Spatial variation in risk factors of child mortality in two urban informal settlements in Kenya

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BACKGROUND

Child mortality rates in sub-Saharan Africa (SSA) remain the highest in the world with under-five mortality rate (U5MR) estimated at 98 deaths per 1000 live births (UNICEF, 2014). Neonatal deaths account for about a third of under-five deaths in SSA (UNICEF, 2014). While Western and Central Africa are seen to be the sub-regions with the highest child mortality rates (U5MR=118), in Eastern and Southern Africa the rates are also high with 77 deaths per 1000 live births among children under the age of five years. In Kenya, the overall under-five mortality rate declined by 36 percent from 115 deaths per 1,000 in 2003 to 74 deaths per 1,000 in 2009 with rates being higher in rural areas (86 per 1,000) as compared to urban areas (74 per 1,000) (KNBS and ICF Macro, 2010). In Nairobi informal settlements, child mortality rates are significantly higher than in Kenya rural areas. For instance, Kimani et al show that under-five mortality rate in Nairobi slums between 2003 and 2010 was 104 deaths per 1000 live births, far higher than in Kenya rural areas (Kimani-Murage et al., 2014).
Child mortality has been often associated with a number of factors including socio-demographic and cultural characteristics, economic status, child nutritional status, and poor access to health services (O'Neill et al., 2012; Mwalali and Ngui, 2009; Anyamele, 2009; Omariba et al., 2007). Urban – rural differences in child mortality have been also stressed in several studies (Kimani-Murage et al., 2014; Garenne, 2010). Using a fixed effect proportional hazards model, Bolstad and Manda also evidenced family and community factors as important predictors of child mortality in Malawi (Bolstad and Manda, 2001).
However, geographical and environmental factors are less documented as important predictors of child mortality. A number of environmental and health promotion theories hypothesized social and community support as well as physical environment to influence residents' health outcomes. For instance, the Bronfenbrenner's socio-ecological model posited that health is shaped by many environmental subsystems, including family, community, workplace, economics, and the physical and social environments (Bronfenbrenner, 1977).
This study explores child mortality estimates in two informal settlements in Nairobi city, Kenya controlling for usual covariates (demographics, economic status, etc...) and accounting for specific residence area (village) and spatial neighboring effects.

METHODS

Data for this study comes from the Nairobi Urban Health and Demographic Surveillance System (NUHDSS), being implemented by the African Population and Health Research Center. The NUHDSS has been in operation since 2002, and covers two informal settlements in Nairobi - Korogocho and Viwandani. The NUHDSS collects data on vital events – births, deaths and migration with households visited three times in a year.
Specifically, this paper utilizes data collected between 2006 and 2011. The data include a total of 30339 children aged less than five years in the study site. The children were observed from birth until the point they reach the age of five years, or out-migrate out of the study site or die.

In case they out-migrated, they were reintegrated in the study population if they came back before end of the observation period.

The paper utilizes different analytical techniques. First, frequencies and percentages are used to describe the distribution of the study population and the number of deaths by key social and demographic characteristics. Secondly, to understand the factors associated with under-five mortality and more specifically the contribution of villages within the study site, we fit a Cox regression model using STATA 13. However, one limitation of the conventional regression models like the Cox regression is that, though a variable capturing the space can be added in the model, they do not account for spatial random effects. Therefore, in order to address this challenge, we further carried out spatial analysis using a Geo-additive regression model in BayesX (Belitz et al., 2012; Brezger et al., 2005). The Geo-additive regression model estimates the risks of death within a village, taking into consideration the neighboring spatial effects. The assumption underlying this estimation is that boarding spatial units, in our case villages, share common risk factors that may be associated with the event being observed.

RESULTS

The results show that for both slum areas, the spatial random effects were not significantly associated with under-five mortality. However, in Viwandani, Paradise village showed a slightly increased risk of under-five mortality while Jamaica village seemed to be associated with a decreased risk. In Korogocho, Grogan B and Korogocho A villages had a 10% non-significant increased risk of under-five mortality. Korogocho B and Gitathuru C villages had a decreased spatial effect on under-five mortality. Looking at the fixed effects of other covariates, the risk of under-five mortality significantly increased in both study sites with increased age of the household head. That is, in both Viwandani and Korogocho, children from households whose heads are over 30 years were at least two times more likely to die before their fifth birthday as compared to those with heads aged below 20 years . Also, in Viwandani, children from older mothers (40 years and above) were about two times more likely to die than those from younger mothers (below 20 years). Mother's higher education was associated with decreased risk of under-five death in Korogocho (HR=0.6) and Viwandani (HR=0.8). Another result from the Bayesian geo-additive survival model was that the size of the household was significantly associated with increased risk of under-five mortality but only in Viwandani. Children from households with at 4 members were at least 30% less likely to die as compared with those from households with utmost 3 members. Finally, Luo ethnicity was associated with 70% increased risk of under-five mortality in Korogocho.

The results on the spatial relationship between village of residence and mortality add to the value of this study. While the informal settlements appear to be homogeneous, there are notable spatial differentials in child mortality and possibly other health outcomes especially in Viwandani.

In addition, the Bayesian geo-additive survival model was able to identify key determinants of under-five mortality in Korogocho and Viwandani. While the mother's higher education (secondary) was associated with decreased risk of child mortality, older age of the head

household's and a *Luo* ethnicity reflected an increased risk of death before the age of five years for children in the two slums as shown in Table 1 below.

Table 1: BayesX geo-additive regression model on under-five mortality (NUHDSS, Kenya 2006 - 2011)

	Korogocho		Viwandani	
1 - Fixed Effect Variables	**HR**	**95% CI**	**HR**	**95% CI**
Child gender				
Girl (ref.)	1.0	-	1.0	-
Boy	1.0	[0.9 ; 1.2]	1.0	[0.8 ; 1.2]
Head Household gender				
Female (Ref.)	1.0		1.0	
Male	0.9	[0.7 ; 1.1]	1.1	[0.9 ; 1.5]
Head Household age				
Below 20 (Ref.)	1.0	-	1.0	-
20 to 29	1.7	[1.2 ; 2.5]	2.2	[1.2 ; 5.1]
30 to 39	2.0	[1.4 ; 3.2]	2.4	[1.3 ; 5.9]
40 to 49	2.1	[1.4 ; 3.4]	2.7	[1.3 ; 6.0]
50 plus	2.1	[1.3 ; 3.5]	2.6	[1.1 ; 7.7]
Mother age				
Below 20 (Ref.)	1.0	-	1.0	-
20 to 29	1.0	[0.8 ; 1.3]	1.3	[0.9 ; 1.7]
30 to 39	1.3	[1.0 ; 1.8]	1.2	[0.8 ; 1.9]
40 plus	0.9	[0.4 ; 1.7]	1.9	[0.8 ; 4.2]
Mother education				
None/Primary (Ref.)	1.0	-	1.0	-
Secondary / Higher	0.6	[0.4 ; 0.7]	0.8	[0.6 ; 0.9]
Unknown	0.3	[0.2 ; 0.5]	0.3	[0.1 ; 0.4]
Wealth Index				
Poor (Ref.)	1.0	-	1.0	-
Middle	1.3	[1.0 ; 1.7]	1.1	[0.8 ; 1.3]
Least poor	1.0	[0.8 ; 1.2]	1.1	[0.9 ; 1.4]
Household size				
1 to 3 (Ref.)	1.0	-	1.0	-
4 to 6	0.9	[0.7 ; 1.2]	0.6	[0.5 ; 0.7]
7 plus	0.9	[0.7 ; 1.2]	0.7	[0.5 ; 1.1]
Ethnicity				
Kikuyu (Ref.)	1.0	-	1.0	-
Luhya	0.9	[0.7 ; 1.2]	0.7	[0.5 ; 1.0]
Luo	1.7	[1.3 ; 2.0]	0.8	[0.5 ; 1.2]
Kamba	0.8	[0.5 ; 1.2]	0.8	[0.6 ; 1.0]
Others	0.7	[0.5 ; 1.0]	0.7	[0.5 ; 0.9]

2 - Village Random Effect: (Korogocho / Viwandani)				
Vill 1: Gitahuru C / Paradise	0.9	[0.9 ; 1.7]	1.1	[0.9 ; 1.7]
Vill 2: Grogan A / Sinaï	1.0	[0.8 ; 1.4]	1.0	[0.8 ; 1.4]
Vill 3: Grogan B / Jamaïca	1.1	[0.7 ; 1.1]	0.9	[0.6 ; 1.1]
Vill 4: Highridge / Lunga-Lunga	1.0	[0.7 ; 1.2]	1.0	[0.7 ; 1.2]
Vill 5: Korogocho A / Industrial Area	1.1	[0.7 ; 1.4]	1.0	[0.7 ; 1.4]
Vill 6: Korogocho B / Donholm	0.9	[0.9 ; 1.3]	1.0	[0.9 ; 1.3]
Vill 7: Nyayo / Kingston	1.0	[0.8 ; 1.3]	1.0	[0.8 ; 1.3]
Number of observations		14,108		15,813
Number of deaths		511		418
PD		23.7		23.9
DIC		4,316.6		3,843.4

CONCLUSION

These findings call for specific efforts from policy makers and health authorities in Kenya to refine maternal and child health programs in view of the urban slum's distinctiveness and their important population. Targeted actions to reduce child mortality in Korogocho and Viwandani slums should be given priority to diminish social inequities and ensure socio-economic development in the Kenya capital is not hampered.