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A growing disadvantage of being born in an urban area? Analysing urban–rural disparities in neonatal mortality in 21 African countries with a focus on Tanzania

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ABSTRACT

Introduction Neonatal mortality rate (NMR) has been declining in sub-Saharan African (SSA) countries, where historically rural areas had higher NMR compared with urban. The 2015–2016 Demographic and Health Survey (DHS) in Tanzania showed an exacerbation of an existing pattern with significantly higher NMR in urban areas. The objective of this study is to understand this disparity in SSA countries and examine the specific factors potentially underlying this association in Tanzania.

Methods We assessed urban–rural NMR disparities among 21 SSA countries with four or more DHS, at least one of which was before 2000, using the DHS StatCompiler. For Tanzania DHS 2015–2016, descriptive statistics were carried out disaggregated by urban and rural areas, followed by bivariate and multivariable logistic regression modelling the association between urban/rural residence and neonatal mortality, adjusting for other risk factors.

Results Among 21 countries analysed, Tanzania was the only SSA country where urban NMR (38 per 1000 live births) was significantly higher than rural (20 per 1,000), with largest difference during first week of life. We analysed NMR on the 2015–2016 Tanzania DHS, including live births to 9736 women aged between 15 and 49 years. Several factors were significantly associated with higher NMR, including multiplicity of pregnancy, being the first child, higher maternal education, and male child sex. However, their inclusion did not attenuate the effect of urban–rural differences in NMR. In multivariable models, urban residence remained associated with double the odds of neonatal mortality compared with rural.

Conclusion There is an urgent need to understand the role of quality of facility-based care, including role of infections, and health-seeking behaviour in case of neonatal illness at home. However, additional factors might also be implicated and higher NMR within urban areas of Tanzania may signal a shift in the pattern of neonatal mortality across several other SSA countries.

Key questions

What is already known?

- Neonatal mortality rate (NMR) is declining in sub-Saharan Africa over time with rates generally lower in urban areas compared with rural (so-called ‘urban advantage’).
- On the 2015–2016 Demographic and Health Survey in Tanzania, neonatal mortality in urban areas was significantly higher compared with rural areas.

What are the new findings?

- After adjusting for available factors which could partly explain the urban–rural disparity in NMRs in Tanzania, urban residence remained a risk factor for higher neonatal mortality.
- This disparity appeared to be driven by early neonatal mortality (within 1 week of birth) which can be a result of poor quality of care.

What do the new findings imply?

- Further research is needed to understand whether this association is true and causal, or potentially a result of reporting bias.
- Patterns similar to Tanzania might be emerging in other countries (eg, Ghana, Uganda and Kenya) and need to be urgently investigated and addressed.

INTRODUCTION

Sub-Saharan Africa (SSA) has one of the highest levels of neonatal mortality in the world.[1] Neonatal mortality is the number of deaths during the first month of life per 1000 live births, and can be further divided into early neonatal mortality (death within the first 7 days) and late neonatal mortality (death between day 8 and day 28).[2 3] Globally, as mortality rates of children have declined more rapidly than those of neonates, the contribution of deaths during the neonatal period to the under-5 mortality rate has increased from

40% to 47% between 1990 and 2018.[1 4 5] The causes of early neonatal mortality and late neonatal mortality differ.[4] Most important causes of early neonatal deaths are prematurity, low birth weight and birth asphyxia, which is related to quality of intrapartum care, such as the facility and presence of a skilled birth attendant (SBA).[6–8] On the other hand, deaths in the late neonatal period are more likely to be caused by infectious diseases.[4 9] Such infections, whether nosocomial or community-acquired, are often preventable and treatable, but are intertwined with underlying vulnerabilities such as prematurity and factors related to poor maternal education, poverty, and access to water and sanitation facilities.[10–12]

Neonatal mortality rates (NMRs) vary between countries, but also within countries.[8 13–19] Historically, NMRs have been higher in rural areas when compared with urban areas in SSA, most likely due to lower healthcare provision and utilisation,[2 20] lower education and poorer housing conditions, and other issues such as poorer community-level infrastructure of water and electricity supply.[21] Recently, researchers have started questioning the so-called 'urban advantage' as evidence emerged on NMR declining more rapidly in rural settings thus narrowing the urban–rural differences.[22 23] Urban population growth in low resource countries is predominantly poverty-driven, with a large proportion of the urban population residing in slums.[24 25] Low levels of education among women, limited access to clean water, sanitation, good quality antenatal and intrapartum care, and poor air quality, all highly prevalent in urban settings and slums, link to poorer neonatal health outcomes.[10 26–30]

This study has two objectives: (1) to understand the trends over time in urban–rural differentials in NMR in SSA and (2) to identify the country with the most pronounced urban–rural differential in NMR, disadvantaging urban areas, and to examine whether this difference can be accounted for by known obstetric and socio-economic risk factors.

METHODS

Study design and data

This was a cross-sectional observational study consisting of two parts. First, we conducted a descriptive analysis of time trends in NMR made available through the Demographic and Health Survey (DHS) programme among SSA countries. The DHS are nationally representative household surveys capturing basic health and demographic indicators, including child and maternal health outcomes and health-seeking. We used the StatCompiler feature on the DHS website to extract NMR estimates for each available survey.[31] Tanzania was the country with the most pronounced urban/rural differences in NMR, showing a significant urban disadvantage in neonatal mortality. Second, we conducted an analysis of factors associated with neonatal mortality in Tanzania, using data from the most recent DHS collected in 2015–2016.[32] The Tanzania DHS was conducted by the National Bureau of Statistics, Dar es Salaam, Tanzania and ICF International, Maryland, USA. All variables used in this study were based on women's self-report.

Population

The study population included women aged 15–49 years at the time of survey who agreed to participate in the surveys. The inclusion criteria for countries for assessing the time trends included a minimum of four DHS surveys available, at least one of which took place in or before 2000 to ensure for a sufficiently long time period for changes to occur. Analysis of the Tanzania DHS included children born alive in the 5 years prior to the survey, if their mother was alive at the time of the interview and had a permanent residence in the sampled household (visitors were excluded).

Measures

Outcome

The main outcome of this study was neonatal mortality. While neonatal mortality is usually defined as deaths between birth and day 28, we also included deaths reported on day 29. This is due to the coding of the response in the DHS questionnaire and to remain consistent with the cut-off that the DHS reports use. We further assessed early (within the first 7 days of life, within which we separated deaths on the day of birth) and late (8–29 days, inclusive) neonatal mortality.

Risk factors

Type of residence was recorded as urban or rural, according to the DHS sampling frame definition. In Tanzania, urban areas were defined by the 2012 National Census and are inclusive of large and small cities and towns. Mode of delivery was defined as a caesarean section or a vaginal birth. Multiplicity of pregnancy was defined as singleton or multiple (twins, triplets, etc). Because of the relationship between birth order and preceding birth interval (first born children have no preceding birth interval), we created a combined variable capturing both; first child, second or third child with ≤24-month birth interval, second or third child with >24-month birth interval, fourth or higher order child with ≤24-month birth interval and fourth or higher order child with >24-month birth interval. Maternal age in years at time of birth was categorised into <20 years, 20–29, 30–39 and 40–49. Sex of child was male or female. The wantedness of the pregnancy was captured as whether the child was wanted at the time of the pregnancy, or not (ie, was wanted later or not wanted). Place of birth was categorised into home, lower level facility and hospital. Missing responses in place of birth, likely to be non-facility locations, were recoded as home births. Birth attendant was classified into an SBA or not. SBA was defined as doctor/assistant medical officer, clinical officer, assistant clinical officer or nurse/midwife. Household wealth quintile was used as a proxy for socio-economic status based on principal component analysis of the inventory of household assets.[32–34] Highest level of maternal education was categorised into three groups: (1) no education or incomplete primary, (2) completed primary or incomplete secondary and (3) completed secondary or higher education. Due to extensive missingness in the variable capturing newborn birth weight, we analysed this variable using a subsample of children weighed at birth (n=5987). We defined low birth weight as <2500 g, average birth weight as 2500–4000 g and fetal macrosomia as >4000 g.[35 36]

Data analysis

The total NMR and urban and rural NMRs of each country and survey with associated 95% CIs were plotted in Microsoft Excel to assess the trends and differences in urban and rural NMRs over time by country. We developed a classification of the 21 countries based on three dimensions: (1) national NMR level on the most recent survey (>30 per 1000 live births or lower), (2) change over time in national NMR (unchanging/increasing vs decreasing) and (3) urban–rural differences in NMR on most recent survey. The purpose of this classification was to understand whether there were any outliers in the 21 included countries, particularly in the direction and size of differences between urban and rural NMR on the most recent survey, and if so, whether such countries had different time trends in NMR compared with other countries. No statistical tests were performed in the analysis of time trends or urban–rural differentials other than an assessment of the overlap of 95% CIs as provided in the StatCompiler data.[31]

For the second objective, data analysis of the Tanzania 2015–2016 DHS birth recode file was carried out using STATA SE V.14. We used descriptive statistics and estimated early and late NMRs, by the main exposure of interest—urban and rural residence area. Next, we conducted bivariate (model 1) and multivariable (models 2 and 3) logistic regression, including an assessment of multicollinearity using Spearman's correlation coefficient (SCC) >0.7 as a threshold for collinearity. Model 2 included all variables which were risk factors for neonatal mortality based on bivariate analysis, the a priori variable of maternal age group, but excluded child's birth weight, due to substantial missingness. There was a high correlation between place of birth and SBA (SCC 0.847); we opted to retain place of birth. Model 3 was performed as a sensitivity analysis by repeating model 2 within a subsample of children who were reported as having been weighed at birth, and including category of birth weight as an independent risk factor. All analyses were adjusted for sampling weights, stratification and clustering within the cross-sectional study design, using the STATA command svyset. This study is reported according to the Strengthening the Reporting of Observational Studies in Epidemiology checklist for cross-sectional studies (online supplemental appendix S2).

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

RESULTS

NMRs in SSA countries

For the analysis of time trends in urban–rural differences in NMR in sub-Saharan African (SSA) countries, 21 countries met the inclusion criteria of DHS data availability. Graphs showing each country's time trends in urban and rural NMR are in online supplemental appendix S1. Within these 21 countries, we identified six broad categories of countries (table 1). Regardless of time trends, the most common category of countries in regard to urban–rural differences was one where the rural NMR estimate was higher than urban, but the 95% CIs overlapped. Only in two countries was rural NMR significantly higher than in urban areas (Guinea and Niger). On the other hand, the most recent DHS estimates of NMR in seven countries showed that the NMR in urban areas was higher compared with rural; but only in Tanzania did the CIs not overlap, indicating that urban NMR was significantly higher than rural NMR (figure 1).

Neonatal mortality in Tanzania

The NMR in Tanzania had been consistently higher in urban areas compared with rural areas since the 1999 DHS survey and this difference was significant on the most recent survey (figure 1). On the 2015–2016 survey, the national-level NMR was estimated at 24.9 per 1000 live

Table 1 Categorisation of included countries based on NMR time trends and recent NMR

Most recent survey Historical trend	Rural NMR higher than urban, overlapping CIs	Rural NMR significantly higher than urban	Urban NMR higher than rural, overlapping CIs	Urban NMR significantly higher than rural
Overall country NMR decreasing since first included survey (1990s)	Benin, Burkina Faso, Liberia, Madagascar, **Mali,** Namibia, Rwanda, Senegal	**Guinea,** Niger	Ghana, Ethiopia, Malawi, Uganda, Zambia	Tanzania
Overall country NMR unchanging or increasing since first included survey (1990s)	Cameroon, **Cote D'Ivoire, Nigeria,** Zimbabwe		Kenya	

Countries in bold have most recent NMR estimates >30 per 1000 live births. All other countries have levels in the range 20–30.
NMR, neonatal mortality rate.

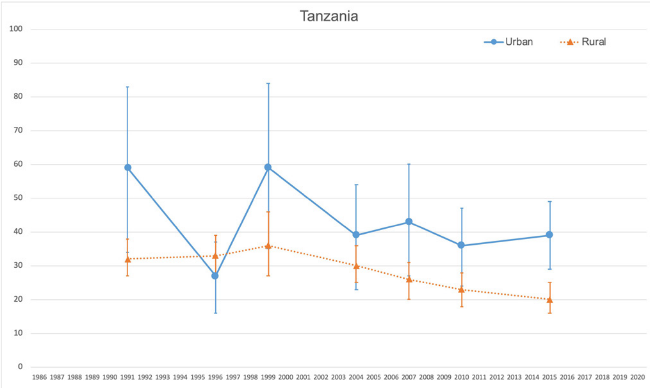

Figure 1 Time trends in neonatal mortality rate (per 1000 live births) from the Tanzania Demographic and Health Survey (DHS), by year of DHS.

births, higher in urban (37.8) compared with rural areas (20.2). We also assessed the distribution of the timing of death within the neonatal period as this is related to causes of death (table 2). The highest rates of neonatal mortality occurred between days 0–7 at 22 deaths per 1000 live births. Early neonatal mortality per 1000 live births was significantly higher in urban[32] compared with rural areas,[18] p=0.001. The level of late neonatal mortality was also twice as high in urban areas compares to rural (6 vs 3 per 1000 live births), but not significantly different (p=0.068), potentially due to the small sample size of deaths captured on the survey during this time period.

Association between area of residence and neonatal mortality in the 2015–2016 Tanzania DHS

In total, 9736 children born alive in the 5-year recall period of the survey were included in the analysis. The majority (72.9%) resided in rural areas (table 3). A higher percentage of births in urban areas were by caesarean section (1.9%) compared with in rural areas (3.4%). The location of births differed between urban and rural areas with higher percentages of hospital births in urban areas (61.5%) than in rural areas (20.7%). Furthermore, SBA present at birth was much higher in urban areas (86.0%) than in rural areas (51.8%). Newborns in urban areas were more likely to have been reported to be weighed at birth; 87.9% of urban mothers provided a recorded birth weight compared with 53.6% of mothers in rural areas. Mothers in urban areas had a higher level of education (secondary or higher) at 29.7%, compared with 8.0% in rural areas.

In crude logistic regression, the odds of neonatal mortality in urban areas was 1.88 times (p<0.001) higher than the odds in rural areas (table 4, model 1). In the fully adjusted model (model 2), type of residence remained significantly associated with neonatal mortality—urban residence was associated with a higher odds of neonatal mortality compared with rural (OR=1.94, p=0.006). In this model, SBA and place of birth were highly correlated; we retained only place of birth due to better validity of self-report compared with SBA. Other factors independently associated with higher odds of neonatal mortality were: multiplicity of pregnancy, being a first child, male sex of the baby and primary/incomplete secondary maternal education (compared with mothers with no/incomplete primary education, those with completed primary education had double the odds of reporting neonatal death). The effect of birth weight is shown on a subsample of 5987 children with this variable available (model 3). Within this model, the ORs of urban relative to rural remained similar to the full model (adjusted OR 2.06, p=0.024).

DISCUSSION

We assessed time trends of neonatal mortality in 21 SSA countries by urban and rural areas between 1990 and 2019. The analysis revealed that urban–rural disparities in NMR differ across countries, with most countries showing a narrowing of the urban–rural gap. Whereas in two countries, Guinea and Niger, rural NMR was still significantly higher than urban NMR, Tanzania is the one country that has a reverse pattern. While the NMR point estimate in urban areas had been higher than rural since 1999, it was significantly higher for the first time in the most recent DHS collected in 2015–2016. It is a result of continued decline in rural NMR over time, which was not matched by equal speed of decline in urban areas; a pattern seen in other SSA countries examined. We assessed potential explanatory factors of this twofold higher urban–rural difference in NMR in Tanzania, but found that even after inclusion of other risk factors, the odds of neonatal death remained 1.9–2.1 times higher in urban compared with rural areas. There could be three broad explanations for this finding: (1)

Table 2 Early, late and total neonatal mortality rate (NMR) on the 2015–2016 Tanzania Demographic and Health Survey and 95% CI, per 1000 live births

Indicator	Day of death	n deaths	National NMR	95% CI	Urban NMR	95% CI	Rural NMR	95% CI
Early NMR	Days 0–7	201	22	18 to 26	32	24 to 42	18	14 to 22
	Day 0	87	10	7 to 12	12	8 to 19	9	6 to 12
	Days 1–7	114	12	10 to 15	20	14 to 29	9	7 to 12
Late NMR	Days 8–29	42	4	2 to 5	6	3 to 10	3	2 to 5
Total NMR	Days 0–29	243	25	21 to 29	38	29 to 48	20	17 to 25

Table 3 Descriptive characteristics of sample of live births on Tanzania Demographic and Health Survey 2015–2016

	Total		Urban		Rural	
Children born within last 5 years	9736		2263		7473	
Neonatal deaths within last 5 years	243		77		166	
	n	*column %*	*n*	*column %*	*n*	*column %*
Residence						
Urban	2263	27.1				
Rural	7473	72.9				
Mode of delivery						
Vaginal	9222	94.3	2017	88.1	7205	96.6
Caeserean	514	5.7	246	11.9	268	3.4
Multiplicity						
No	9382	96.4	2183	95.9	7199	96.6
Yes	354	3.6	80	4.1	274	3.4
Birth order and preceeding birth interval (BI)						
First child	2216	24.1	673	30.7	1543	21.6
Second/third with ≤24-month BI	755	7.4	145	6.1	610	7.9
Second/third with >24-month BI	2426	26.2	813	37.0	1613	22.2
Fourth+with ≤24-month BI	1048	9.6	130	5.2	918	11.2
Fourth+with >24-month BI	3291	32.7	502	21.0	2789	37.1
Mother's age at time of birth (years)						
<20	1552	17.2	338	15.4	1214	17.9
20–29	4782	49.2	1219	53.9	3563	47.4
30–39	2864	28.6	630	27.7	2234	28.9
40–49	538	5.0	76	3.0	462	5.8
Sex of child						
Male	4812	50.8	1176	52.4	3736	50.1
Female	4824	49.2	1087	47.6	3737	49.9
Wanted pregnancy						
No	2969	30.6	748	33.3	2221	29.6
Yes	6767	69.4	1515	66.7	5252	70.4
Place of birth						
Home	3770	38.0	306	13.8	3464	47.0
Lower level facility	2866	30.2	542	24.7	2324	32.3
Hospital	3100	31.8	1415	61.5	1685	20.7
Skilled birth attendant present at birth						
No	3886	38.9	320	14.0	3566	48.2
Yes	5850	61.9	1943	86.0	3907	51.8
Household wealth index						
Poorest	2252	24.4	124	5.9	2128	31.3
Poorer	2002	21.3	57	2.2	1945	28.4
Middle	1887	19.1	147	5.5	1740	24.1
Richer	2013	18.6	738	32.9	1275	13.3
Richest	1582	16.6	1197	53.5	385	2.9
Mother's education (highest level completed)						
No education/incomplete primary	2114	21.1	204	9.2	1910	25.5
Primary	5904	65.0	1281	61.1	4623	66.5

Continued

Table 3 Continued

	Total		Urban		Rural	
Secondary or higher	1718	13.9	778	29.7	940	8.0
Child weighed at birth						
No	3749	37.1	283	12.1	3466	46.4
Yes	5987	62.9	1980	87.9	4007	53.6
Child's birth weight in grams (n=5987)						
Low (<2500 g)	422	6.9	139	7.2	283	6.7
Normal (2500–4000 g)	5186	86.7	1746	88.2	3440	85.7
Macrosomia (>4000 g)	379	6.4	95	4.6	284	7.6

it is a result of confounding (ie, important explanatory factors/confounders are not included, or insufficiently included, in the multivariable model); (2) the result is due to biased reporting of neonatal deaths (ie, that neonatal deaths are over-reported in urban areas and/or under-reported in rural areas) or some level of misclassification of the exposure to urban/rural environments and (3) that the NMR is truly higher in urban compared with rural areas. It is possible that several of these explanations are involved. The overarching question we raise in this paper is, if such difference truly exists in Tanzania, whether such pattern of higher NMR in urban areas is an indication of a phenomenon occurring also in other SSA countries. We focus on three potential explanations for the high estimated NMR in urban areas in Tanzania, with a view of understanding the drivers that could potentially contribute to such findings, and implications for further research and policy-making.

First, the urban–rural difference in NMR in Tanzania could not be explained by the available socioeconomic, pregnancy-related and sanitation measures, although some of these factors were independently associated with NMR (multiplicity of pregnancy, birth order and birth interval, older maternal age and male sex). The higher NMR in urban areas was largely driven by higher mortality rate of newborns between 1 and 7 days following birth. The most likely causes of death in this time period relate to the quality of intrapartum care. If our finding is true, the most likely contributing factors are quality of maternal and newborn care during the intrapartum period, followed by delays in care-seeking for babies with complications (whether born at home or those who developed symptoms after discharge from facility where they were born), and quality of care provided to sick newborns. The chance of being born in a hospital is three times as high for babies from urban compared with rural areas (62% vs 21%). Given the pressure exerted by population increase in urban areas on existing resources, particularly public health facilities providing care to the poor, it is possible that crowding, staff shortages, and lack of routine provision of essential care elements converge in such urban health facilities and contribute to increased risk of neonatal mortality.[37–39] Additionally, the risk of acquiring nosocomial infections within health facilities is particularly relevant to premature and low-birth newborns who are highly vulnerable to acquiring and dying from such infections.

As for the analyses in the subsample of babies weighed at birth, we report some nuances. If the babies were being weighed that means an SBA was probably present. However, the presence of an SBA did not necessarily decrease the risk of NMR. No distinction was made between SBA cadres, and the overall category SBA consists of varying levels of skilled health personnel including doctors, nurses, midwives and combinations of these providers within professional teams. Women tend to seek help at a healthcare facility more often when complications occur, which might explain our finding of nearly double risk of NMR associated with caesarean sections. In future studies, the reasons for women delivering in a healthcare facility or at home, incorporating the diversity of people involved/services provided by the different SBAs, needs to be disentangled.

Second, beyond individual health-seeking behaviour, obstetric risk factors, and quality of care, broader issues related to socioeconomic determinants, urban living conditions and urbanisation processes might also play a role in an increased risk of neonatal mortality in urban settings. Today, Tanzania is undergoing rapid urbanisation and Dar es Salaam is predicted to have over 10 million inhabitants by 2030, increasing from 2.3 million in 2000.[40] This growth is largely fuelled by rural–urban migration resulting in the lateral expansion of informal settlements and rapid expansion of rural trading centres amalgamating with other rural towns and nearby cities within Tanzania.[25] Where historically the urban population was better educated and had higher incomes compared with the rural population,[2 3] rapid urbanisation, including in peripheral towns, has led to haphazard informal settlements evident today, increasing the heterogeneity of the urban population[25] and exacerbating vulnerability through a complex interplay between urban conditions, health service provision, and suboptimal quality of care. For example, air pollution is worse in urban areas and is a risk factor for prematurity, which in turn is a risk factor for neonatal mortality in the absence of accessible, affordable high-quality care for sick/small newborns. Mapping urbanisation processes, and the consequences

Table 4 Logistic regression models

Model	1 Crude ORs n=9736 OR	95% CI	P value	2 Multivariable (except birth weight) n=9736 OR	95% CI	P value	3 Multivariable n=5987 OR	95% CI	P value
Residence									
Urban	1.88	1.34 to 2.62	<0.001	1.94	1.22 to 1.31	0.006	2.06	1.10 to 3.85	0.024
Rural	Reference			Reference			Reference		
Mode of Delivery									
Vaginal	Reference			Reference			Reference		
Caesarean	2.47	1.47 to 4.14	0.001	1.69	0.90 to 3.18	0.104	1.81	0.90 to 3.62	0.095
Multiplicity									
No	Reference			Reference			Reference		
Yes	5.56	3.19 to 9.72	<0.001	6.94	3.77 to 12.77	<0.001	2.50	1.23 to 5.09	0.011
Birth order and preceeding birth interval (BI)									
First child	2.07	1.36 to 3.15	0.001	2.43	1.47 to 4.01	0.001	1.59	0.86 to 2.97	0.142
Second/third with ≤24-month BI	1.20	0.57 to 2.52	0.625	1.53	0.75 to 3.23	0.253	1.39	0.59 to 3.26	0.454
Second/third with >24-month BI	Reference			Reference			Reference		
Fourth+with ≤24-month BI	1.49	0.83 to 2.65	0.179	1.84	0.97 to 3.44	0.058	1.76	0.71 to 4.36	0.224
Fourth+with >24-month BI	1.23	0.78 to 1.95	0.371	1.20	0.72 to 2.01	0.491	0.96	0.56 to 1.66	0.895
Mother's age at time of birth (years)									
<20	1.51	1.00 to 2.27	0.051	1.14	0.72 to 1.80	0.582	0.85	0.46 to 1.59	0.628
20–29	Reference			Reference			Reference		
30–39	0.94	0.63 to 1.41	0.777	1.09	0.71 to 1.66	0.704	0.94	0.56 to 1.55	0.804
40–49	1.97	0.92 to 4.20	0.079	2.39	1.13 to 5.06	0.023	0.79	0.22 to 2.77	0.707
Sex of child									
Male	1.5	1.09 to 2.13	0.017	1.59	1.14 to 2.23	0.007	1.94	1.32 to 2.85	0.001
Female	Reference			Reference			Reference		
Wanted pregnancy									
No	0.77	0.53 to 1.13	0.186						
Yes	Reference								
Place of birth									
Home	Reference			Reference			Reference		
Lower level facility	1.28	0.88 to 1.95	0.115	1.15	0.78 to 1.71	0.476	1.57	0.63 to 3.96	0.333
Hospital	1.75	1.18 to 2.61	0.006	1.10	0.68 to 1.76	0.703	1.53	0.59 to 3.94	0.378
Skilled birth attendant present at birth									
No	Reference								
Yes	1.53	1.08 to 2.20	0.019						
Household wealth index									
Poorest	Reference			Reference			Reference		
Poorer	1.44	0.87 to 2.50	0.159	1.50	0.90 to 2.49	0.118	1.11	0.53 to 2.36	0.778
Middle	1.09	0.64 to 1.90	0.764	0.93	0.53 to 1.61	0.785	0.70	0.34 to 1.45	0.338
Richer	1.76	1.02 to 2.90	0.034	1.05	0.61 to 1.80	0.873	0.88	0.45 to 1.71	0.703
Richest	1.93	1.12 to 3.39	0.017	1.00	0.53 to 1.89	0.999	0.83	0.39 to 1.79	0.637
Mother's education									
No education/ incomplete primary	Reference			Reference			Reference		
Primary	2.25	1.42 to 3.62	0.001	2.00	1.23 to 3.22	0.005	1.46	0.74 to 2.84	0.272
Secondary or higher	2.08	1.17 to 3.69	0.013	1.27	0.65 to 2.46	0.488	0.77	0.32 to 1.84	0.559

Continued

Table 4 Continued

Model	1 Crude ORs n=9736 OR	95% CI	P value	2 Multivariable (except birth weight) n=9736 OR	95% CI	P value	3 Multivariable n=5987 OR	95% CI	P value
Child weighed at birth									
No	Reference								
Yes	0.96	0.69 to 1.30	0.810						
Child's birth weight in grams (n=5987)									
Low (<2500 g)	6.08	3.81 to 9.71	<0.001				4.74	2.82 to 7.96	<0.001
Normal (2500–4000 g)	Reference						Reference		
Macrosomia (>4000 g)	1.82	0.95 to 3.52	0.072				1.92	0.97 to 3.80	0.061

P value of Wald test.

for sociodemographics and quality of care affecting population health need to be further examined in future research.[10 11 41] This can be done, for example, by examining whether a dose–response relationship exists between the extent of urbanisation and NMR in Tanzania and other countries at risk of reversing the urban advantage in neonatal survival, including Ghana, Ethiopia, Malawi, Uganda, Zambia and Kenya.

Third, the potential presence of bias needs to be considered. The characterisation of clusters as urban or rural on the DHS sampling strategy might not accurately capture the lived reality, especially if it based on historical census tract designations rather than on urbanicity at the time of survey. It is also possible that the higher NMR in urban areas in Tanzania can be partly explained by the under-reporting of neonatal death in rural areas; these deaths might have been misclassified as stillbirths or not reported at all.[42] However, the Tanzania DHS 2015–2016 results showed that also the perinatal mortality rate (stillbirths and early neonatal deaths per 1000 pregnancies of seven or more months' duration) was higher in urban (47) compared to rural areas (37). If this bias plays a role in the findings in our paper, it is therefore more likely to operate through under-reporting of perinatal deaths in rural areas rather than through differential misclassification of neonatal deaths as stillbirths. Lower levels of maternal education were more common in rural areas, and may contribute to underreporting neonatal deaths. This resonates with our finding that women with some education reported higher NMR than women without education. Furthermore, reporting of neonatal deaths in urban areas may be higher as more births take place with the presence of an SBA.[43] There is potential that recall bias is present and future studies should focus on the urban–rural differences in the combined phenomenon of perinatal mortality as both are critically linked to quality of intrapartum care. However, it seems implausible that bias would account for the entirety of the urban–rural difference in NMR in Tanzania, as this pattern, has been evident in the DHS data since 1999 and not just persisted but widened over time, while many of the socioeconomic characteristics giving rise to under-reporting and misclassifications have changed dramatically over the past 20 years.

Limitations

First, we limited our time trend analysis of SSA countries to those with DHS surveys, in order to maximise comparability. However, due to varying sample sizes over time, we see a volatility in the DHS NMR estimates in some countries. Our analysis of Tanzania benefited from a large sample size of births to examine a range of obstetric and neonatal factors, healthcare factors, child characteristics and distal factors previously linked to neonatal mortality, and which we hypothesised might be on the causal pathway between urban residence and neonatal mortality. The nature of the cross-sectional study design does not allow for causality to be inferred and self-reported nature of all variables, including neonatal mortality, was a further limitation. We found a large extent of missingness in birth weight, and had no data on gestational age and other important covariates, such as perception and accessibility of maternal and child health services, and quality of care within health facilities.[44 45] Finally, this study would have benefitted from a more nuanced, granular understanding of the extent of urbanicity in order to discuss the potential for causality in this association. We recommend that future studies (1) capture relevant distal and proximal factors potentially on the causal pathway (eg, quality of healthcare, exposure to air pollution) and (2) assess the extent of a dose–response relationship between NMR and increasing urban-nature of residence.[46]

CONCLUSION

The time series analysis of 21 SSA countries indicates that Tanzania is the first country in SSA to show a reversed pattern in the urban–rural difference in neonatal mortality, with levels of NMR in urban areas double those in rural. While we acknowledge the need for additional research to elucidate the causal pathways underlying this association, we also call for urgent action to address important gaps in access to high-quality childbirth and postnatal care in urban settings in Tanzania and SSA.

The high NMR rate in Tanzania (25 per 1000 live births) means that substantial changes are needed to achieve the SDG of 16 deaths per 1000 by 2030. However, the specific strategy to achieve this should consider separate approaches in urban vs rural areas. Further research should delve into the reporting of stillbirths, as underreporting and misclassification of perinatal deaths appears to be more prominent in rural areas. Accurate documentation of pregnancies and pregnancy outcomes could address differential self-reporting of stillbirths between the areas. Finally, this study highlights the shifting burden in neonatal mortality, from rural to urban areas. If this pattern is true and causal, we would expect that other SSA countries such as Ghana, Ethiopia, Malawi, Uganda, Zambia and Kenya are at risk of this phenomenon.

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