Extended abstract

Background

Despite efforts to prevent malaria, Uganda is ranked 3rd globally with the highest number of children who die of malaria (UBOS and ICF Macro, 2010).There is malaria stratification with low and high transmission areas in Uganda. High transmission areas have an average of 55 infectious bites per person per year and less in low transmission areas (Okello et al, 2006). The Northern, Southern, East Central and Central regions of Uganda are high transmission areas whereas the Eastern, Southwest and Western regions are low transmission zones. Although the Uganda Demographic and Health Survey shows higher ownership of bednets in low transmission areas of eastern and western Uganda, there were high malaria cases among children (Kiwanuka, 2003). There was an increase in infant mortality in western Uganda between 1995 and 2001 when there was malaria outbreak due to *elnino* (Nuwaha et al, 2011). Although it is within public domain that malaria is the major cause of under-five mortality in Africa, the relationship between ecological factors, proxied by altitude and malaria transmission intensity remain for public debate (Snow et al, 2001). High altitude areas tend to have low temperature and such an ecological condition is not conducive for malaria breeding. Population in such areas tend to have low immunity since the chances of malaria inoculation reduce (Rulisa et al, 2013; Bodker et al, 2003). However, previous authors in Uganda did not control for ecological factors. Thus, this study aims to answer the following questions: 1) To what extent do ecological factors affect under-five mortality? 2) Do ecological factors modify the effects of malaria prevention on under-five mortality?

Methods and materials

The study utilized 2011 Uganda Demographic and Health Survey (UDHS) data. We analyzed data from a nationally representative sample drawn from 10,086 households, out of which 9480 were occupied and 9033 interviewed. The household had 9247 eligible women aged 15–49 years but 8674 were interviewed who had a total of 12,559 live births within five years preceding the survey. The risks of death in children below age five were estimated using Cox proportional regression analysis. Results were presented as hazard ratios (HR) with 95% confidence intervals (CI).

Definition of Variables

Using information from 2009 Malaria Indicator Survey, regions were collapsed into two to create high and low malaria transmission areas. Areas with high malaria transmission were collapsed to make high transmission, and did the same for low and medium transmission areas to generate low transmission group. An area is considered of high malaria transmission when it is over 50% malaria endemic and below that is considered low. UDHS has variable on altitude in metres. The values were grouped into four: <1000, 1000-1200, 1201-1400, and >1400. Household ownership of bed nets was grouped as: 0=No, 1=Yes. Fansidar is used as malaria prophylaxis during pregnancy grouped as: 0=No, 1=Yes. It was important to control for birth weight since malaria during pregnancy can affect it. It was grouped as: 1= <2500 and 2=>=2500 grams. The type of building materials was added to the model because it can provide breeding places for mosquitoes. Other variables were place of residence, household seize, and source of drinking water.

Analysis

The analysis was done using Cox proportional hazards model. Kaplan-Meier (K-M) curves are used to explore data and assess the fitness of using Cox proportional hazard model. The hazard of under-five mortality at any time t is denoted as:

$$h(t/x) = h_0(t)\exp\sum_{i=1}^{p} x_i\beta_i$$

Where:$h_0(t)$= baseline hazard representing the probability of under-five death before any exposure to x. X_s are predictors, β=Coefficient. It changes with an additional x in the model. The analysis had 4 models. Models 1 and 2 are unadjusted meant to determine the effects of ecological variables and malaria prevention on under-five mortality respectively. Model 3 was designed to estimate the extent to which ecological factors can modify effect of malaria prevention on under-five mortality. Model 4 establishes the effects of other potential variables on under-five mortality.

Findings

The results of survival analysis are presented in Table 1 (Appendix). In model 1, under-five mortality risk is lower in high altitude areas. The hazards ratios dropped by 28.0% (CI:0.57-0.88), 27.0% (CI:0.58-0.93) and 39.0% (CI: 0.45-0.82) in 1000-1200, 1201-1400 and >1400 metres above sea levels respectively with very strong associations ($p<0.01$). But, there is insigificant increase of 1.0% in hazard ratio in high malaria transmission areas. Materials used for the construction of houses were not associated with under-five mortality.

The K-M surival curves in Fig.1 depicts higher survivorship among under-five children in low altitude areas. Fig. 2 shows no major gap in survivorship at younger ages by level of malaria intensity but as age advances survivorship increases in low malaria prevalent areas.

Fig 1: Kaplan-Meier survival curve among under-five children in Uganda by Altitude

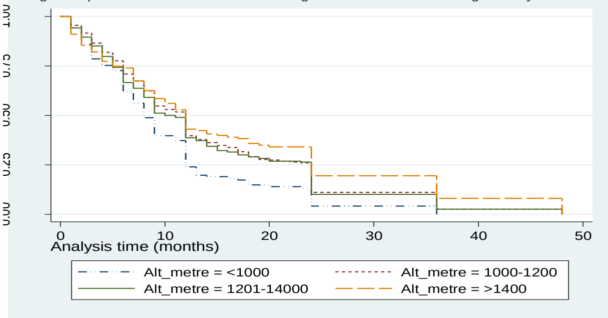
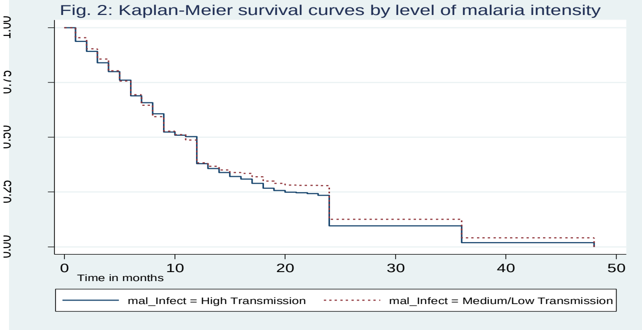


Fig. 2: Kaplan-Meier survival curves by level of malaria intensity



Model 2 depicts 33.0% reduction in hazard ratio although insignificant for households that owned bednets. Surprisingly, taking malaria prophylaxsis by pregnant women significnalty increased under-five mortality risk by 301% (HR= 3.01, $p<0.05$, CI:1.20-7.59). Althouh weight at birth was not associated with under-five mortality, the hazards ratio was lower by 18.0% for children with normal weigh at birth relative to the underweight.

Model 3 is an extension of model 2 but adjusted for ecological factors for comaprative purpose with results in mdoels 1 and 2. After adjusting for the ecoloigcal factors, altitude 1201-1400 and >1400 lost their significance and the strength of malaria prophylaxis in under-five mortality becomes weak. The point estimates of the hazard ratio and the confidence intervals become wider, confirming the importance of taking ecological factors into account when analysing malaria prevention variables. This depicts the effects of ecological factors has over malaria prophylaxis on under-five mortality. Although there was no significant change (p>0.05), the hazard on under-five increased by 36.0% in high transmission areas after controlling for malaria prevention variables. The hazard ratio of under-five mortality declined by 57.0% in households that owned bednets, but a significant increase of 237.0% among women who took malaria prophylaxis, lower when ecological variables are excluded (model 2). That is, ecological variables modify malaria prevention on under-five mortality while the latter nulifies the effects of the former on the mortality.

The last model controls for other potentially important factors such as residence, water source and household size. These is meant to pick the effect of such factors on malaria prevention variables and ecology. Altitude regains a strong significance, but only at the range of 1000-1200 metres above sea level. The hazard of under-five mortality increases by 97.0% in high malaria transmission areas although insigificant. The hazard ratio increases in household size of 5-7 by 73.0%, but significantly (p<0.01) attenuates by 91% in households that had 8 members and above.

Conclusion and Recommendations

Altitude as a proxy of ecological condition has a strong effect on under-five mortality in Uganda. The risk of under-five mortality reduces with increase in altitude but malaria intensity shows no effect in the unadjusted model. However, the adjusted model shows that ecological factors modify the effect of malaria prevention on under-five mortality, but at the same time altitude loses much of its importance in explaing under-five mortality. An extended adjusted model shows that residence, household size and water source modify the effect of ecological variables and bednet use on under-five mortality. Thus, it is recommended that policies on malaria prevention must consider altitude as a key factor in malaria prevention. Women in high altitudes should be encouraged to take malaria prophylaxis. While at the same time family size should be regulated and also target urban children in policy implementation.

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Table 1: Hazard ratios (HR) and 95% confidence interval for ecological variables, malaria prevention and under-5 mortality, Uganda 2011

	Model 1		Model 2		Model 3		Model 4	
Variables	**HR**	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**
Altitude in metres								
<1000	1.00				1.00		1.00	
1000-1200	0.72**	0.57-0.88			0.35*	0.10-1.17	0.07**	0.01-0.35
1201-1400	0.73**	0.58-0.93			0.47	0.08-2.62	0.31	0.01-.8.74
>1400	0.61**	0.45-0.82			0.32	0.06-1.69	0.17	0.01-2.11
Malaria Transmission								
Low	1.00				1.00		1.0	
High	1.01	0.88-1.16			1.36	0.52-3.57	1.97	0.54-7.20
Bednets in household								
No			1.00		1.00		1.00	
Yes			0.67	0.22-2.02	0.43	0.11-6.51	0.26**	0.07-0.96
Fansidar in pregnancy								
No			1.00		1.00		1.00	
Yes			3.01**	1.20-7.59	2.37*	0.86-6.51	2.66	0.75-9.43
Birth weight								
<2500 grams			1.00		1.00		1.00	
>=2500 grams			0.82	0.35-1.93	0.69	0.23-2.05	1.26	0.28-5.51
Residence								
Urban							1.00	
Rural							0.72	0.15-3.43
Household size								
2-4							1.00	
5-7							1.73	0.41-7.26
8+							0.09**	0.01-0.63
Roof materials								
Thatch	1.00							
Iron sheets/Tiles	0.96	0.84-1.09						
Wall materials								
Mad and wattle	1.00							
Bricks and cement	0.99	0.86-1.14						
Water Source								
Tap/Boreholes							1.00	
Open Source							0.40	0.06-2.71

**p<0.05, *p<0.1