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Predictors of Hospitalization During the First Year of Life among 31 999 Tanzanian Infants

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ABSTRACT

Objective: This study explored the risk factors for infant hospitalization in urban and peri-urban/rural Tanzania.

Methods: We conducted a prospective cohort study examining predictors of hospitalization during the first year of life among infants enrolled at birth in a large randomized controlled trial of neonatal vitamin A supplementation conducted in urban Dar es Salaam ($n = 11\,895$) and peri-urban/rural Morogoro region ($n = 20\,104$) in Tanzania. Demographic, socioeconomic, environmental and birth outcome predictors of hospitalization were assessed using proportional hazard models.

Results: The rate of hospitalization was highest during the neonatal period in both Dar es Salaam (102/10 000 neonatal-months) and Morogoro region (78/10 000 neonatal-months). Hospitalization declined with increased age and was lowest for infants 6–12 months of age in both Dar es Salaam (11/10 000 infant-months) and Morogoro region (16/10 000 infant-months). In both Dar es Salaam and Morogoro region, older maternal age, male sex, low birth weight and being small for gestational age were significant predictors of higher risk of hospitalization ($p < 0.05$). Increased wealth and having a flush toilet were significantly associated with an increased risk of hospitalization in Morogoro region only ($p < 0.05$).

Conclusions: This study determined high rates of neonatal hospitalization in Tanzania. Interventions to increase birth size may decrease risk of hospitalization. Equity in access to hospitals for poor rural families in Tanzania requires attention.

KEYWORDS: hospitalization, neonatal, infancy, morbidity, Tanzania.

INTRODUCTION

In 2013 an estimated 6.3 million children <5 years of age died worldwide, of which an estimated 44% of deaths occurred during the neonatal period [1]. The three leading causes of child death globally are preterm birth complications, pneumonia and intrapartum-related complications; preterm and intrapartum complications often require complex hospital care [2]. Therefore sufficient access to and utilization of health-care services is crucial for significant

improvement of child survival in resource-limited settings [3, 4].

Despite the importance of access to health-care services in resource-limited settings for improving child survival, relatively few population-based studies have investigated risk factors for infant hospitalization. Numerous hospital-based case-series have been published in African settings, which present data on causes of hospitalization and other patient characteristics [5–8]; however, these studies do not allow for calculation and analysis of hospitalization rates at the population level. Few prospective cohort studies of infant hospitalization have been conducted in sub-Saharan Africa [6].

To better understand risk factors for hospitalization in urban and rural settings in sub-Saharan Africa, we conducted a large prospective cohort study among 31 999 infants enrolled in a randomized double-blinded neonatal vitamin A supplementation trial conducted in urban Dar es Salaam and peri-urban/rural (Morogoro region) Tanzania. We examined environmental, sociodemographic and delivery predictors, in addition to investigating potential effect modification by study region.

METHODS

Study design

This study uses prospective cohort data from an individually randomized, double blind, placebo controlled trial of vitamin A supplementation of newborns. Both the protocol and main findings of the controlled trial have been described elsewhere [9, 10]. Briefly, the parent trial was conducted in Dar es Salaam and Morogoro region Tanzania between August 2010 and March 2014 [10]. The population of Dar es Salaam metro area is approximately 4.3 million people, and Morogoro region catchment area is ~400 000. The 2010 Tanzania Demographic and Health Survey estimated a similar infant mortality rate among live births in urban (63 per 1000) and rural areas (60 per 1000) of Tanzania [11].

In Dar es Salaam, pregnant women were identified either during regular antenatal visits or in the labor wards of 10 large clinics and screened for trial enrollment. In Morogoro region, all births within the Ifakara Health Institute's health and demographic surveillance system that were identified during home visits or at designated labor wards were screened for enrollment. Newborn babies were eligible if they were able to feed orally, if the family intended to stay in the study area for at least 6 months and if parents provided written informed consent to participate.

Data collection

A total of 31 999 infants enrolled in the parent trial formed the sample for this study. Trained study staff administered a baseline questionnaire to collect information on demographic, socioeconomic and environmental information as reported by the mother or caregiver of the infant, as well as date of mother's last menstrual period. At randomization, study staff measured birth weight using calibrated scales with digital screens for all infants. Follow-up home visits were conducted at 1, 3, 6 and 12 months after birth during which field interviewers collected data on infant vital status and any morbidity that resulted in hospital admission since the last visit.

Risk factors and outcome definitions

The demographic, socioeconomic and environmental predictors of hospitalization included: location of residence (Dar es Salaam or Morogoro region), maternal age, maternal and paternal education, wealth index quintile, water source and waste disposal. Maternal and paternal education was categorized into no formal school (zero years), some primary (<7 years), completed primary (7 years) and secondary plus (>7 years). Wealth index quintile was defined by a principal component analysis of household assets and characteristics [12]. Water source quality was dichotomized as unimproved or improved based on the World Health Organization (WHO) Joint Monitoring Programme definition [13]. Waste disposal was categorized by flush toilet or no flush toilet.

Delivery predictors of hospitalization that were examined included: sex of infant, multiple births, parity, birth weight, gestational age and size for gestational. Birth weight was categorized as <2000 g, 2000–2500 g and >2500 g and preterm birth was defined as <37 completed weeks of gestation based on maternal report of the last menstrual period [14]. Small for gestational age was defined as birth weight

<10th percentile for gestation age and sex using International Fetal and Newborn Growth Consortium (INTERGROWTH) standards [15].

Infant hospitalization was recorded by study staff during follow-up visits and defined as infant admitted to the hospital since last follow-up visit. Date of admission, length of hospital stay and symptoms present at admission were recorded from either the child health card or from caregiver's accounts.

Statistical analysis

Proportional hazard models were used to assess risk factors for hospitalization [16]. We employed a two-stage analysis plan for all multivariate models to avoid adjustment for potential mediators of the relationship between exposure and outcome, as this can result in biased results [17]. The first stage of the multivariate model included sociodemographic and environmental risk factors, which may be associated with hospitalization by way of adverse birth outcomes like small birth size. The second model examined delivery-related predictors of hospitalization, and included adjustment for all sociodemographic and environmental predictors in the first stage of the analysis.

We included multivariate models of delivery predictors for either only birth weight, or both preterm birth and small for gestational age. To assess whether the relationship of a particular predictor with hospitalization varied by study site, we used interaction terms, and statistical significance of the interaction was determined by the likelihood ratio test. If significant interaction of a predictor and study site was identified in multivariate models ($p < 0.05$), then crude and multivariate models for the predictor were presented stratified by study site. Subjects who were not hospitalized were censored at the date of last follow-up visit. Missing data for covariates were retained in the analysis, using the missing indicator method for variables. As a sensitivity analysis, we present multivariate estimates of hospitalization restricted to singletons in Table A2 owing to the potential for different relationships of risk factors with the outcome among multiple births. *P*-values for trend in categorical analyses were calculated by treating the median value of each maternal age or birth interval category as a continuous variable. All *p*-values were two sided, and a *p*-value of < 0.05 was considered statistically significant. Statistical analyses were performed using the SAS v 9.4 (SAS Institute, Cary, NC).

Ethical approval

The institutional review boards of the Harvard School of Public Health, Ifakara Health Institute, National Medical Research Coordinating Council of Tanzania and the WHO Ethical Review Committee approved the study protocol. Individual informed consent was sought for all participants.

RESULTS

Baseline characteristics of the study cohort, stratified by study location are presented in Table 1. Of the total 31 999 infants enrolled, 20 104 were from Morogoro region and 11 853 from Dar es Salaam. The mean (±SD) age of mothers in Morogoro region was 25.9 ± 6.1 years and in Dar es Salaam 26.0 ± 5.6 years. The main source of water in Morogoro region was borehole/tube well (30.1%), while in Dar es Salaam it was piped home (41.0%). For both Dar es Salaam and Morogoro region, latrine/dry toilet was the main source of waste disposal (79.2 and 70.2%, respectively). A higher proportion of infants in Morogoro region were small for gestational age—19.1% compared with 13.9% in the Dar es Salaam sample.

In total there were 1214 hospitalizations among the combined Dar es Salaam and Morogoro region sample: 1143 first hospitalizations and 71 re-hospitalizations. The rate of hospitalizations was highest during the neonatal period (<28 days) in both urban Dar es Salaam (102/10 000 person-months) and Morogoro region (78/10 000 person months). The rate of hospitalization was lowest from 6 to 12 months of age in both Dar es Salaam (11/10 000 person-months) and Morogoro region (16/10 000 person-months). See Figure 1 for a bar graph of the hospitalization rate stratified by study site, infant sex and age. The median duration of hospitalization was 3 days (interquartile range: 2–5 days). A similar proportion of caregivers reported diarrhea and respiratory symptoms were present at the time of hospitalization in Dar es Salaam (74.9% diarrhea and 65.9% respiratory symptoms) and Morogoro region (79.0% diarrhea and 68.9% respiratory symptoms). In Dar es Salaam, the proportion of cases reporting

Table 1. Baseline cohort characteristics stratified by Dar es Salaam and Morogoro regions, Tanzania

	Dar es Salaam ($n = 11\,895$) *N* (%) or mean (SD)	Morogoro Region [$n = 20\,104$] *N* (%) of mean (SD)
Maternal age (years)	26.0 ± 5.6	25.9 ± 6.1
Maternal education		
No formal schooling	478 (4.7)	2131 (10.9)
Some/completed primary	7904 (78.3)	16 115 (82.7)
Secondary and advanced	1703 (17.0)	1246 (6.4)
Paternal education		
No formal schooling	197 (2.0)	1234 (6.3)
Some/completed primary	7096 (70.2)	16 347 (83.8)
Secondary and advanced	2820 (27.9)	1917 (9.8)
Water source		
Piped home	4051 (41.0)	4086 (20.9)
Public tap	3869 (39.2)	5144 (26.3)
Borehole/tube well	1244 (12.6)	5887 (30.1)
Closed well	513 (5.2)	613 (3.1)
Open well	181 (1.8)	3475 (17.8)
Surface water	18 (0.1)	348 (1.8)
Waste disposal		
Flush toilet	3052 (29.7)	3712 (19.0)
No flush toilet	7235 (70.3)	15 859 (81.0)
Infant sex		
Male	6073 (51.1)	10 710 (53.3)
Female	5815 (48.9)	9396 (46.7)
Multiple birth		
Twin/triplet	437 (3.7)	671 (3.3)
Singleton	11 456 (96.3)	19 435 (96.7)
Parity		
First born	2749 (30.6)	4966 (28.8)
2nd–4th birth	5527 (61.4)	9225 (53.4)
5th birth or greater	719 (8.0)	3065 (17.8)
Birth weight		
≤2000 g	112 (0.94)	163 (0.81)
2000–2500 g	942 (7.9)	2665 (13.3)
>2500 g	10 841 (91.1)	17 276 (85.9)
Preterm <37 weeks[a]	1477 (18.0)	1761 (15.0)
Small for gestational age[a] (<10th percentile)	1196 (14.5)	2288 (19.5)

[a]Gestational age was available for 8228 births in Dar es Salaam and 11 749 in Morogoro.

fever (65.6%) was significantly higher as compared with Morogoro region (45.0%) ($p < 0.01$).

Crude and adjusted analyses for predictors of hospitalization which were not significantly different by study site are presented in Table 2. Older maternal age was significantly associated with hospitalization in both crude (*p*-value for trend: 0.04) and multivariate models (*p*-value for trend: 0.04). Infants whose

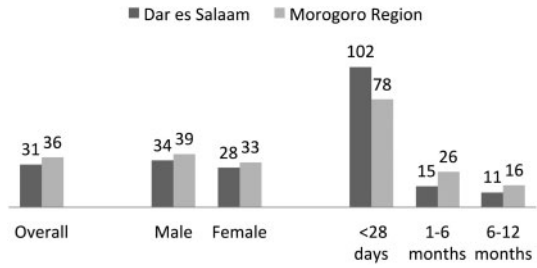

Fig. 1. Hospitalization rate per 10 000 child-months in Dar es Salaam and Morogoro region stratified by sex and age.

fathers did not complete primary school had significantly increased hazard of hospitalization as compared with infants whose father completed primary school [multivariate hazard ratio (HR): 1.35; 95% confidence interval (CI): 1.06–1.73; $p = 0.02$]. In multivariate models, male sex was associated with 17% increased hazard of hospitalization as compared with females (HR: 1.17; 95% CI: 1.04–1.32; $p < 0.01$). Birth weight <2000 g (HR: 2.70; 95% CI: 1.77–4.14; $p < 0.01$) and small for gestational age infants (multivariate HR: 1.26; 95% CI: 1.05–1.50; $p = 0.01$) also had significantly increased risk of hospitalization. There was no significant association between maternal education, water source, parity or preterm birth and infant hospitalization. In crude analysis, twins and triplets had significantly increased risk of hospitalization ($p < 0.01$); however, after adjustment for birth size in multivariate models, there was no significant excess hazard of hospitalization for multiple births ($p = 0.82$). These risk factors were not modified by study site (Table A1).

Crude and adjusted analyses for predictors of hospitalization, which were significantly modified by study site, are presented in Table 3 (p-value for interaction: <0.05). In Dar es Salaam, there was no association between wealth quintile and hospitalization in crude (p-value for trend: 0.57) or adjusted models (p-value for trend: 0.22). On the contrary, in Morogoro region, increased wealth was associated with a greater hazard of hospitalization in crude (p-value for trend: <0.01) and multivariate (p-value for trend: <0.01) models (p-value for interaction: 0.01). In addition, there was no significant association between sanitation method and hospitalization in Dar es Salaam after multivariate adjustment ($p = 0.61$), whereas in Morogoro region, not having a flush toilet was associated with decreased hazard of hospitalization in crude (p-value < 0.01) and multivariate (p-value < 0.01) analyses (p-value for interaction: <0.01). As a sensitivity analysis, the primary analysis stratified by site and restricted to singletons is presented in Table A2. There was no difference in the magnitude of associations for analyses including vs. excluding multiple births.

DISCUSSION

In this large, prospective cohort study of 31 999 infants in Dar es Salaam and Morogoro region in Tanzania, the risk of hospitalization during the first year of life was highest during the neonatal period and dramatically declined after the neonatal period. In both Dar es Salaam and Morogoro region, older maternal age, male sex, low birth weight and small for gestational age infants had increased risk of hospitalization. Increased wealth and having a flush toilet were significantly associated with an increased risk of hospitalization in Morogoro region, but this relationship was not present in Dar es Salaam.

We found infants with older mothers had an increased risk of being hospitalized. This may be because older mothers are more willing to seek hospital care for their children as compared with young and relatively inexperienced mothers. While some research supports this [18], a recent study in the urban slums of Nairobi found mothers >35 years of age were 49% less likely to seek care for infants as compared with mothers <20 years of age [19]. Context-specific factors may help explain the varied findings for the influence of maternal age and experience on health-care seeking behaviors in sub-Saharan Africa. Increased maternal age >35 years is also associated with poor obstetric outcomes such as preterm delivery and low birth weight, which may provide a biological explanation for our findings [20, 21].

We also found being male had an increased risk of hospitalization. This finding suggests that families may be more willing to seek care or use resources for male infants; some cultural norms place higher value on male children, which has been shown to increase health-care seeking for male children [22–25]. Alternatively, males may have an increased risk of hospitalization because they have poorer health as

Table 2. Predictors of hospitalization among infants in Dar es Salaam and Morogoro regions, Tanzania

	No. hospitalizations/ no. subjects (%)	Crude HR (95% CI)	*p*-value	Multivariate HR (95% CI)	*p*-value	*p*-value for interaction by site
Maternal age						
<20 years	169/4987 (3.4)	0.83 (0.68–1.01)		0.84 (0.70–1.02)		
20–25 years	314/9201 (3.4)	0.92 (0.79–1.07)		0.92 (0.79–1.08)		
25–30 years	323/8.597 (3.8)	Ref.		Ref.		
30–35 years	192/5380 (3.6)	0.95 (0.80–1.14)		0.94 (0.79–1.11)		
≥35 years	87/2070 (4.2)	1.07 (0.87–1.32)	0.04[a]	1.12 (0.89–1.42)	0.04[a]	0.68
Maternal education						
No formal schooling	78/2609 (3.0)	0.81 (0.64–1.02)	0.08	0.92 (0.72–1.18)	0.52	
Some primary	65/2273 (2.9)	0.78 (0.60–1.00)	0.05	0.78 (0.60–1.02)	0.08	
Completed primary	800/21 719 (3.7)	Ref.		Ref.		
Secondary plus	122/2949 (4.1)	1.13 (0.93–1.37)	0.21	1.07 (0.86–1.32)	0.55	0.56
Paternal education						
No formal schooling	30/1431 (2.1)	0.58 (0.40–0.84)	<0.01	0.70 (0.48–1.03)	0.07	
Some primary	75/1744 (4.3)	1.21 (0.96–1.54)	0.11	1.35 (1.06–1.73)	0.02	
Completed primary	779/21 699 (3.6)	Ref.		Ref.		
Secondary plus	183/4747 (3.9)	1.08 (0.92–1.27)	0.34	0.98 (0.81–1.17)	0.80	0.94
Water source category						
Unimproved	137/4439 (3.1)	0.83 (0.70–1.00)	0.05	1.02 (0.84–1.23)	0.88	0.78
Improved	936/25 409 (3.7)	Ref.		Ref.		
Infant sex						
Male	521/15 467 (3.4)	1.17 (1.04–1.32)	<0.01	1.17 (1.04–1.32)	<0.01	0.42
Female	622/16 532 (3.8)	Ref.		Ref.		
Multiple birth						
Twin/triplet	56/1108 (5.1)	1.51 (1.16–1.98)	<0.01	1.07 (0.74–1.54)	0.72	0.82
Singleton	1087/30 891 (3.5)	Ref.		Ref.		
Parity						
First born	254/7715 (3.3)	0.91 (0.78–1.06)	0.21	0.94 (0.79–1.11)	0.44	
2nd–4th birth	538/14 752 (3.6)	Ref.		Ref.		
5th birth or greater	120/3692 (3.3)	0.85 (0.70–1.04)	0.12	0.82 (0.66–1.02)	0.07	0.33
Birth weight						
≤2000 g	25/275 (9.1)	2.98 (2.00–4.44)	<0.01	2.70 (1.77–4.14)	<0.01	0.95
2001–2500 g	138/3607 (3.8)	1.11 (0.93–1.33)	0.25	1.05 (0.87–1.26)	0.64	
>2500 g	980/28 101 (3.5)	Ref.		Ref.		
Gestational age						
Preterm (<37 weeks)	93/3174 (2.9)	0.71 (0.57–0.88)	<0.01	0.80 (0.64–1.00)	0.05	0.54
Term ≥ 37 weeks	679/16 739 (4.1)	Ref.		Ref.		
Small for gestational age						
Yes	174/3350(5.2)	1.40 (1.18–1.67)	<0.01	1.26 (1.05–1.50)	0.01	0.50
No	598/16 493 (3.6)	Ref.		Ref.		

[a]*p*-value for trend.

Table 3. Crude and multivariate adjusted HRs for hospitalization which were significantly modified by study site

	No. hospitalizations/ no. subjects (%)	Crude HR (95% CI)	*p*-value	Adjusted HR (95% CI)	*p*-value	*p*-value for interaction by site
Dar es Salaam						
Wealth quintile						
Q1 (poorest)	46/1652 (2.8)	Ref.		Ref.		
Q2	67/2423 (2.8)	0.97 (0.67–1.42)		0.97 (0.67–1.42)		
Q3	53/1761 (3.0)	1.03 (0.69–1.53)		1.02 (0.68–1.52)		
Q4	101/3066 (3.3)	1.14 (0.81–1.62)		1.12 (0.78–1.61)		
Q5 (wealthiest)	37/1317 (2.8)	0.98 (0.63–1.50)	0.57[a]	0.96 (0.61–1.50)	0.22[a]	0.01
Waste disposal						
No flush toilet	94/3052 (3.1)	0.94 (0.74–1.20)	0.61	0.96 (0.74–1.23)	0.61	<0.01
Flush toilet	238/8843 (2.7)	Ref.		Ref.		
Morogoro Region						
Wealth quintile						
Q1 (poorest)	133/4051 (3.3)	Ref.		Ref.		
Q2	130/4433 (2.9)	0.89 (0.70–1.14)		0.89 (0.70–1.14)		
Q3	140/3303 (4.2)	1.29 (1.02–1.64)		1.14 (0.89–1.45)		
Q4	167/3866 (4.3)	1.32 (1.05–1.66)		1.15 (0.91–1.46)		
Q5 (wealthiest)	214/3901 (5.5)	1.69 (1.36–2.10)	<0.01[a]	1.23 (0.96–1.57)	0.03[a]	0.01
Waste disposal						
No flush toilet	525/15 334 (3.3)	0.49 (0.43–0.58)	<0.01	0.56 (0.47–0.67)	<0.01	<0.01
Flush toilet	246/3712 (6.6)	Ref.		Ref.		

[a]*p*-value for trend.

compared with females. Studies have found that that male neonates have less mature lungs as compared with females at the same gestational age, and are at greater risk of birth asphyxia and delivery complications [26, 27]. A recent study in Nepal also found male neonates were at 20% greater risk of early mortality as compared with female neonates [25].

The relationship between wealth and the risk of hospitalization was significantly different between the two study sties. In Morogoro region, wealthier families were more likely to have their infants hospitalized, whereas in Dar es Salaam, there was no relationship between wealth and hospitalization. Sanitation facilities related to wealth, such as having a flush toilet, were also associated with increased hospitalizations in Morogoro region, but not in Dar es Salaam. While previous studies in Tanzania [28] and Kenya [19, 29] have also shown that wealthier families are more likely to seek care, no comparisons between rural and urban were made. Our finding that wealthier families in Morogoro region hospitalize their infants at higher rates than poorer families suggests that in rural areas poverty may be an important barrier to health-care access. Decreasing hospital fees or providing reduced transportation costs for poor, rural families may help mitigate this barrier to equity in hospital access.

Lastly, we found birth size was a significant predictor of hospitalization during the first year of life in both Dar es Salaam and Morogoro region. As corroborated with a number of other studies [5–7, 30, 31], low birth weight and being small for gestational age are associated with an increased risk of hospitalization, likely owing to higher probability and severity of morbidity resulting from complications associated with being born small or premature.

Interventions that increase birth size may therefore have significant effects on reducing severe neonatal and infant morbidity and decrease hospitalization rates.

There are a few limitations to our study. First, the parent trial excluded newborns that were unable to feed orally at birth and thus some neonates with a potentially high risk of morbidity and mortality were not included in our cohort, although only 38 newborns were excluded for this reason. Another limitation is that we did not collect other known predictors of hospitalization such as distance to nearest health facility, which may be an important factor in Morogoro region [32].

CONCLUSION

This study contributes to our understanding of the predictors of hospitalization during the first year of life in sub-Saharan Africa. Interventions to increase birth size may decrease the risk of hospitalization and equity in access to hospitals for poor rural families in Tanzania requires attention.

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Table A1. Crude and adjusted predictors of hospitalization during the first year of life stratified by Dar es Salaam and Morogoro region, Tanzania

	Dar es Salaam Crude HR (95% CI)	*p*-value	Dar es Salaam Adjusted HR (95% CI)	*p*-value	Morogoro Region Crude HR (95% CI)	*p*-value	Morogoro Region Adjusted HR (95% CI)	*p*-value
Maternal age								
<20 years	0.83 (0.55–1.26)		0.79 (0.52–1.21)		0.79 (0.63–0.98)		0.82 (0.65–1.03)	
20–25 years	1.02 (0.78–1.33)		0.98 (0.74–1.29)		0.89 (0.74–1.06)		0.88 (0.4–1.06)	
25–30 years	Ref.		Ref.		Ref.		Ref.	
30–35 years	1.17 (0.86–1.60)		1.01 (0.65–1.56)		0.86 (0.69–1.06)		0.85 (0.65–1.11)	
≥35 years	1.24 (0.78–1.95)	0.09	1.13 (0.75–1.70)	0.09	1.03 (0.78–1.35)	0.11	1.01 (0.79–1.29)	0.37
Maternal education								
No formal schooling	0.71 (0.38–1.34)	0.30	0.72 (0.38–1.37)	0.30	0.79 (0.61–1.01)	0.06	0.97 (0.74–1.28)	0.84
Some primary	0.94 (0.50–1.77)	0.85	0.90 (0.47–1.72)	0.85	0.71 (0.54–0.94)	0.01	0.77 (0.58–1.02)	0.07
Completed primary	Ref.		Ref.		Ref.		Ref.	
Secondary and advanced	1.06 (0.79–1.43)	0.16	1.07 (0.78–1.49)	0.16	1.36 (1.05–1.74)	0.02	1.06 (0.81–1.40)	0.67
Paternal education								
No formal schooling	0.70 (0.26–1.88)	0.48	0.77 (0.28–2.10)	0.48	0.54 (0.37–0.81)	<0.01	0.68 (0.45–1.04)	0.07
Some primary	1.36 (0.70–2.64)	0.37	1.45 (0.73–2.85)	0.37	1.14 (0.88–1.47)	0.32	1.33 (1.02–1.74)	0.03
Completed primary	Ref.		Ref.		Ref.		Ref.	
Secondary and advanced	1.03 (0.80–1.32)	0.84	0.97 (0.39–2.42)	0.84	1.32 (1.06–1.63)	0.01	0.98 (0.77–1.25)	0.89
Wealth quintile								
Q1 (poorest)	Ref.		Ref.		Ref.		Ref.	
Q2	0.97 (0.67–1.42)		0.96 (0.66–1.40)		0.89 (0.70–1.14)		0.89 (0.70–1.14)	
Q3	1.03 (0.69–1.53)		1.01 (0.67–1.50)		1.29 (1.02–1.64)		1.14 (0.89–1.45)	
Q4	1.14 (0.81–1.62)		1.10 (0.77–1.59)		1.32 (1.05–1.66)		1.15 (0.91–1.46)	
Q5 (wealthiest)	0.98 (0.63–1.50)	0.57	0.92 (0.59–1.44)	0.57	1.69 (1.36–2.10)	<0.01	1.23 (0.96–1.57)	0.03
Water source category								
Unimproved	1.08 (0.68–1.71)	0.76	1.07 (0.67–1.71)	0.76	0.74 (0.61–0.90)	<0.01	0.99 (0.81–1.23)	0.99
Improved	Ref.		Ref.		Ref.		Ref.	
Waste disposal								
No flush toilet	0.94 (0.74–1.20)	0.61	0.96 (0.74–1.23)	0.61	0.49 (0.43–0.58)	<0.01	0.56 (0.47–0.67)	<0.01
Flush toilet	Ref.		Ref.		Ref.		Ref.	

Continued

Table A1. Continued

	Dar es Salaam Crude HR (95% CI)	*p*-value	Dar es Salaam Adjusted HR (95% CI)	*p*-value	Morogoro Region Crude HR (95% CI)	*p*-value	Morogoro Region Adjusted HR (95% CI)	*p*-value
Infant sex								
Male	1.10 (0.88–1.36)	0.41	1.10 (0.89–1.38)	0.41	1.20 (1.04–1.38)	0.01	1.20 (1.05–1.39)	<0.01
Female	Ref.		Ref.		Ref.		Ref.	
Multiple birth								
Twin/triplet	1.13 (0.65–1.97)	0.66	1.05 (0.50–2.18)	0.66	1.70 (1.25–2.31)	<0.01	1.02 (0.62–2.31)	0.93
Singleton	Ref.		Ref.		Ref.		Ref.	
Parity								
First born	0.91 (0.70–1.19)	0.50	0.99 (0.72–1.36)	0.50	0.90 (0.76–1.08)	0.27	0.92 (0.75–1.13)	0.42
2nd–4th birth	Ref.		Ref.		Ref.		Ref.	
5th birth or greater	1.17 (0.78–1.76)	0.02	1.18 (0.76–1.82)	0.02	0.77 (0.61–0.96)	0.02	0.79 (0.62–1.01)	0.06
Birth weight								
≤2000 g	2.63 (1.24–5.56)	0.01	2.77 (1.23–6.21)	0.01	3.16 (1.98–5.04)	<0.01	2.74 (1.66–4.54)	<0.01
2001–2500 g	1.02 (0.69–1.53)	0.91	1.06 (0.70–1.60)	0.91	1.09 (0.89–1.33)	0.41	1.05 (0.85–1.29)	0.66
>2500 g	Ref.		Ref.		Ref.		Ref.	
Gestational age								
Preterm (<37 weeks)	0.69 (0.47–1.02)	0.07	0.73 (0.49–1.08)	0.07	0.75 (0.57–0.96)	0.03	0.85 (0.65–1.11)	0.24
Term ≥ 37 weeks	Ref.		Ref.		Ref.		Ref.	
Small for gestational age								
Yes	1.31 (0.94–1.86)	0.11	1.27 (0.89–1.81)	0.11	1.37 (1.13–1.67)	<0.01	1.24 (1.01–1.51)	0.04
No	Ref.		Ref.		Ref.		Ref.	

Table A2. Multivariate adjusted predictors of hospitalization during the first year of life restricted to singleton births

	Dar es Salaam Adj. HR (95% CI)	*p*-value	Morogoro Region Adj. HR (95% CI)	*p*-value
Maternal age				
<20 years	0.82 (0.54–1.25)		0.85 (0.68–1.06)	
20–25 years	1.00 (0.75–1.33)		0.92 (0.76–1.11)	
25–30 years	Ref.		Ref.	
30–35 years	1.00 (0.65–1.55)		0.89 (0.73–1.10)	
≥35 years	1.19 (0.79–1.79)	0.10	1.12 (0.85–1.47)	0.17
Maternal education				
No formal schooling	0.67 (0.34–1.31)	0.24	0.97 (0.74–1.28)	0.84
Some primary	0.83 (0.42–1.63)	0.59	0.77 (0.58–1.02)	0.07
Completed primary	Ref.		Ref.	
Secondary and advanced	1.07 (0.42–1.63)	0.59	1.07 (0.81–1.40)	0.66
Paternal education				
No formal schooling	0.82 (0.30–2.22)	0.69	0.68 (0.45–1.04)	0.07
Some primary	1.53 (0.78–3.01)	0.22	1.32 (1.01–1.72)	0.04
Completed primary	Ref.		Ref.	
Secondary and advanced	0.97 (0.73–1.29)	0.84	0.98 (0.77–1.25)	0.88
Wealth Quintile				
Q1 (poorest)	Ref.		Ref.	
Q2	0.89 (0.61–1.30)		0.89 (0.70–1.14)	
Q3	0.96 (0.65–1.45)		1.13 (0.89–1.44)	
Q4	1.09 (0.76–1.57)		1.15 (0.91–1.46)	
Q5 (wealthiest)	0.92 (0.58–1.44)	0.91	1.24 (0.97–1.58)	0.02
Water source category				
Unimproved	0.98 (0.60–1.61)	0.95	1.01 (0.81–1.25)	0.94
Improved	Ref.		Ref.	
Waste disposal				
No flush toilet	0.96 (0.74–1.24)	0.73	0.57 (0.48–0.68)	<0.01
Flush toilet	Ref.		Ref.	
Infant sex				
Male	1.08 (0.87–1.35)	0.49	1.23 (1.07–1.42)	<0.01
Female	Ref.		Ref.	
Parity				
First born	1.02 (0.74–1.40)	0.90	0.96 (0.77–1.18)	068
2nd–4th birth	Ref.		Ref.	
5th birth or greater	1.08 (0.68–1.70)	0.76	0.86 (0.67–1.11)	0.25
Birth weight				
≤2000g	4.68 (2.05–10.65)	<0.01	2.99 (1.55–5.78)	<0.01
2001–2500 g	1.02 (0.65–1.59)	0.94	1.08 (0.87–1.34)	0.49
>2500 g	Ref.		Ref.	
Gestational age				
Preterm (<37 weeks)	0.75 (0.50–1.12)	0.16	0.85 (0.64–1.11)	0.25
Term ≥ 37 weeks	Ref.		Ref.	
Small for gestational age				
Yes	1.18 (0.81–1.72)	0.18	1.25 (1.02–1.55)	0.04
No	Ref.		Ref.	