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Kyle Tiemeier Date

THE EFFECT OF GEOGRAPHY AND DEMOGRAPHY ON OUTCOMES OF UGANDAN EMERGENCY DEPARTMENT PATIENTS

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THE EFFECT OF GEOGRAPHY AND DEMOGRAPHY ON OUTCOMES OF UGANDAN EMERGENCY DEPARTMENT PATIENTS

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Abstract

THE EFFECT OF GEOGRAPHY AND DEMOGRAPHY ON OUTCOMES OF UGANDAN EMERGENCY DEPARTMENT PATIENTS

By Kyle Tiemeier

Background: In Sub-Saharan Africa (SSA) geography represents a significant challenge to accessing health services. Patients' ability to negotiate these challenges is strongly influenced by poverty, urban versus rural household location (urbanicity), and transportation options. Numerous studies have demonstrated the influence of these factors on healthcare access, but their influence on health outcomes has not been well understood. Geographic barriers to healthcare access and outcomes in the clinical context of emergency care in SSA have not been studied. Understanding the influence of these factors on emergency care access and outcomes can inform future emergency care development and resource allocation among central hospital-based care and pre-hospital care and transportation.

Methods: An emergency department in Rukungiri district, Uganda has collected patient demographic, geographic and outcome data since 2009. We used geographic imaging systems to measure and categorized patient distance-to-hospital into <5km, 5 to <10km, and 10km+ tertiles. Urbanicity and poverty data was available at the subcounty level. We used logistic regression modeling to evaluate if patients' distance-to-hospital is associated with 3-day mortality, controlling for urbanicity, poverty prevalence, age, gender and dry versus rainy season.

Results: 3767 Rukungiri residents with sufficient geographic information were treated in the emergency department from November 2010 to November 2012, with an observed 3-day mortality of 2.0%. Distance-to-hospital was found to be positively associated to 3-day mortality after controlling for poverty, urbanicity, age and malnutrition. Compared to patients living <5km from the hospital, patients living 5km to <10km from the hospital had 1.7 times the odds of 3-day death (95% CI: 0.8-3.7, p=0.155), and patients living 10km+ from the hospital had 2.2 times the odds of 3-day death (95% CI: 1.0-5.0; p=0.048).

Conclusion: Distance-to-hospital is an independent risk factor for 3-day mortality of emergency department patients after controlling for other demographic risk factors. This may have implications for the future development of emergency care in Uganda and SSA.

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Introduction

In Sub-Saharan Africa geography represents a significant barrier to accessing healthcare. The terrain and the distance between people's homes and health facilities can pose challenges to seeking preventive and curative healthcare. People's ability to negotiate these challenges is strongly influenced by a number of economic and demographic factors. In more remote areas road and communication infrastructure can be poor, the population tends to be more impoverished, adequate health facilities are often far away and rains can render roads impassable. These factors result in both slower and costlier transportation (1). Patients living farther from health facilities have been found to utilize health facilities later and less frequently (1–3), and they receive less preventive healthcare (4). In the context of urgent and emergent health conditions, which necessitate rapid access to appropriate care, geographic barriers are all the more relevant.

There are a number of distinct features of Ugandan demography, economics and health relative to other countries in Sub-Saharan Africa (SSA) (Table 1). These features may have strong implications for geographic access to healthcare and demand for healthcare. This study aims to quantify the effect of geographic determinants on the outcomes of patients with urgent and emergent healthcare conditions in Uganda. The field of emergency care training, provision and research is in early stages of development in Uganda—as it is in numerous countries in SSA—and momentum is building (5–7). As emergency care continues to develop, there is a need to further understand the geographic determinants to emergency care access and outcomes.

Background

Sub-Saharan Africa (SSA)

Numerous studies have sought to measure the association between geography and healthcare access in SSA. While we are aware of no studies that have investigated this specifically in the context of emergent care, a number of studies have investigated the relationship between pediatric patient mortality and distance-to-health-facilities. The results of these studies have been inconsistent. A positive correlation between pediatric mortality and distance-to-health-facility has been found in community-based studies of children under 5 in rural Tanzania (4) and of infants in Burkina Faso (8). A hospital-based study also found this positive correlation among children with malaria admitted to a district hospital in Zambia (9). A study of infants less than 4 months in rural Congo showed a trend, but this was not statistically significant (10).

Other studies, however, have found no association between distance-to-health-facility and health outcomes. There was no significant association between pediatric mortality and distance-to-health facility in population-based studies of infants in rural South Africa (11) and of children under 5 in rural Kenya (12). A study of children under 5 in a mixed urban-rural population in Gambia did show a univariate association between pediatric mortality and distance-to-health facility, but this association disappeared when controlling for urban versus rural household location (13).

Moïsi et. al. postulate that the inconsistencies in these results may be in part attributed to differences in the density of health services among the study sites (12). Below a certain density of health services, Moïsi states that distance-to-health-facility may remain a relevant risk factor to pediatric mortality. This is supported by the studies in Burkina Faso and Congo, which have a relatively low density of health services and did demonstrate a positive correlation between pediatric mortality and distance-to-health center (8,10). Moïsi's study in Kenya, which has a higher density of health services, did not show a correlation. However, this hypothesis is not supported by Schellenberg et. al., as they found a statistically significant correlation in Tanzania where the density of health facilities is relatively high (75% of households reside within 5 km of a health center).

We are aware of two non-pediatric studies in sub-Saharan Africa which suggest a positive correlation between distance-to-health-facility and mortality among patients receiving outpatient TB treatment (14) and obstetric patients (15). However, the methodology of these studies makes it more difficult to make a conclusion.

In sub-Saharan Africa the body of literature that has attempted to quantify geographic determinants of healthcare access and health outcomes is inconclusive and is almost entirely within the context of pediatrics. We are not aware of studies that have investigated this topic in the setting of Uganda or in the clinical context of emergency care.

Uganda

Only 16% of Uganda's population resides in urban areas, making it the second-least urban of 47 measured countries in sub-Saharan Africa (Table 1). Simultaneously, it is also a relatively densely populated country (85th percentile of 47 sub-Saharan African countries measured) (16). Urban versus rural residence (referred to as urbanicity in this paper) encompasses a number of factors that makes it more difficult to negotiate geographic barriers to healthcare.

Transportation to health facilities is more challenging to secure in rural areas. Emergency transportation, if it exists, is often hindered by lack of ability to call someone with an appropriate vehicle (17). Bicycles and motorcycles tend to be the most accessible form of transportation in rural Uganda. For laboring women, whose transportation needs resemble those of acutely ill and incapacitated emergency patients, these forms of transportation were found to be inappropriate and not fast enough (18). Rural areas also have less developed road infrastructure that is more susceptible to adverse weather (18–20). Furthermore rural areas are more remote from health facilities (19,20). One study estimated that Ugandan patients travel an average of 33 km to reach the nearest hospital (21). All of this may explain why rural populations were found to have an higher direct and indirect cost of seeking healthcare (1).

Rural populations tend to be poorer than urban populations, have more risk factors for illness and have worse health outcomes. In urban Uganda 9.1% of the population is below the urban poverty line, while 27% of the rural population is below the rural poverty line. This discrepancy is consistent in Rukungiri district, the site for this study. Using a different estimator of poverty, 2.9% of the one urban subcounty in Rukungiri was categorized as impoverished. In contrast, 6.4%-9.5% of the population in rural subcounties was found to be impoverished (22). Access to water and sanitation is also poorer in rural areas. Ninety five percent of urban Ugandans have access to improved water source and sanitation facilities. In comparison, 68% of rural Ugandans have access to improved water sources, and 34% have access to improved sanitation facilities (16). Rural populations also suffer higher morbidity and mortality (1,9,13).

Uganda is relatively poor by SSA standards, ranking 38th of 47 SSA countries by GDP per capita (16). Being poor has a number of implications for healthcare access and outcomes. For the poor, there is a greater opportunity cost to seeking healthcare (23). This may partially explain why the poorest quintile of Ugandans was approximately twice as likely to indicate distance to health facility as a constraining factor and 2.4 times more likely to report ill health compared to the wealthiest quintile, (23,24).

The Ugandan government has attempted to address the financial limitations to healthcare access. In 2001 it abolished user fees for government health facilities, which includes 48% of Ugandan hospitals and 67% of lower-level health centers (25,26). During this period outpatient visit attendance in government facilities nearly doubled, from 9.3 million visits in 2000 to 17.1 million in 2003. The poorest quintile of Ugandans also benefited from this elimination of user fees. They reported an increase in healthcare seeking when sick from 46% of respondents in 2000 to 73% of respondents in 2003 (26).The increase in healthcare utilization was much less pronounced in public not-for-profit health facilities, where user fees were still maintained (20,27). However abolishing user fees does not eliminate the financial limitations of healthcare access. In comparison to public not-for-profit health facilities, government health facilities tend to be much more undersupplied and patients' attendants must frequently go out to purchase medications and supplies for treatment in these facilities.

Methods

Study Population, Location and Data Collection

We conducted a retrospective cohort study of patients presenting to Karoli Lwanga Hospital emergency department in the district of Rukungiri, Uganda. Rukungiri is a rural agricultural district in southwest Uganda with a population of 275,162 (34). Rukungiri district is divided into 11 subcounties and the subcounties are further divided into 73 parishes. Karoli Lwanga Hospital is a district-level not-for-profit hospital. District hospitals are the lowest-level health facilities that are staffed by physicians. The hospital resides just outside Rukungiri Town Council, the only urban area in the district (Figure 1). In 2008-9, Karoli Lwanga Hospital partnered with the non-profit organization Global

Emergency Care Collaborative (GECC) to construct an emergency department and run 2-year training programs for nurses to become mid-level providers specialized in emergency care. The Karoli Lwanga Hospital emergency department has provided emergency care to patients since this time, and it is the only known health facility in Uganda that is staffed by trained specialists in emergency care.

The emergency department receives patients triaged as high and moderate acuity, patients requiring minor surgical procedures not appropriate for the operating theater, all pediatric malnutrition patients and outpatients requiring indwelling urinary catheter changes. The inpatient ward occasionally sends patients to the emergency department to receive procedures requiring sedation or pain control. After the outpatient clinic closes in the afternoon the emergency department receives all the new patients until it closes at approximately midnight. The emergency department does not see patients receiving obstetric care, outpatient preventive and primary care, dental care, patients admitted to the hospital directly from outpatient clinic or any patient who arrived at the hospital when the emergency department was closed, typically between midnight and 8:00 AM.

Formal pre-hospital emergency response and transport services are minimally developed in Rukungiri district, and few people make use of them. Ambulances are typically staffed by a driver who has very limited medical training and few medical supplies. The vast majority of patients arrived to the emergency department by means of their own transportation,

Since November 2009 GECC has maintained a quality assurance database on all patients seen in the emergency department. Data collected in the emergency department included patient demographics, the parish in which they reside, vital signs, lab results, diagnoses, treatments administered and patient disposition. Follow-up data on patient survival/mortality was collected from hospital records on the third day after being seen in the emergency department. Considering the working hours of the emergency department and data collection staff, patient survival was determined between 56-80 hrs (2 -3 days) after treatment in the emergency department. Patients provided a phone number of themselves, a neighbor or a family member when they registered in the emergency department. If the patient had been discharged by the 3^{rd} day, follow-up was attempted by phone between day 3 to day 10.

Clinical and Demographic Variables

The study dataset includes all emergency department patients from November 2009 to November 2011 who reported living within Rukungiri district. Patients excluded from the study include non-Rukungiri residents, Rukungiri residents without geographic information precise enough to be placed into a distance-to-hospital group and patients with missing residence data (Figure 2).

Death within 3 days of presenting to the emergency department is the primary outcome of this study. This study included patients who died in-transit to the hospital, in the emergency department in the hospital ward and after discharge from the hospital. Patients with an undetermined date of death (n=12) were not included in the 3-day death outcome.

Initial blood pressure of emergency department patients was obtained using manual sphygmomanometers upon patient presentation to the emergency department. Initial systolic blood pressure was dichotomized to greater-than and less-than-or-equal-to 80mm Hg (35,36). This variable did not include patients under 18 years of age. Patients who died in transit to the emergency department were categorized as "missing" for blood pressure.

Patient age was categorized into <1 year, 1-4 years, 5-17 years, 18-49 years, and >49 years.

The diagnosis of malnutrition in this study was defined as children age 6-60 months with moderate or severe acute malnutrition, following WHO and UNICEF diagnostic standards (bilateral pitting edema, ≥ 2 standard deviations below average middle upper arm circumference [MUAC] or ≥ 2 standard deviations below average weight-for-height or weight-for-length) (37).

Geographic and Population Variables

A political map of Rukungiri was obtained from a database maintained by the International Livestock Research Institute (ILRI) that included borders of Rukungiri's subcounties and parishes. Each parish contained a population-weighted centerpoint (22).

Individual-level socioeconomic status data (SES) have been found to be more associated to all-cause mortality than area-level measures of SES. However when individual-level data is unavailable, area-level SES measures are often used to explore associations to all-cause mortality (38). Poverty prevalence at the subcounty level was estimated by a team from the World Bank, Uganda Bureau of Statistics and the ILRI. Rukungiri Town Council (a subcounty equivalent) had poverty prevalence of 2.86%, and the other subcounties had poverty prevalence ranging from 6.43% to 9.46% (22). Poverty was categorized into 3 groups: "low" for subcounties with poverty prevalence of 2.86% to <5%, "moderate" for 5% to < 7.5% and "high" for 7.5% to 9.46%.

Patients' distance-to-hospital was estimated as the straight-line distance between Karoli Lwanga Hospital and the population-weighted centerpoint the patient's parish of residence. The GPS coordinates of the hospital were identified on Google Maps (39). The straight-line distance-to-hospital was calculated with ArcGIS. Patient distance-to-hospital was then grouped into three categories of "less than 5 km", "5km to <10km", and "10km or farther" (Table 1).

Some subcounties resided entirely within one of the distance-to-hospital tertile groups. Patients who lived in these subcounties but who had missing parish-level data (n=389) were also included in analysis.

Data collected before November 22, 2010 was excluded from analysis (n=4723) because geographic data collection was poor during this time period (10.7% of patients records included a district of residence), in comparison to after this date (n=6211, 89.0% of patient records had a district of residence).

Wet season in Rukungiri district was classified as October to April and was defined by an average monthly rain precipitation of 25mm or greater (40). Patients were assigned "wet season" or "dry season" based on the date of their visit to the emergency department.

Analysis

Logistic regression modeling was employed to evaluate the association between distance-to-hospital and patient mortality as a primary outcome. Potential interaction and confounding was evaluated for patient age group, patient sex, malnutrition, wet season versus dry season, urbanicity and poverty prevalence. Statistical analysis was performed using SAS 9.2 (Cary, NC). Statistical significance was set at $p \leq 0.05$. All study covariates were assessed for collinearity using the criteria of a variance inflation factor of 10 or greater. Potential interaction terms were removed by backward elimination until remaining terms were statistically significant. Confounding variables were removed from the model if they changed the primary exposure-to-outcome AOR by less than 10%. The final logistic model was assessed for goodness-of-fit with the Hosmer-Lemeshow test.

Rukungiri Town council had “low” poverty prevalence and was “urban,” while the remaining 10 subcounties were rural and had “moderate” or “high” poverty prevalence. Malnutrition and age group were kept a priori as confounders in the logistic model. An outreach program actively identified pediatric malnutrition patients in remote parishes in Rukungiri district and brought them to the Karoli Lwanga Hospital emergency department.

Results

Karoli Lwanga Hospital emergency department treated 4878 Rukungiri district residents between November 22, 2010 and November 30, 2012 (Table 2). We observed 87 deaths (1.8%) occurring within three days of emergency department presentation among this cohort.

Patients living closer to the hospital were more represented in the emergency department patient population. Among the 3767 patients with distance-to-hospital data, 46.1% (n=1736) lived less than 5 km from the hospital (Table 3). This <5km distance-to-hospital tertile also included the only subcounty in Rukungiri district that was “urban, low poverty” (Figure 1). 19.1% of patients lived between 5km and <10km from the hospital, and 34.8% lived 10km or more from the hospital.

Distance-to-hospital was found to be positively associated to 3-day mortality on univariate analysis, using the <5km distance-to-hospital as a reference group (Table 3). On multivariate analysis this relationship continued to be significant for the 10km+ distance-to-hospital group (AOR: 2.2; 95%CI: 1.0-5.0; p=0.048), but became insignificant for the 5 to <10 km group (AOR: 1.7; 95% CI: 95%CI: 0.8-3.7; p=0.155), controlling for poverty, urbanicity, age group and pediatric malnutrition. Gender and season were not included in the final model, as they were not identified as potential confounders.

Urbanicity had a statistically significant association to 3-day mortality on univariate analysis. The odds of 3-day death were 3.5 times higher for patients from rural subcounties in comparison to the one urban subcounty (CI: 1.4-8.4; p=0.0090). However, this association also became insignificant when controlling for distance-to-hospital, poverty group, age group and malnutrition.

Low initial blood pressure was found to be strongly associated to mortality on univariate analysis (OR: 5.0; 95% CI: 2.2-11.4; p<0.001). However, only 13.7% of patients who died within 3 days had low blood pressure on their initial presentation (7 of 51 deaths).

The age group 5-14 yrs had a markedly lower mortality (0.6%) than the other age groups (1.8% to 2.3%). Compared to patients age 15-49, patients age 4-15 had 0.3

times the odds of 3-day mortality (95% CI: 0.1-0.8; p=0.018). Age group, dry season and gender had no statistically significant association to 3-day mortality.

Discussion

This study supports the hypothesis that distance-to-hospital is an independent risk factor for 3-day mortality of emergency department patients in rural Uganda, when controlling for poverty, urbanicity, age group and the hospital's malnutrition outreach program. Odds of death were 2.2 times higher for emergency department patients living greater than 10km from the hospital compared to the referent group of patients living less than 5 km from the hospital. While the 3-day mortality between the "5km to <10km" group was not significantly different from the referent group (p=0.155), the AOR of 1.7 did suggest a strong trend that was also consistent with the study hypothesis. It is possible that the study was not adequately powered for this comparison.

Distinguishing the effect of distance-to-health-facility from urbanicity is particularly relevant in Uganda, where relatively little of the population lives in urban areas. The results suggest that greater resources should be dedicated toward developing pre-hospital emergency care systems. Lower-level health centers are more plentiful and typically more geographically accessible than district-level hospitals. Improving the capabilities of these health centers to assess and treat emergency patients may mitigate some of the geographic determinants of mortality.

Emergency transportation is currently poorly developed in rural Uganda, and expanding emergency transportation services may improve the disparities in emergency health outcomes among remote populations. Furthermore, the literature on financial determinants of healthcare access in Uganda suggests that the more affordable these services are, the more widely they will be utilized.

Low blood pressure is widely known risk factor for mortality, and this study supports this association. Consequently, we hypothesized that low initial systolic blood pressure may be an appropriate secondary outcome. While we observed a strong univariate relationship between low blood pressure and mortality, low initial blood pressure had only 13.7% sensitivity for 3-day mortality (7 out of 51 deaths). For this reason we determined that low-blood pressure would not be an appropriate secondary outcome to approximate mortality.

There are a number of limitations to this study. This was an emergency department-based study and therefore inferences cannot be made about patients with urgent and emergent conditions who were unwilling or unable to seek care at Karoli Lwanga Hospital. Compared to patients residing close to the hospital, patients residing farther away may seek care from closer, lower-level health centers and only make the relatively long and costly journey to the hospital for more life-threatening emergencies. This may elevate the 3-day mortality observed for these patients relative to patients living closer to the hospital.

We believe that data collection was very strong for 3-day mortality of patients who died in the emergency department and during hospital admission. However, we had worse follow-up of patients who required phone call follow-up because they had been discharged before the 3rd day. As a result, 3-day mortality may be underreported due to loss to follow-up of these patients. We are unable to estimate this potential bias because we could not distinguish hospital-based follow-up from phone call follow-up from the dataset, and we were unable to determine the phone call follow-up success rate.

Few hospitals in SSA have an emergency department staffed by clinicians with specialized training in emergency care. The presence of emergency medicine physicians has been shown improved patient outcomes in the United States and the same effect may be taking place at Karoli Lwanga Hospital, resulting in an overall reduced observed mortality compared to hospitals in SSA without this service.

Variables used in this study may not have been adequately precise to reflect their true effect on mortality. Urbanicity and poverty prevalence data was only available at the subcounty-level and may not reflect the individual's circumstances. The location of patients' household was estimated based on the population-weighted centerpoint of each parish, but many parishes spanned multiple distance-to-hospital tertiles. Distance-to-hospital was measured as the straight-line distance to the hospital, but as Moïsi's study in Kenya demonstrated (12), access to road infrastructure can be extremely different for two patients living the same straight-line distance from the hospital.

Season was not associated to 3-day mortality in this analysis. The variable rainy season versus dry season was intended to reflect challenging road conditions during rainy periods of time. Measuring this in a seasonal manner, as opposed to measuring rainy and dry days, may not be precise enough to reflect these challenges to transportation.

Emergency care is a young and growing field in SSA. As with all of healthcare in SSA, emergency care faces significant financial constraints to its future development. We are not aware of other studies in SSA that that found a positive correlation between distance-to-health facility and mortality after controlling for the demographic variables urbanicity and poverty. This is also the first study we are aware of to explore this topic in the SSA emergency department patient population. This study demonstrates that geographic determinants of health have a significant effect on patient outcomes. It may help inform decisions on healthcare resource allocation, but further study is also warranted to confirm the results in different settings.

References

1. Ewing VL, Lalloo DG, Phiri KS, et al. Seasonal and geographic differences in treatment-seeking and household cost of febrile illness among children in Malawi. *Malaria journal* [electronic article]. 2011;10:32. (http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3049750&tool=pmcentrez&rendertype=abstract)

2. Hjortsberg C. Why do the sick not utilise health care? The case of Zambia. *Health economics* [electronic article]. 2003;12(9):755–70. (http://www.ncbi.nlm.nih.gov/pubmed/12950094). (Accessed November 21, 2012)

3. Schellenberg J a, Newell JN, Snow RW, et al. An analysis of the geographical distribution of severe malaria in children in Kilifi District, Kenya. *International journal of epidemiology* [electronic article]. 1998;27(2):323–9. (http://www.ncbi.nlm.nih.gov/pubmed/9602418)

4. Armstrong Schellenberg JRM, Mrisho M, Manzi F, et al. Health and survival of young children in southern Tanzania. *BMC public health* [electronic article]. 2008;8:194. (http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2442074&tool=pmcentrez&rendertype=abstract). (Accessed February 1, 2013)

5. African Journal of Emergency Medicine. *African Federation of Emergency Medicine, Elsevier*. 2013;(http://www.afjem.org). (Accessed April 8, 2013)

6. African Federation of Emergency Medicine. 2013;(http://www.afem.info)

7. Global Emergency Care Collaborative. No Title. 2013;(www.globalemergencycare.org). (Accessed January 29, 2013)

8. Becher H, Muller O, Jahn A, et al. Risk factors of infant and child mortality in rural Burkina Faso. *Bulletin of the World Health Organization*. 2004;82(4):265–273.

9. Kazembe LN, Kleinschmidt I, Sharp BL. Patterns of malaria-related hospital admissions and mortality among Malawian children: an example of spatial modelling of hospital register data. *Malaria journal* [electronic article]. 2006;5:93. (http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1635723&tool=pmcentrez&rendertype=abstract). (Accessed January 31, 2013)

10. Van den Broeck J, Eeckels R, Massa G. Maternal determinants of child survival in a rural African community. *International journal of epidemiology* [electronic article]. 1996;25(5):998–1004. (http://www.ncbi.nlm.nih.gov/pubmed/8921486)

11. Sartorius BKD, Kahn K, Vounatsou P, et al. Young and vulnerable: spatial-temporal trends and risk factors for infant mortality in rural South Africa (Agincourt), 1992-2007. *BMC public health* [electronic article].

2010;10:645.
(http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3091567&tool=pmcentrez&rendertype=abstract)

12. Moïsi JC, Gatakaa H, Noor AM, et al. Geographic access to care is not a determinant of child mortality in a rural Kenyan setting with high health facility density. *BMC public health* [electronic article]. 2010;10:142. (http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2848200&tool=pmcentrez&rendertype=abstract)

13. Rutherford M, Dockerty JD, Jasseh M, et al. Access to health care and mortality of children under 5 years of age in the Gambia: a case-control study. *Bulletin of the World Health Organization* [electronic article]. 2009;87(3):216–225. (http://www.who.int/bulletin/volumes/87/3/08-052175.pdf). (Accessed February 1, 2013)

14. Barker RD, Nthangeni ME, Millard FJC. Is the distance a patient lives from hospital a risk factor for death from tuberculosis in rural South Africa? *The international journal of tuberculosis and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease* [electronic article]. 2002;6(2):98–103. (http://www.ncbi.nlm.nih.gov/pubmed/11931423)

15. Mbonye AK. Risk factors associated with maternal deaths in health units in Uganda. *African journal of reproductive health* [electronic article]. 2001;5(3):47–53. (http://www.ncbi.nlm.nih.gov/pubmed/12471928)

16. World Bank. World Development Indicators. 2013;(http://data.worldbank.org/indicator). (Accessed March 30, 2013)

17. Peterson S, Nsungwa-Sabiiti J, Were W, et al. Coping with paediatric referral--Ugandan parents' experience. *Lancet* [electronic article]. 2004;363(9425):1955–6. (http://www.ncbi.nlm.nih.gov/pubmed/15194257)

18. Atuyambe L, Mirembe F, Annika J, et al. Seeking safety and empathy: adolescent health seeking behavior during pregnancy and early motherhood in central Uganda. *Journal of adolescence* [electronic article]. 2009;32(4):781–96. (http://www.ncbi.nlm.nih.gov/pubmed/19054551). (Accessed November 29, 2012)

19. Peters DH, Garg A, Bloom G, et al. Poverty and access to health care in developing countries. *Annals of the New York Academy of Sciences* [electronic article]. 2008;1136:161–71. (http://www.ncbi.nlm.nih.gov/pubmed/17954679). (Accessed December 4, 2012)

20. Improving Health Outcomes for the Poor in Uganda. 2005.

21. Linden AF, Sekidde FS, Galukande M, et al. Challenges of surgery in developing countries: a survey of surgical and anesthesia capacity in Uganda's public hospitals. *World journal of surgery* [electronic article].

2012;36(5):1056–65. (http://www.ncbi.nlm.nih.gov/pubmed/22402968). (Accessed December 19, 2012)

22. GIS Services. *International Livestock Research Institute*. 2007;(http://192.156.137.110/gis/search.asp). (Accessed February 10, 2013)

23. Odaga J, Cattaneo A, Garofolo B. HEALTH INEQUITY IN UGANDA : THE ROLE OF FINANCIAL AND NON-FINANCIAL BARRIERS. *Health Policy and Development* [electronic article]. 2004;2(3):192–208. (https://tspace.library.utoronto.ca/handle/1807/6059). (Accessed January 24, 2013)

24. Uganda Demographic and Health Survey 2000-2001. 2001.

25. Uganda Ministry of Health. Health Sector Strategic Plan III 2010/11-2014/15. Kampala: 2010.

26. Poverty Eradication Action Plan (2004/5-2007/8). Washington, D.C.: 2005.

27. Annual Health Sector Performance Report Financial Year 2004/2005. 2005.

28. Hutchinson P, Habte D, Mulusa M. Health care in Uganda: selected issues. Washington, D.C.: The World Bank; 1999 (Accessed January 24, 2013).(http://books.google.com/books?hl=en&lr=&id=QhR6Djc2nnQC&oi

=fnd&pg=PP13&dq=Health+Care+in+Uganda:+Selected+Issues&ots=L6YE_RS8En&sig=UxeNWwJTHdwRareVJnmt0KpgMhI). (Accessed January 24, 2013)

29. Nabukera SK, Witte K, Muchunguzi C, et al. Use of postpartum health services in rural uganda: knowledge, attitudes and barriers. *Journal of Community Health* [electronic article]. 2006;31(2):84–93. (http://www.springerlink.com/index/10.1007/s10900-005-9003-3). (Accessed November 6, 2012)

30. Kiwanuka SN, Ekirapa EK, Peterson S, et al. Access to and utilisation of health services for the poor in Uganda: a systematic review of available evidence. *Transactions of the Royal Society of Tropical Medicine and Hygiene* [electronic article]. 2008;102(11):1067–74. (http://www.ncbi.nlm.nih.gov/pubmed/18565559). (Accessed November 20, 2012)

31. Mbonye AK, Neema S, Magnussen P. Treatment-seeking practices for malaria in pregnancy among rural women in Mukono district, Uganda. *Journal of biosocial science* [electronic article]. 2006;38(2):221–37. (http://www.ncbi.nlm.nih.gov/pubmed/16490155). (Accessed December 19, 2012)

32. Pearson L, Shoo R. Availability and use of emergency obstetric services: Kenya, Rwanda, Southern Sudan, and Uganda. *International journal of gynaecology and obstetrics* [electronic article]. 2005;88(2):208–15.

(http://www.ncbi.nlm.nih.gov/pubmed/15694109). (Accessed November 23, 2012)

33. Buregyeya E, Kulane a, Colebunders R, et al. Tuberculosis knowledge, attitudes and health-seeking behaviour in rural Uganda. *The international journal of tuberculosis and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease* [electronic article]. 2011;15(7):938–42. (http://www.ncbi.nlm.nih.gov/pubmed/21682968). (Accessed December 19, 2012)

34. Uganda Bureau of Statistics. 2002 Uganda Population and Housing Census. 2006;(http://www.ubos.org/index.php?st=pagerelations2&id=16&p=related pages 2:2002Census Results). (Accessed April 9, 2013)

35. Lalezarzadeh F, Wisniewski P, Huynh K, et al. Evaluation of Prehospital and Emergency Department Systolic Blood Pressure a a Predictor of In-Hospital Mortality. *The American Surgeon*. 2009;75(10):1009–1014.

36. Marchick MR, Kline J a, Jones AE. The significance of non-sustained hypotension in emergency department patients with sepsis. *Intensive care medicine* [electronic article]. 2009;35(7):1261–4. (http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2923927&tool=pmcentrez&rendertype=abstract). (Accessed March 29, 2013)

37. WHO & UNICEF. WHO child growth standards and the identification of severe acute malnutrition in infants and children. 2009.

38. Steenland K, Henley J, Calle E, et al. Individual- and area-level socioeconomic status variables as predictors of mortality in a cohort of 179,383 persons. *American journal of epidemiology* [electronic article]. 2004;159(11):1047–56. (http://www.ncbi.nlm.nih.gov/pubmed/15155289). (Accessed April 22, 2013)

39. Google. Google Maps. 2013;(https://maps.google.com). (Accessed February 25, 2013)

40. World Weather Online. (http://www.worldweatheronline.com/Rukungiri-weather-averages/Rukungiri/UG.aspx). (Accessed April 10, 2013)

Tables

Table 1. Comparison of Uganda to other SSA Countries on Indicators of Health, Demography & Wealth

	Uganda	**Uganda compared to other SSA countries***	
	Indicator value	Percentile rank	Numerical rank
Health			
Life Expectancy (yrs)	54	43%	27th of 47
Malaria (notified cases per 100,000 persons)	36,233	80%	9th of 46
HIV Prevalence among age 15-49	7.2%	78%	10th of 46
Tuberculosis incidence (per 100,000 persons)	193	48%	25th of 48
Maternal Mortality Ratio (per 100,000 live births)	310	22%	36th of 46
Under-5 Mortality Rate (per 1,000 live births)	90	48%	25th of 48
Adult Female Mortality Rate (per 1,000 adults)	407	68%	15th of 47
Adult Male Mortality Rate (per 1,000 adults)	385	77%	11th of 47
Demography			
Population Density (people/square km)	167	85%	7th of 47
Population in urban areas	16%	2%	46th of 47
Population below15 yrs of age	48%	96%	2nd of 26
Fertility (births per woman)	6.1	90%	5th of 48
Wealth & Infrastructure			
GDP Per Capita	$487	19%	38th of 47
Population with Access to Electricity	9%	0%	28th of 28
Population with access to improved water	72%	55%	20th of 44
Motor vehicles with 3+ wheels (per 1000 population)	7	23%	30th of 39

Source: World Bank (16)

Table 2. Characteristics of Study Population Stratified by Distance Tertile[a]

	Total		Distance to hospital <5 km		5km to <10km		≥10 km	
Variable	n	(%)	n	(%)	n	(%)	n	(%)
3 day survival*								
Alive	3692	(98.0)	1715	(98.8)	701	(97.4)	1276	(97.3)
Dead	75	(2.0)	21	(1.2)	19	(2.6)	35	(2.7)
Initial blood pressure[a]								
Low	68	(3.0)	26	(2.5)	16	(3.7)	26	(3.4)
Normal/high	2068	(91.6)	971	(92.2)	392	(90.1)	705	(91.7)
Missing	121	(5.4)	56	(5.3)	27	(6.2)	38	(4.9)
Age <18 yrs	1955	--	683	--	285	--	542	--
Urbanicity*								
Urban	833	(22.1)	833	(48.0)	0	(0)	0	(0)
Rural	3910	(74.3)	768	(44.2)	720	(100)	1311	(100)
Missing	135	(3.6)	135	(7.8)	0	(0)	0	(0)
Poverty*								
Low	833	(22.1)	833	(48.0)	0	(0)	0	(0)
Middle	1911	(50.7)	768	(44.2	720	(100)	423	(32.3)
High	888	(23.6)	0	(0)	0	(0)	888	(67.7)
Missing	135	(3.6)	135	(7.8)	0	(0)	0	(0)
Season*								
Wet	1836	(48.7)	896	(51.6)	326	(45.3)	614	(46.8)
Dry	1931	(51.3)	840	(48.4)	394	(54.7)	697	(53.2)
Gender								
Male	1994	(52.9)	901	(51.9)	371	(51.5)	722	(55.1)
Female	1770	(47.0)	833	(48.0)	349	(48.5)	588	(44.9)
Missing	3	(0.1)	2	(0.1)	0	(0)	1	(0.1)
Age								
<1 yr	265	(7.0)	115	(6.6)	48	(6.7)	102	(7.8)
1-4 yrs	555	(14.7)	249	(14.3)	104	(14.4)	202	(15.4)
5-14 yrs	679	(18.0)	314	(18.1)	131	(18.2)	234	(17.9)
15-49 yrs	1609	(42.7)	821	(47.3)	291	(40.4)	497	(37.9)
50+ yrs	642	(17.0)	230	(13.3)	143	(19.9)	269	(20.5)
Missing	17	(0.5)	7	(0.4)	3	(0.4)	7	(0.5)
Pediatric malnutrition patients[c]*								
No	3648	(96.8)	1727	(99.4)	707	(98.2)	1214	(92.6)
Yes	119	(3.2)	9	(0.5)	13	(1.8)	97	(7.4)

[a]Excludes non-Rukungiri residents (n=647) ,patients with unidentifiable geographic data (n=686) and Rukungiri residents without identified parish (n=1111)
[b]Low initial blood pressure is defined as systolic blood pressure of ≤ 80mm Hg for adults ≥ 18 years old
[c]A hospital-based malnutrition outreach program actively identified and transported pediatric malnutrition patients from remote parishes to the hospital
*Statistically significant association to distance-to-hospital tertile

Table 3. Association between 3-day mortality and determinants of geographic and demographic healthcare access

Variable	Mortality deaths/total (%)		Crude OR (95% CI)	p	Adjusted OR (95% CI)[a]	p
Distance to hospital						
<5km	22/2038	(1.1)	1		1	
5-<10km	19/763	(2.5)	2.2 (1.2-4.1)	<0.013	1.7 (0.8-3.7)	0.155
>10km	36/1381	(2.6)	2.2 (1.3-3.9)	<0.004	2.2 (1.0-5.0)	0.048
Urbanicity						
Urban	5/833	(0.6)	1			
Rural	78/3910	(2.0)	3.4 (1.4-8.4)	<0.009		
Poverty						
Low	5/1104	(0.5)	1			
Middle	58/3051	(1.9)	3.2 (1.3-7.9)	<0.014		
High	26/1080	(2.4)	4.0 (1.5-10.5)	<0.005		
Season						
Dry	41/2190	(1.9)	1			
Wet	46/2688	(1.7)	0.9 (0.6-1.4)	<0.673		
Gender						
Male	51/2623	(1.9)	1			
Female	36/2250	(1.6)	0.8 (0.5-1.3)	<0.366		
Age						
<1 yr	8/354	(2.3)	1.3 (0.6-2.8)	<0.533		
1-4 yrs	17/728	(2.3)	1.3 (0.7-2.4)	<0.346		
5-14 yrs	5/861	(0.6)	0.3 (0.1-0.8)	<0.018		
15-49 yrs	37/2083	(1.8)	1			
50+ yrs	18/834	(2.2)	1.2 (0.7-2.2)	<0.494		
Initial Blood Pressure[b]						
Normal or high	44/2679	(1.6)	1			
Low	7/91	(7.7)	5.0 (2.2-11.4)	<0.001		

[a] Controlling for urbanicity, poverty group, age group and malnutrition. No interaction terms were found to be significant.
[b] Not considered as a potential confounding or interaction variable

Figures

Figure 1. Map of Parishes Within Rukungiri District, with Distribution of Distance-to-Hospital Tertiles and Urban Parishes

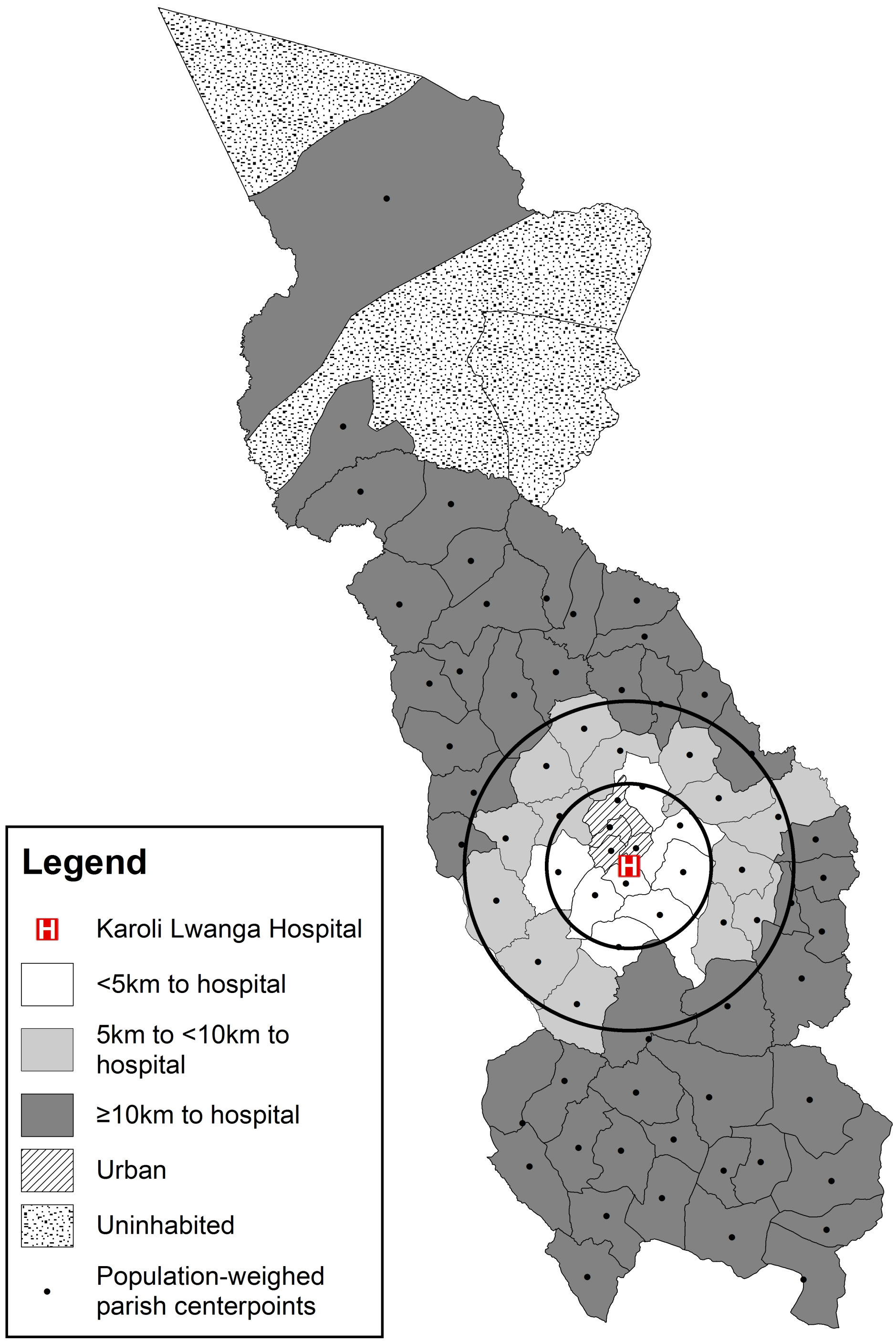
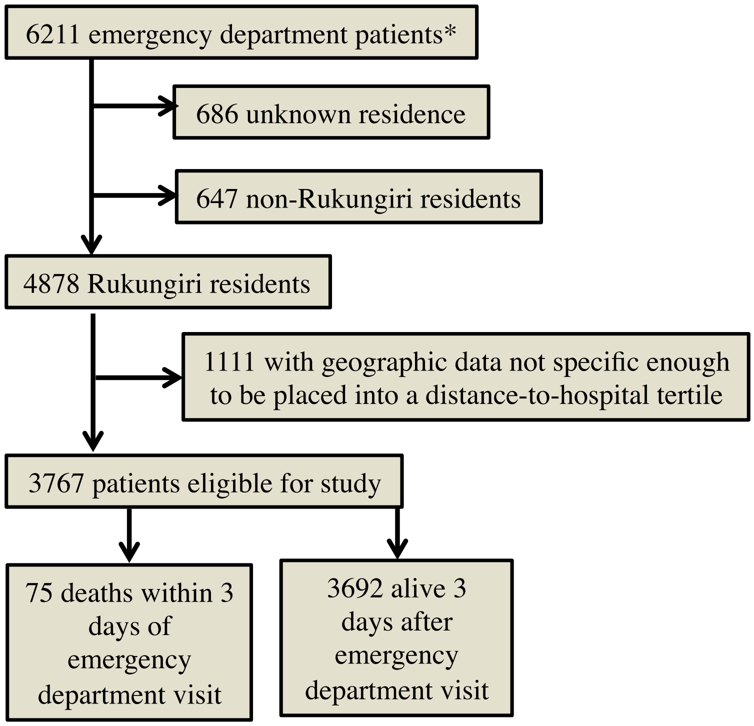


Figure 2. Study Cohort Selection for Analysis of Distance-to-Hospital Association to Mortality



*Data collection from Nov. 22, 2010 to Nov. 30, 2011