose mothers were working were fully immunised. Nearly half of the children of women who reported that distance to health facility was not a problem or a big problem were fully immunised (49.1%). There were no statistically significant differences between the sex (male vs female) of the head of household and full immunisation status of

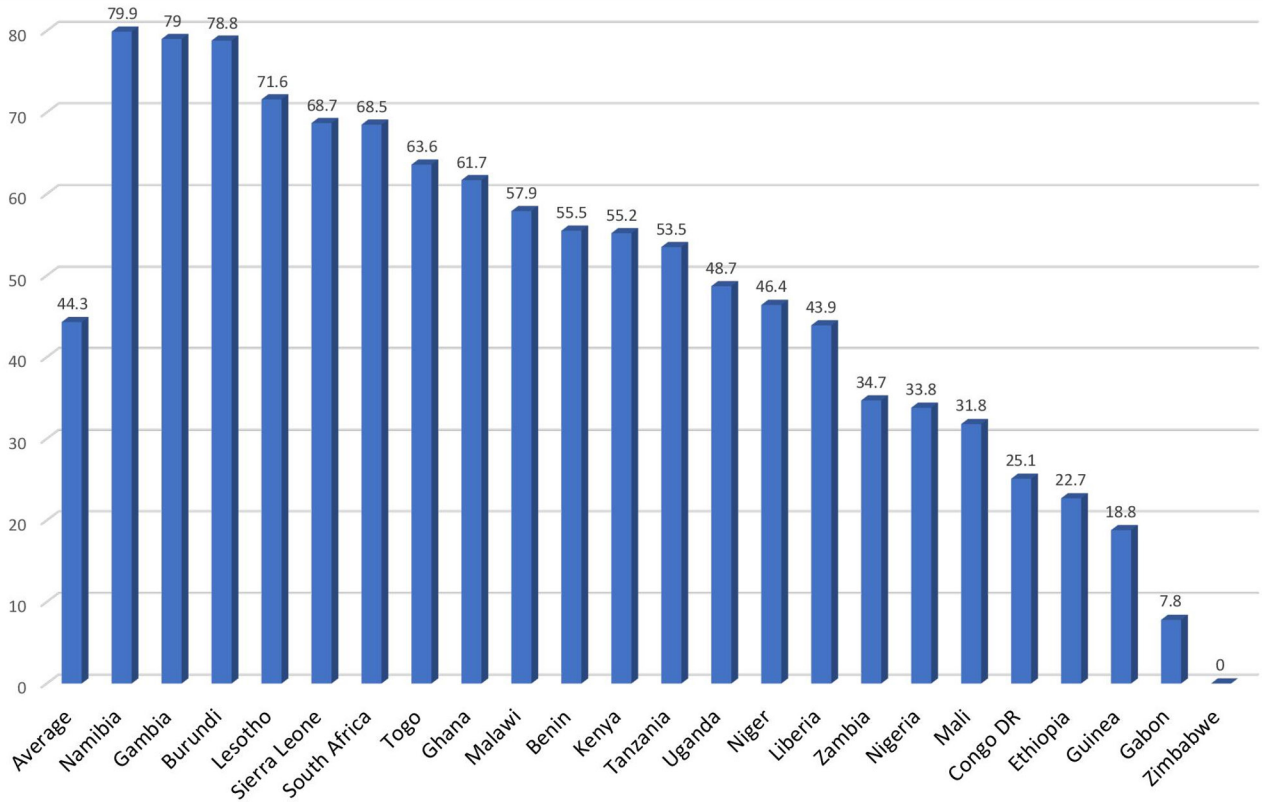

Figure 1 Full immunisation coverage per country.

a child (44.2% vs 45.3%; p=0.717). Also, more than half of children whose mothers had health insurance were fully immunised (56.0%).

The pooled analysis of the explanatory variables by residence presented in table 4 showed that 26.7% of children in the urban areas belonged to the first birth order compared with 19.0% in the rural areas whereas 24.4% of children in the rural areas were in the six or more-birth order compared with 11.3% in the rural areas. A higher proportion (7.7%) of mothers in the rural areas were adolescent (15–19 years) compared with 6.8% in the urban settings. Similarly, there were striking differences in mothers' level of education and wealth status between place of residence. A higher proportion of mothers in the rural areas (43.4%) had no formal education compared with 19.8% in the urban areas while 29.8% of mothers belonged to the poorest wealth quintile compared with 5.5% in the urban areas; whereas only 4.0% of mothers in the rural areas belong to the richest wealth quintile compared with 46.4% in the urban setting. There were more mothers in the rural areas compared with those in the urban settings that had a job (70.0% vs 65.6%; p<0.001). About half of the mothers who resided in rural areas had a big problem to access health facility due to distance compared with those in the urban locations (47.6% vs 22.5%; p<0.001). In the urban areas, a higher proportion of household had a female head compared with rural areas (24.2% vs 20.2%; p<0.001) whereas in the rural areas a higher proportion of mothers had a health insurance scheme compared with those in the urban setting (9.1% vs 5.7%; p<0.001)

The full immunisation status of children across the 23 countries as indicated in figure 1 revealed an average of 44.3% full immunisation status among children in SSA. Although, a large variation in full immunisation status was observed across countries, ranging from 0%–79.9%. None of the children between 11 and 23 months in Zimbabwe had full immunisation, and only about one in 10 children were fully immunised in Gabon. Countries with high level of full immunisation compliance, where at least seven in 10 of the children had full immunisation include Burundi (78.8%), Gambia (79.0%) and Namibia (79.9%). Although only Burundi had no statistically significant observed differences in urban–rural gap in full immunisation status (78.7 vs 77.8; p=0.862) among these countries. Other countries where no statistically significant exist in the urban-rural prevalence of full immunisation include Liberia (49.2 vs 43.3; p=0.384), Malawi (56.0 vs 55.7; p=0.961), Sierraleone (63.2 vs 67.5; p=0.380) and South Africa (66.9 vs 68.9; p=0.769) (table 2).

Multivariable Poisson regression of full immunisation on the exposure variables

Table 5 presents the relative risk of full immunisation coverage between urban and rural residents. Children who occupy sixth or higher birth orders had lower relative risk of full immunisation compared with first birth order children in urban (relative risk, RR 0.61; 95% CI 0.53 to

Table 5 Multivariable poisson regression of full immunisation on the exposure variables

	Urban		Rural	
	RR	95% CI	RR	95% CI
Child factors				
Child's sex				
Male	Ref	Ref	Ref	Ref
Female	0.96	0.91 to 1.01	1.00	0.96 to 1.05
Birth order				
1	Ref	Ref	Ref	Ref
2	0.94	0.88 to 1.01	0.88‡	0.83 to 0.94
3	0.81‡	0.74 to 0.88	0.82‡	0.76 to 0.89
4	0.82‡	0.74 to 0.91	0.79‡	0.73 to 0.87
5	0.74‡	0.65 to 0.84	0.75‡	0.68 to 0.83
6+	0.61‡	0.53 to 0.70	0.69‡	0.62 to 0.76
Maternal factors				
Age				
15–19	0.80†	0.70 to 0.92	0.76‡	0.68 to 0.85
20–24	0.91*	0.84 to 0.98	0.96	0.89 to 1.02
25–29	Ref	Ref	Ref	Ref
30–34	1.06	0.98 to 1.15	1.07*	1.01 to 1.15
35–39	1.15†	1.04 to 1.26	1.10*	1.02 to 1.19
40–44	0.99	0.82 to 1.18	1.10	0.98 to 1.23
45–49	1.37*	1.03 to 1.83	1.04	0.86 to 1.25
Education				
No education	Ref	Ref	Ref	Ref
Primary	1.14†	1.04 to 1.24	1.03	0.98 to 1.08
Secondary	0.98	0.90 to 1.07	1.01	0.94 to 1.07
Higher	0.97	0.86 to 1.09	0.95	0.77 to 1.16
Wealth quintile				
Poorest	Ref	Ref	Ref	Ref
Poorer	0.84	0.69 to 1.02	1.11†	1.04 to 1.18
Poor	0.93	0.79 to 1.11	1.23‡	1.16 to 1.31
Richer	0.95	0.82 to 1.11	1.28‡	1.20 to 1.38
Richest	1.19*	1.02 to 1.38	1.32‡	1.18 to 1.47
Occupation				
Not working	Ref	Ref	Ref	Ref
Working	1.02	0.96 to 1.09	1.29‡	1.22 to 1.36
Distance to health facility				
Not a big problem/no problem	Ref	Ref	Ref	Ref
A big problem	0.85‡	0.79 to 0.92	0.85‡	0.81 to 0.89
Sex of household head				
Male	Ref	Ref	Ref	Ref
Female	0.96	0.89 to 1.02	1.05	0.99 to 1.10
Health insurance				
No	Ref	Ref	Ref	Ref
Yes	0.94	0.87 to 1.0	1.34***	1.25 to 1.43

*P<0.05.
†P<0.01.
‡P<0.001.
Ref, reference category; RR, relative risk.

0.70) and rural (RR 0.69; 95% CI 0.62 to 0.76) settings. Children of women aged 45–49 had lower relative risk in urban (RR 0.80; 95% CI 0.70 to 0.92) and rural (RR 0.76; 95% CI 0.68 to 0.85) locations compared with children of women aged 25–29. Among urban residents, the highest relative risk was recorded among children of 45–49 aged women (RR 1.37; 95% CI 1.03 to 1.83).

Relative to children of women without formal education, children of primary educated women in urban locations had higher relative risk of full immunisation (RR 1.14; 95% CI 1.04 to 1.24) same as children of richest urban women compared with those having poorest mothers or caregivers (RR 1.19; 95% CI 1.02 to 1.38). In the case of rural children, relative risk was high among children whose mothers/caregivers were richest (RR 1.32; 95% CI 1.18 to 1.47). Similarly, relative risk of full immunisation was higher among children whose mothers were working (RR 1.29; 95% CI 1.22 to 1.36) or had health insurance (RR 1.34; 95% CI 1.25 to 1.43) in rural locations compared with children whose mothers were neither working nor had health insurance respectively. Meanwhile, children whose mothers/caregivers indicated that distance to health facility was a big problem had lower risk ratio of full immunisation (RR 0.85; 95% CI 0.81 to 0.89) in urban locations.

Decomposition of disparity in full immunisation coverage between rural and urban residence

Decomposition of the disparity in full immunisation coverage between rural and urban residence revealed that 76.5% variation is attributable to differences in child and maternal characteristics (table 6). Household wealth was an important component contributing to the rural–urban gap. Specifically, richest wealth status substantially accounted for immunisation disparity (35.7%). First and sixth birth orders contributed 7.3% and 14.9%, respectively, towards the disparity while 7.9% was attributable to distance to health facility.

DISCUSSION

This study examined full childhood immunisation gap between rural and urban populace in SSA. The study revealed variation in full immunisation in favour of urban children. Most children of higher birth order were in rural locations. No child was fully immunised in Zimbabwe and this may be aligned with the immunisation funding gap in the country.[19] The over-reliance on donor

Table 6 Multivariate decomposition of child and maternal factors associated with full immunisation inequality between rural and urban residence

	Difference due to characteristics (E)		Difference due to coefficients (C)	
Characteristics	**Coefficient**	**Percentage (%)**	**Coefficient**	**Percentage (%)**
% total explained disparity		76.47		23.53
Child factors				
Child's sex				
Male	0.00018	0.16	0.00576	4.78
Female	0.00019	0.16	−0.00578	−4.80
Birth order				
1	−0. 00880***	7.31	0.00483	4.01
2	−0. 00484***	4.03	0.00788	6.55
3	−0. 00013	−0.11	−0.00091	−0.76
4	−0. 00001	−0.01	0.0198	1.65
5	−0. 00143**	1.18	−0.00187	−1.56
6+	−0. 01799***	14.94	−0.01544	−12.82
Maternal factors				
Age				
15–19	0.00121***	1.01	−0.00147	−1.22
20–24	0.00015**	0.13	−0.01200*	−9.97
25–29	−0. 00032	−0.27	−0.00422	−3.51
30–34	0.00031**	0.26	−0.00221	−1.84
35–39	−0. 00014**	−0.12	0.00263	2.18
40–44	0.00015	0.12	−0.00289	−2.40
45–49	0.00135*	−1.12	0.00206*	1.70
Education				
No education	0.00223	1.85	0.00364	−3.03
Primary	−0. 00670***	−5.57	−0.01793*	14.89
Secondary	−0. 00569	−4.73	0.00378	−3.14
Higher	0.00241	−2.00	−0.00015	0.12
Wealth quintile				
Poorest	−0.00218	−1.81	0.02299**	19.10
Poorer	0.01464*	12.16	−0.01040	−8.64
Poor	0.00297	2.47	−0.00878	−7.29
Richer	−0.00294	−2.44	−0.00748**	−6.21
Richest	0.04304***	35.74	0.00194*	1.61
Occupation				
Not working	−0.00027	−0.23	−0.01306***	10.85
Working	−0.00027	−0.23	0.03056***	−25.38
Distance to health facility				
Not a big problem/no problem	−0.00957***	7.94	−0.00217	1.79
A big problem	−0.00957***	7.94	0.00197	−1.63
Sex of household head				
Male	−0.00042	−0.35	−0.01640*	13.61
Female	−0.00042	−0.35	−0.00414*	−3.44
Health insurance				
No	−0.00097	−0.81	−0.08356***	69.39

Continued

Table 6 Continued

Characteristics	Difference due to characteristics (E)		Difference due to coefficients (C)	
	Coefficient	Percentage (%)	Coefficient	Percentage (%)
Yes	−0.00097	−0.81	−0.00469***	−3.89

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

partners needs to be reconsidered in order to ensure that most children, if not all, are fully immunised. Further, a number of contexual factors may also account for this finding from Zimbabwe. For instance, the freezing of posts within the health sector of Zimbabwe has adversely affected management of Expanded Programme on Immunisation (EPI).[19] Primary Care Nurses who operate the health centres in rural locations are inadequate, possess limited skills and knowledge in EPI, and receive little payments which do not motivate them enough.[19] Besides, geographical access to health centres is a challenge to some women as some of them walk 30km to the nearest health facility. Intermittent shortage of essential medicines has also been reported as well as hesitancy and refusal by women.[19 20]

Since most of these 23 countries have health insurance schemes that are propoor and absorb immunisation cost,[21–24] it was anticipated that full immunisation will be generally high across the countries. Yet, the wide variation in full immunisation status is suggestive that context-specific factors sometimes transcend the 'cost component'. In Namibia, for instance, where most children were fully immunised (79.9%), evidence indicates that even mothers in rural locations are knowleageable about the implications of missed immunisation on their children and are willing to access vaccines for their children amidst transportation cost and other barriers.[25] Other countries with high proportion of fully immunised children such as Burundi benefit consistently from central government's commitment and funding from external bodies such as the GAVI Alliance and the Measles and Rubella Initiative.[26] These context-specific variations must, therefore, be appreciated by governments of sub-Saharan African countries and private entities aiming to improve full immunisation coverage in SSA.

The study revealed that factors contributing to this gap were maternal factors such as age, wealth quintile, occupation, distance to health facility and health insurance subscription. Birth order, however, was a child factor that made significant contribution towards the variation in full immunisation. The observed variation is not unexpected in light of the high concentration of health facilites and health personnel in urban locations across SSA. For instance, in the case of Sierra Leone, over 70% of surgeons are concetrated in the capital of the country, Freetown, and between 2005 and 2011, the doctor–patient ratio for the sectors hosting the capital rose from 0.07 to 0.12 per 1000 population. Within the same period, an increase from 0.03o to 0.05 occurred in the rural locations (eg, Koinadugu) per 1000 population.[27] Analogous observation was made for the patient–nurse ratio.[28] Similarly in Mali, 55% of healthcare providers operate within its capital of Bamako while the remaining 45% cater for the health needs of all persons outside the captial.[29]

Literature indicates that rural residents increasingly have significantly lower utilisation of public health services across several low-income and middle-income countries.[30 31] Ability of sub-Saharan African countries to mitigate this deep-seated rural–urban disparity may certainly address the current disparity and thereby enhance the prospects of SSA to achieve the 3.2 SDG target of plummeting under-five mortality to at worst 25 per 1000 live births, respectively.[5] A promising strategy in achieving this may be marshalling resources to knit childhood immunisation services with the primary healthcare concept in order for rural residents to access immunisation with the least setbacks such as covering long non-motorable distances and associated costs. This could motivate rural residents to ensure that their children obtain all the full immunisation doses within the recommended time frame.

Birth order of 6 or higher appeared to intensify the disparity in full immunisation status. This observation coincides with evidence from a recent study from Cameroon where through multinomial probit model, authors noticed that birth order has a negative and highly significant effect on full and timely childhood immunisation.[32] Maternal experience and information received by the women during antenatal care visits of their pervious births could partly account for this observation.[33] While first time mothers are less confident, and perceive themselves as requiring much support, a woman with multiple births may be less concerned about childhood ailments that have been exhibited by her child in the past.[34] Maternal health workforce of SSA may be able to neutralise this disparity by acknowledging that anxieties and maternal healthcare utilisation levels vary by parity. Among the numerous strategies to improve the situation include targeting and educating multiparous women to appreciate that all children who miss any dose of immunisation stand a chance of ill health conditions. This may serve as a cue or prompt for them to seek the full immunisation for all their children.

Full immunisation status was aligned with richest wealth status. Even in countries where health insurance and free maternal healthcare exist like Ghana,[35 36] women incur out of pocket expenses to cover transportation, laboratory and other services. Consequently, richest women have some leverage over poorest women.[37] Moreover, wealth is a pathway to empowerment[38] and it is well established

in the literature that once a woman is empowered, it is more probable that she will use maternal healthcare.[39 40] A poor woman may know and acknowledge the essences to get her child immunised in full, but her passion may remain a mirage if the requisite financial capacity is non-existent.

Distance to health facility was a significant indicator for disparity in full immunisation. After birth, a woman may require a substantial amount of time to recover and this period varies subject to a number of factors. For instance, a woman who underwent a caesarean section may require more time than a woman who had a normal vaginal birth.[41] Owing to these factors, covering a long distance to immunise one's child may be difficult for most women if not impossible. Distance has been noted as a cardinal determiner of maternal healthcare utilisation and in the perspective of Thaddeus, Maine,[42] it is the second leading delay leading to maternal and newborn ill health and deaths in low-income and middle-income countries as espoused in their three delays model.

Strengths and limitations

Findings from the study are supported by large datasets covering 23 countries in SSA. The data were gathered following a common internationally acceptable methodological procedure. Due to the representative nature of the survey, the findings are representative of included countries and generalisable to women of reproductive age. In spite of these strengths, the survey is cross-sectional in nature and as such causal inference cannot be made. Also, the sample size is generally not large for some of the countries and may allow for a wider CI for the prevalence of full immunisation.

CONCLUSION

The study has illustrated that rural–urban disparity in full childhood immunisation exist in favour of urban children. Factors that explain this partly include child's birth order, maternal age, wealth quintile, occupation and distance to health facility. Subregional, national and community-level interventions to obviate this disparity should taregt poorest women, distance to health facilities and women who are not working. Moreover, sub-Saharan African countries with very low full immunisation rate like Zimbabwe and Gabon may understudy countries with high coverage like Namibia and Gambia and adopt some of the interventions that have culminated in high full immunisation rate. However, much caution needs to be taken with respect to contexutal and cultural diversities.

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Provenance and peer review Not commissioned; externally peer reviewed.

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Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	#3	State specific objectives, including any prespecified hypotheses	5
Methods			

Study design	#4	Present key elements of study design early in the paper	5-8
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	n/a
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	5
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	n/a
Bias	#9	Describe any efforts to address potential sources of bias	n/a
Study size	#10	Explain how the study size was arrived at	5
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	n/a
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	7
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	n/a
Statistical methods	#12c	Explain how missing data were addressed	n/a
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	n/a
Statistical methods	#12e	Describe any sensitivity analyses	n/a

Results

Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	n/a
Participants	#13b	Give reasons for non-participation at each stage	n/a
Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	8
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	n/a
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	n/a
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-11
Main results	#16b	Report category boundaries when continuous variables were categorized	n/a
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	#18	Summarise key results with reference to study objectives	11-14
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14

Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	11-14
Generalisability	#21	Discuss the generalisability (external validity) of the study results	11-14
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	n/a