Intra-urban Child Mortality Declines in Accra, Ghana

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Abstract

While health gains in urban areas have outpaced progress in rural areas, inequalities appear to have grown larger, as richer urban residents have realized more health gains than their poor urban counterparts. Few studies have attempted to describe mortality trends within cities. The data for this study come from a UNHABITAT survey of slum areas in Accra, the Housing and Welfare Study of Accra, and the Demographic and Health Surveys. To control for individual, mother and household characteristics, a Cox proportional hazards model was used to predict the hazard of dying among all children under five during 1999-2008 for slum and non-slum areas. Separate models were fit for infants and children ages one to four. Results suggest mortality rates among slum dwellers have decreased at a sharper pace compared to those in non-slum areas, and that these declines are associated with the use of sachet water and duration of residence.

Background

In 2010, the proportion of the world's population living in urban areas became the majority, and the share is projected to continue to rise while the growth rate of rural areas falls (UNFPA 2007; UN Population Division 2010). Past forecasts have overestimated growth rates of urban populations, yet trends in the last 50 years clearly show the pace of urban population growth has increased while the pace of rural growth appears to be leveling off (UNFPA 2007; UN Population Division 2010). Health gains in urban areas, such as for infant and child mortality, appear to have also outpaced gains in rural areas (Montgomery 2003). However, inequalities appear to have grown larger, where richer urban residents have realized more health gains than their poor urban counterparts, or the rest of the population (Montgomery 2003). And yet more recent evidence suggests further complexities in the health and mortality experiences of recent migrants to urban areas (Bocquier, Madise et al. 2011). Health and socioeconomic inequalities within cities may have also grown larger, though survey data such as the Demographic and Health Surveys (DHS) is generally not adequate to estimate within-city differentials. These trends suggest that how cities manage their growth may be as or more important than the growth itself. Perhaps one of the most important factors influencing the potential health and welfare gains in cities is the growth of unplanned or underserved areas, commonly referred to as slums.

In the Global Report on Human Settlements published in 2003, UNHABITAT defines slums as areas that combine some or all of the following characteristics:

- inadequate access to safe water
- inadequate access to sanitation and other infrastructure

- poor structural quality of housing
- overcrowding
- insecure residential status

The UN Millennium Declaration raised the profile of slum dwellers when it included Target 11 under Millennium Development Goal 7: "By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers." The indicator to measure progress towards this goal is the proportion of households with access to secure tenure (UNHABITAT 2005). Rising inequities in health outcomes and socioeconomic status within countries threaten progress towards Target 11. Reducing such inequities is increasingly becoming a focus of development programs, yet significant challenges remain in the ability to measure baseline health status and track changes over time (UNHABITAT 2003).

About one billion people worldwide live in urban slums, and one out of three urban residents lives in inadequate housing with no or few basic services. By 2020, UNHABITAT projects the slum population to reach 1.4 billion (UNHABITAT 2006). UNFPA estimates that over 70 percent of urban sub-Saharan Africa's population lives in slum conditions (UNFPA 2007). Urban population growth in Ghana far outpaces rural growth, at a rate of 3.5 percent in urban areas compared to 0.5 percent in rural areas (UN Statistics Division 2011). While demographic and health data are not consistently available for many slum areas around the world, a recent UNHABITAT study found that in spite of the global decrease in mortality among children under five in urban areas, mortality rates can be up to five times higher for slum than for non-slum groups (UNHABITAT 2006).

The most recent estimates of child mortality in Ghana available from the 2008 DHS indicate that child mortality rates have declined in the most recent five year period (Ghana Statistical Service (GSS), Ghana Health Service (GHS) et al. 2009). The 2008 estimates suggest the resumption of a downward trend in child mortality which began in 1993 yet stalled during the subsequent 10 years.

National rates of mortality for the five-year period prior to the 2008 DHS estimate that 80 deaths per thousand occurred to children under the age of five (Ghana Statistical Service (GSS), Ghana Health Service (GHS) et al. 2009) (Table 3.1). Infant deaths made up a large share of these deaths, about 50 per thousand, and among those who survive the first year, about 31 per thousand died before reaching their fifth birthday. These national figures obscure wide regional differences in both levels and trends. Regional rates of mortality calculated for the 10-year period prior to the survey give some indication of this variation. Under-five mortality rates range from 50 in Greater Accra and Volta to over 130 in Northern and Upper West regions. In rural areas, under-five mortality was 91, compared to 75 in urban areas.

Trends in urban and rural mortality rates calculated from DHS data for ten year periods prior to each survey indicate a general downward trend at the national level, from 154 to 85 over the 30 year period (Figure 3.1). However, comparisons between urban and rural areas show that infant and under-five mortality in urban areas has either increased or stalled in the decline. In urban areas, under-five mortality was hardly different between the 1998 and 2008 periods: 77 in 1998, and 75 in 2008. Infant mortality was 42 in urban areas in the 1998 period, and 49 in the 2008 period. These figures presumably mask variation within urban areas in Ghana.

Accra is the capital and the largest city in Ghana, with approximately 2.1 million residents (UN Statistics Division 2011). Recent studies of women's health in Accra suggest substantial spatial heterogeneity in health outcomes and child mortality within the city (Weeks, Hill et al. 2006; Stoler, Weeks et al. 2009). A number of recent studies on Accra examine a variety of topics including food security and livelihoods of Accra residents (Maxwell, Levin et al. 2000), diabetes (Amoah, Owusu et al. 2002), urban pollution and chronic disease (Songsore 1993), malaria incidence and case management (Biritwum, Welbeck et al. 2000), and general health (Hill, Darko et al. 2007). Yet none of these studies focuses on differences between slum and non-slum urban residents, and no study has attempted to describe the health status or mortality rates of slum dwellers in Accra as compared to non-slum dwellers.

In this analysis, we explore the possibilities of another approach to the understanding of child mortality trends at a local level. In this application, we show how two independent household surveys for the same geographical areas can be used to measure recent trends and differentials in child mortality over relatively short periods. Although the populations in the two surveys are independent samples, they share a common set of exposures in that housing and living conditions may change more slowly over the five intervening years. The analysis illustrates the importance of individual level analysis for small areas to understand mortality changes over time. The importance of this work is related to the growing salience of urban populations in the overall development of low-income countries.

Aims of this analysis:

The purpose of this study is to compare child mortality rates for slum and non-slum areas of Accra, Ghana using DHS and similar cross-sectional surveys for slum and non-slum areas from two time points: 2003 and 2008/9. A secondary aim is to identify and compare the determinants of mortality between slum and non-slum areas.

Data

The data for this study come from four sources: the 2003 UNHABITAT household survey of slum areas in Accra, the 2008/9 Housing and Welfare Study of Accra (HAWS), and the 2003 and 2008 Demographic and Health Surveys. The UNHABITAT and HAWS data provide household level data for the slum areas, while the DHS contains household level data for the non-slum areas (Figure 2). The slum attribute was defined by the Ghana Statistical Services (GSS), and was designated to enumeration areas (EA) ranked in the bottom quartile on an index based on the housing and socioeconomic characteristics from the 2000 Census (Megill 2002). The GSS index included the following household level dwelling characteristics: lighting, water supply, toilet facilities, cooking fuel, cooking space, bathing facilities, and highest level of schooling and educational grade by any member of the household (Megill 2002). The index approximates the UNHABITAT guidelines for the use of household survey data to identify slum areas based on household characteristics (UNHABITAT 2003). The DHS samples in 2003 and 2008 did not stratify the sample selection on slum areas; the Accra samples did not include any of the slum EAs selected and surveyed by UNHABITAT or HAWS (Figure 3.2).

All survey protocols were approved by the Noguchi Memorial Institute for Medical Research Institutional Review Board (NMIMR). The DHS surveys also received approval from the Macro Institutional Review Board (Ghana Statistical Service (GSS), Noguchi Memorial Institute for Medical Research (NMIMR) et al. 2004; Ghana Statistical Service (GSS), Ghana Health Service (GHS) et al. 2009). In addition to the NMIMR approval, the HAWS study protocol also received approval from the Harvard School of Public Health Institutional Review Board in 2009.

UNHABITAT 2003

The household-based sample for this survey was selected from 37 enumeration areas drawn from 433 EAs in the bottom quartile of 1,731 EAs in Accra according to the socioeconomic ranking (Megill 2002). The 2003 UNHABITAT survey, an extension of the 2003 DHS fieldwork, used the questionnaires of the 2003 DHS to assess the health and demographic status of the population living in these slum areas. As in the 2003 DHS, biomarker data for height, weight, and hemoglobin were collected, but blood samples for HIV tests were not collected. The 2003 UNHABITAT study was implemented by UNHABITAT and GSS shortly after the 2003 DHS fieldwork was completed. The recoded dataset of completed household and individual interviews, processed and coded following the DHS protocols and data processing programs, was obtained from the GSS. A total of 759 households completed the household interview; all women between the ages of 15 and 49 in the selected households were eligible to respond to the individual interview. A total of 688 women were interviewed in the selected households since some contained no eligible women. The survey was carried out from September to November, 2003.

HAWS 2009-10

A team of researchers from the University of Ghana at Legon and Harvard School of Public Health, directed by the author, relisted the 37 slum EAs to select a new sample of households to be interviewed in 2009. The aim of the HAWS survey was to assess the current health status and living standards of the population in these slum areas as they were defined in 2003. The 37 slum EAs were listed during July and August 2009.[1] From this listing, a total of 1,740 households were systematically selected (every 8th household) for interview. Of these, 64 households refused to participate in the survey, and there were no eligible women in 395 households. Interviewer training and the supervision of the pretest by the author were carried out in August 2009. Main fieldwork for the survey began in September 2009, and was completed in March 2010.

The survey consisted of a household interview and individual interviews with all women aged 18 and above in the household. The household questionnaire developed in final form by the author included a household schedule of age, sex and educational attainment of all household members, as well as asset ownership and housing characteristics. The individual woman's questionnaire consisted of sections on background characteristics, migration, health insurance, general health, mental health, nutrition, malaria, a full pregnancy history, pre- and post-natal care and immunizations for children born in the last five years, marriage and sexual activity, reproductive health,

[1] Household listing in one EA, Agbogbloshi, was interrupted due to political instability in August 2009; the final sample from this EA was selected from the listed segment, representing approximately 30% of the total geographical size of the EA populated with housing structures.

family planning, and fertility preferences. In addition, height and weight measurements for all women in the household, and all children under the age of five were collected using height boards for children, portable stadiometers for adults, and SECA solar scales (model 881).[2] Of 2,140 eligible women in participating households, 2,017 women completed the individual interview.

DHS 2003, 2008

The sampling details of the DHS surveys have been described elsewhere (Ghana Statistical Service (GSS), Noguchi Memorial Institute for Medical Research (NMIMR) et al. 2004; Ghana Statistical Service (GSS), Ghana Health Service (GHS) et al. 2009). While both DHS surveys were designed to be representative of the Greater Accra region, the 2003 survey sample excluded the 37 slum EAs, since those were an over-sample of the slum areas identified prior to 2003. Enumeration identifiers were obtained from ICF Macro for the 2008 DHS in order to identify and drop any respondents who resided in slum areas which overlapped with the HAWS study. Five of 35 enumeration area from the 2008 GDHS overlapped with the HAWS study area; these EAs were dropped from the analysis. The DHS samples used in this analysis were restricted to EAs which fell in the Greater Accra area, a representative sample domain in both DHS surveys.

Variables

Maternal, household and child level factors, as well as environmental factors are explored as they relate to the risk of a child's death. Age of mother at time of childbirth, birth intervals, parity, birth order, mother's height, and mother's education level are all

[2] The measuring boards and SECA scales were borrowed from GSS; the same equipment was used for the DHS surveys.

well documented in their influences on childhood mortality outcomes (Hobcraft, McDonald et al. 1985; Rutstein 2000; Black, Morris et al. 2003; Ozaltin, Hill et al. 2010). In addition to these factors, this study specifically identifies the associations between residence in a slum area and childhood mortality. The maternal, child and household level factors are measured at the time of the survey. Exposure time is generated from the full birth histories of all children born to women in each survey. The full birth histories include dates of birth and death for all children. Births in the five years prior to the survey interview are included in this study.

The variables included in this analysis are drawn largely from the Mosley and Chen proximate determinants analytical framework (Mosley and Chen 1984). The Mosley and Chen framework implies that socioeconomic covariates should affect child mortality at later ages more so than at earlier ages, since very young children are often in a more protected environment close to the mother. Early childhood morbidities and mortality is often associated with complications at birth, congenital malformations, and contagious illnesses. After a few months of life, external environmental insults may become more prominent and may have a stronger influence on mortality at older ages (Bourgeois-Pichat 1951; Mosley and Chen 1984). High rates of malnutrition and immunization-preventable disease, for example, may affect children at older ages as they may be more exposed to these causes of morbidity and mortality.

Methods

Life table measures of mortality were calculated for the five-year periods prior to each survey for slum and non-slum areas. In order to control for individual, mother and household characteristics, a survival regression model was used to predict the hazard of dying among all children. Time until death was modeled using a proportional hazards model, where exposure time or time at risk is measured in month increments.

Since it is well known that the first year of life is critical to child survival, the models were applied to three population samples: one that assessed the determinants of infant mortality (1q0), one for child mortality (4q1), and one for all children under five (5q0). The advantage of a proportional hazards model is that it allows the risk of dying to vary across individuals with different background characteristics accounted for in the model. One of the earliest examples to apply a proportional hazards model to study child mortality notes perhaps the most important advantage of the method: a hazards model is not restricted to studying one completed time interval and thus uses age explicitly as a factor in determining risks (Trussell and Hammerslough 1983). While previous literature has shown that simple methods replicate covariate effects and significance compared to proportional hazards estimates for child mortality, interactions between covariates and the underlying risk function can justify the choice of a hazards model (Trussell and Preston 1982).

The following is the hazard model used in this study:

$$h(t/X) = h_0(t)\exp\{\beta_1 X_C + \beta_2 X_M + \beta_3 X_H\}$$

Where:
$h(t/X)$: The hazard of dying
t: Exposure time in months (0-11, 12-59, 0-59 months)
h_0: The baseline hazard of dying
β: The estimated coefficients
X_C: Vector of child level variables
X_M: Vector of mother level variables
X_H: Vector of area level variables

Children born in the five years prior to each survey are included in the analysis; exposure time is measured in months lived. An observation exits from the analysis if the event is observed (infant, child or under-five death); observations are censored if they reach the end of the maximum exposure time without dying.

The proportional hazards model is based on the assumption that the hazard ratio for any two given individuals is constant. In other words, if the logs of both the hazard of dying for children under five in slum areas and the hazard of dying for children under five in non-slum areas are plotted against age, the curves will be parallel. If the curves are not parallel, or if they cross over, the assumption of proportionality is violated. An interaction term (in this case, time and slum) can also be introduced into the model to test proportionality; significance of the term confirms the non-proportionality and the interaction term can then be included in the model to control for this nuisance (Allison 2009).

The four datasets were pooled for this analysis. The pooled sample includes all children born less than 60 months prior to the date of the household interview for that survey. Each model includes fixed effects for birth cohort (survey year), dummy variables for time of survey (2003 or 2008/9) and whether or not the child resided in a slum at the time of interview. All standard errors are clustered at the EA level. Statistical analysis was carried out using Stata MP (StataCorp LP 2011).

Results

The pooled dataset contains information on 1,635 children; 610 in non-slum areas and 1,025 in slum areas. Descriptive statistics on background characteristics and factors included in the models are included in Table 3.2. There were few major differences between slum and non-slum dwellers in 2003. Notably, slum dwellers were less likely to deliver at home and more likely to have trained assistance at delivery compared to their non-slum counterparts. By 2008/9 this gap narrowed; 84 percent of slum dwellers reported trained assistance at delivery for the last birth, while 82 percent of non-slum dwellers reported trained assistance. In 2003, five percent of non-slum dwellers relied on sachet water for drinking. Sachet water is packaged in small disposable bags, and tests have shown that it is generally uncontaminated (G Kwakye-Nuako 2007). No slum dwellers reported relying on sachet water in 2003. But this changed dramatically; by 2009, 43 percent of slum dwellers relied on sachet water, while 31 percent of non-slum dwellers did.

Unadjusted life table mortality rates are presented for the five year periods prior to each survey in Table 3.3. None of these differences are statistically significant. The wide confidence intervals reflect the uncertainty due to the small sample size.

Hazard model results

Cox proportional hazard model results for infant, child and under-five mortality among all children born five years prior to the survey are presented in Tables 3.4, 3.5 and 3.6. All models estimate the hazard of dying, where age or exposure time is measured in single months. Fixed effects for birth cohort (year of birth) are included in all models. Standard errors are clustered at the EA level.

Under-five mortality

The hazards of dying among children born in the five years prior to each survey are presented in Table 3.4. Among children living in slum areas, the hazard of dying by age five is about 70 percent lower than that for non-slum dwellers. This relationship is significant and stable across various model specifications, regardless of whether time of the survey is included in the model. When an interaction term of slum and time is included in the model, the interaction term and time are both highly significant and indicate a more rapid downward trend in mortality risks among slum dwellers over time compared to the trend and level among non-slum dwellers. Over time, mortality rates decline significantly, regardless of whether slum is included in the model. These results echo the descriptive findings in Table 3.2 where life table mortality estimates among children under five declined among all children, yet the rates declined faster among slum dwellers compared to non-slum dwellers. Over time, mortality declines in both slum and non-slum areas. When an interaction effect of time and slum is included in the model, the interaction term becomes significant while the significance of the slum term disappears. This indicates that mortality declines in slum areas have occurred at a greater pace than declines in non-slum areas. However, the coefficient on time is practically zero, so in spite of the significance, adjusted mortality rates may have declined little over time in either slums or non-slums.

Mother’s height is inversely associated with under-five mortality, and this association is significant and unchanging across various model specifications. Multiple births experience more than two and a half times greater hazards of dying compared to singleton births; this significant association persists across all model specifications. As expected, births with preceding intervals below 24 months or longer than 59 months experience significantly higher hazards of dying. Female children experience about the same hazard of dying as male children. The total number of children ever born to the mother is positively associated with mortality across all models. The hazards of dying for children under five born to women who have lived in their current place of residence for any period of time greater than one year are lower compared to recent movers who have lived in their current residence for less than one year, representing exposures accumulated in a different location. The pattern suggests immunity buildup or adaptation after a year, and wearing off of that immunity after 10 years.

Use of sachet water has grown tremendously in Accra since 2003, when no one in slum areas and only five percent of the non-slum population relied on this source for their drinking water. The use of sachet water was not collected in the 2000 Ghana census and so it was not included in the socioeconomic ranking which was used to identify slum areas in 2003. A term was included in the models for use of sachet drinking water in the household. The use of sachet water reduces the hazard of dying by about 55 percent, and this effect remains the same in all but the full model, where the statistical significance disappears yet the effect size remains practically unchanged.

Infant mortality

The hazard ratios of mortality among all children born in the five years prior to each survey and surviving or dying before age one are presented in Table 3.5. The risk of dying for infants is not significantly different for slum dwellers compared to non-slum dwellers. This effect changes little across multiple model specifications. In a reduced model, the interaction effect of time and slum residence is significant and implausibly greater than one, though the significance of the term drops out in the full model.

Multiple births experience more than two times the hazards of dying of singleton births. The greater the total number of children born to the mother, the significantly greater the hazard of dying is among infants. Taller stature of mother is associated with a slightly lower risk of dying among infants.

Child mortality

The Cox proportional hazard ratios in Table 3.6 are for children between the ages of one and five born one to five years prior to each survey. As for infants and children under five, children aged one to five of women who lived in slums at the time of the survey experience about 65 percent lower hazards of dying compared to their non-slum dwelling counterparts. Across various model specifications, the risk of dying is constant and significantly lower among slum dwellers. The significant interaction term for slum and time indicates that among children between ages one and five, the reduction in mortality risk over time was faster in slum areas. The use of sachet water is significantly associated with lower hazards of dying across all model specifications.

As for infants and all children under five, multiple births among children age one to five experience mortality rates more than twice as high as singleton births. Short birth intervals increase the risk of dying, as do greater than five year intervals. These effects are significant and constant across various model specifications.

Test for proportional hazards

In order to address the potential concern of non-proportional hazards between slum and non-slum dwellers over time, Kaplan-Meier survivor curves among the three age groups presented in Figures 3.3 and 3.4 suggest no significant differences in trends over time for slum dwellers compared to non-slum dwellers. However, some crossovers do occur. In order to account for potential non-proportionality, the interaction term of slum and time was fitted in each model. If the hazards are not proportional, the inclusion of the interaction term in the models can account for this violation of the proportional hazards assumption.

Data quality

Among the potential threats to the validity of this study is data quality. The analysis depends on the assumption that the information gathered in the full birth history is accurate. In a review of approaches to measure child mortality, Hill concludes that full birth histories generally provide good information on child mortality (Hill 1991). Nonetheless, the quality of birth history information is highly dependent on the training and fieldwork implementation of a survey. An assessment of the age of death in months, and age distribution of children under five is included in Table 3.7. Poor data quality can lead to under or overestimation of mortality rates. Transference of dates of birth or death can also affect mortality rates. Among deaths of children reported as occurring at 12 months, if deaths actually occurred before age 12 months, then we will underestimate infant mortality. If they occurred after 12 months, we will overestimate child mortality.

Omission of births may also result in under or overestimation of mortality if deaths occurred differentially in omitted births. Omission of children who have died can lead to underestimates of infant and child mortality rates; this may occur if a respondent does not wish to recall a painful memory, or may misunderstand the question (Curtis 1995) Displacement of ages outside of the eligibility window for the child health section of the questionnaires can have the same implications as omissions. A recent DHS study of data quality for 34 surveys found that more than 10 percent of children who were actually born in the first year of the eligibility window were transferred to the preceding year, resulting in a lighter workload for surveyors (Pullum 2006). Dropping children with incomplete information may also bias mortality results downward, as missing year and month of birth is more likely to occur among children who have died (Chidambaram and Sathar 1984; Sullivan, Bicego et al. 1990). Missing dates of birth and death in DHS, UNHABITAT and HAWS data were imputed according to the DHS Editing Manual (http://www.measuredhs.com/pubs/pdf/DHSG3/DHS_Data_Editing.pdf).

Births by calendar year for each survey are presented in Table 3.7. The DHS data indicate that all birth dates were 100 percent complete in Greater Accra. This is not surprising since DHS data collection rules stipulate that interviewers must record dates or ages for births and deaths; if the respondent cannot recall events, the interviewer uses specific probing techniques including using last-resort ancillary information on other births and deaths to estimate dates and ages during the interview (Curtis 1995). Furthermore, DHS interviewers are trained to probe further when the difference between births is more than four years. The UNHABITAT and HAWS surveys indicate somewhat less than 100 percent completeness. The UNHABITAT survey indicates missing information for one out of six children who died among births in 2000. The HAWS data ranged between 97 and 99 percent complete for living children born between 2005 and 2009. Completeness of dates among children who died was generally high, with the exception of 2006.

The calendar year ratios of births suggest some displacement or transfers of births outside the five-year period prior to the survey. High ratios for the total births and total deaths for the given year five years prior to the survey (1999, 2004 and 2005) compared to ratios below 100 for the year following suggest some transference of births outside the five-year period. This pattern is typical for many DHS surveys (Pullum 2006).

The distribution of age in months among all children born in the five years prior to the survey shows a somewhat uneven distribution of children younger and older than 12 months. The peaks occur around 6 months, 12 months, 30 months, and subsequent 12 month intervals. The distribution of age in months at death shows the expected pattern of the majority of deaths occurring in the first month of life, and thereafter within the first six months of life. Age at death is then heaped at 24 and 36 months, most likely reflecting the editing and imputation procedure for DHS (http://www.measuredhs.com/pubs/pdf/DHSG3/DHS_Data_Editing.pdf). Neither distribution suggests serious concerns with the distribution of ages, or ages at time of death among children born in the five years prior to each survey.

Discussion

On a methodological level, this paper underlines the importance of individual level data collected at two or more points in time. For the short term monitoring of child mortality, it is often thought that the only alternative to full vital registration is a longitudinal study following the same population over a number of years. These longitudinal studies have now become widespread in developing countries and have been coordinated by the INDEPTH network (http://www.indepth-network.org/). These demographic surveillance sites have contributed a great deal to understanding of the factors driving changes in child mortality but they are extremely expensive to run and inevitably restricted to quite small populations, with the exception of Matlab, Bangladesh. Here, without necessarily following the same individuals over a number of years with all the concomitant costs, we have shown that by chaining together several surveys for the same geographical areas, we can generate meaningful child mortality measures and determinants. This approach obviates many of the difficult technical issues associated with matching individuals from successive surveys or censuses. The method thus holds out the prospect of being able to repeat this form of analysis for other populations. One important condition arising from this work is the need for the samples from the successive surveys to come from the same geographical areas. In Accra, we return to the same enumeration areas identified at baseline but it is not out of the question, provided latitude and longitude coordinates or enumeration area identifiers were available, for future analysis to use DHS clusters within some predefined distance of each other from successive surveys.

The substantive findings confirm declines in all measures of early childhood mortality in Accra from 1999 to 2008. Mortality among children in slums decreased at a significantly faster rate than elsewhere in Accra. Significant reductions in mortality occurred among one to five-year old children. Among these, children living in slums experienced about 65 percent lower hazards of dying compared to their non-slum dwelling counterparts.

The maternal and child level indicators confirmed the influence of known factors on child mortality outcomes. The multiple birth effect of significantly increasing the hazards of dying was present in all models. The effect was significant among infants and for children under five.

By adding and exponentiating coefficients from the full model for slum residence and sachet water use, groups can be compared. Among children age one to five, coefficients were combined from model 6. Children age one to five of mothers living in slums using sachet water experienced 84 percent lower hazards of dying than their non-slum non-sachet water counterparts. The pattern remains when examining hazard ratios for all children under the age of five. Slum dwellers that use sachet water have a 60 to 70 percent lower risk of dying, across multiple model specifications.

While the variables listed above have been shown to relate to mortality outcomes, a number of variables are omitted from this study: nutrition intake, anthropometric measures, vaccination status, and malaria transmission or treatment, among others. It is also well known that these factors strongly relate to mortality risks, yet information on these factors was not collected for children who have died in any of the surveys used here. To the extent that these factors are positively related to the risk of dying and factors already in the models, the study here may over- or underestimate the true risks by omitting these variables. Negative associations may result in over or underestimates in this study.

The findings in this study contradict conventional wisdom about the health and mortality status of young children who live in poor conditions (Fink, Günther et al. 2011). There are a number of reasons that could support the findings in this study, though data are not available to test them. Slum dwellers exhibit slightly higher rates of mobility than non-slum dwellers, and the population in slums may have changed. The slum areas themselves may have changed, and the areas identified in 2003 may have improved over time.

Clearly one major difference across the time period explored in this study is the reliance on sachet water. There are no representative surveys of the sachet water quality. But it clearly is perceived to be cleaner than other sources, and has rapidly gained popularity as a major source of drinking water for a large proportion of the population. To the extent that child deaths may have been caused by contaminants in dirty water in the past, the rapid take-up of sachet water may help explain the declines in mortality in both slum and non-slum areas. Use of sachet water is more prevalent in slum areas, but it has also grown in non-slum areas.

Recent analysis of DHS data suggests that rural to urban migrants more often have experienced lower mortality than their rural counterparts, and when they arrive in urban areas, they maintain lower mortality rates than their urban counterparts who are not recently-arrived. One interpretation of the findings in this study could be that the mortality rates in the slum areas is perhaps due to recently arrived migrants who self-selected to move to Accra, and these migrants experienced already lower rates of mortality, and continue that trend when they arrive in Accra. None of the duration of residence variables in these models was significant, however. Either these measures do not adequately describe the migration patterns, or the factors simply aren't important in this population.

In conclusion, this paper illuminates the intra-urban differentials in mortality in Accra which have previously been unstudied. Given the expected rates of urban growth for the future, it will be even more important to focus on collecting data in urban areas that allows for representative intra-urban comparisons, or to further develop methodologies of matching and multiple imputation to fill in where data is insufficient.

Child survival is clearly a function of effects working at different levels. Whilst Fink et al (2011) have indicated the important role played by both water supply and sanitation, both the mother's characteristics (education, work, income) and the broader environment (access to services, cooking fuel etc.) can affect child mortality. In Accra, with high levels of labor force participation and a growing economy, it seems plausible that families, although resident in poor quality housing, are able to protect the health of their children by the provision of clean drinking water bought in sachets and by extensive use of the public health services, many provided free at point of service or at subsidized rates thanks to national health insurance.

Tables

Table 3.1. Life table mortality rates by geographic region for the 10 year period prior to the survey, Ghana DHS 2008.

	Neonatal mortality (NN)	Postneonatal mortality (PNN)	Infant mortality (1q0)	Childhood mortality (4q1)	Under-5 mortality (5q0)
Region					
Western	40	11	52	14	65
Central	47	26	73	38	108
Greater Accra	21	15	36	14	50
Volta	26	11	37	13	50
Eastern	29	25	53	30	81
Ashanti	35	19	54	28	80
Brong-Ahafo	27	10	37	41	76
Northern	35	35	70	72	137
Upper West	45	52	97	50	142
Upper East	17	30	46	33	78
Place of residence					
Urban	30	19	49	27	75
Rural	34	23	56	36	91
Total	32	21	54	33	85

Source: DHS StatCompiler, http://www.statcompiler.com.

Table 3.2. Descriptive statistics for slum and non-slum areas among births in the five years prior to each survey.

	2003						2008/9					
	Non-slum			Slum			Non-slum			Slum		
	n	%	SE	n	%	SE	n	%	SE	n	%	SE
Child level												
Singleton birth	367.0	96%	(0.02)	264.0	98%	(0.01)	325.1	95%	(0.02)	739.7	97%	(0.01)
Female	209.1	55%	(0.03)	130.0	48%	(0.03)	176.1	51%	(0.03)	347.2	46%	(0.03)
Birth interval:												
First birth or >=24 & <59mo	161.6	42%	(0.03)	107.0	40%	(0.03)	136.5	40%	(0.03)	272.4	36%	(0.03)
Birth interval <24mo	33.0	9%	(0.02)	21.0	8%	(0.02)	32.5	9%	(0.03)	44.1	6%	(0.01)
Birth interval >59mo	188.3	49%	(0.03)	142.0	53%	(0.03)	174.3	51%	(0.03)	444.4	58%	(0.03)
Birth order: First birth	103.2	27%	(0.03)	79.0	29%	(0.03)	109.7	32%	(0.03)	233.7	31%	(0.03)
Second birth	98.3	26%	(0.02)	69.0	26%	(0.02)	86.4	25%	(0.03)	179.8	24%	(0.02)
Third birth +	181.5	47%	(0.03)	122.0	45%	(0.03)	147.3	43%	(0.04)	347.4	46%	(0.03)
Child delivered at home	65.4	17%	(0.05)	31.0	11%	(0.03)	50.5	15%	(0.03)	87.4	11%	(0.02)
Doctor/nurse/trained midwife assistance at delivery	303.0	79%	(0.05)	234.0	87%	(0.04)	282.7	82%	(0.03)	638.1	84%	(0.02)
Mother level												
Mother's height (cm)		159.25	(0.46)		159.80	(0.52)		159.00	(0.50)		159.64	(0.41)
Mother's current age												
18-19	11.5	3%	(0.01)	4.0	1%	(0.01)	8.4	2%	(0.01)	56.0	7%	(0.04)
20-24	58.3	15%	(0.02)	59.0	22%	(0.03)	54.9	16%	(0.03)	158.3	21%	(0.03)
25-29	102.6	27%	(0.03)	74.0	27%	(0.04)	104.9	31%	(0.05)	233.4	31%	(0.03)
30-34	111.6	29%	(0.03)	74.0	27%	(0.03)	92.2	27%	(0.04)	130.6	17%	(0.02)
35-39	55.8	15%	(0.03)	44.0	16%	(0.03)	57.0	17%	(0.03)	128.2	17%	(0.02)
40-44	34.3	9%	(0.02)	13.0	5%	(0.01)	19.8	6%	(0.02)	49.4	6%	(0.01)
45-49	8.8	2%	(0.01)	2.0	1%	(0.01)	6.1	2%	(0.01)	5.0	1%	(0.00)
Mean age of childbearing		28.1	(0.50)		27.0	(0.39)		27.7	(0.52)		26.6	(0.51)

Table 3.2 continued

	2003						2008/9					
	Non-slum			Slum			Non-slum			Slum		
	n	%	SE	n	%	SE	n	%	SE	n	%	SE
Mean total children ever born		3.1	(0.15)		2.9	(0.11)		2.8	(0.11)		2.7	(0.10)
Mother's age at birth: <20	30.7	8%	(0.02)	23.0	9%	(0.02)	26.0	8%	(0.02)	111.5	15%	(0.04)
20-39	326.7	85%	(0.02)	242.0	90%	(0.02)	303.4	88%	(0.02)	631.9	83%	(0.04)
40+	25.5	7%	(0.02)	5.0	2%	(0.01)	13.9	4%	(0.01)	17.5	2%	(0.01)
No education	69.3	18%	(0.04)	50.0	19%	(0.03)	41.7	12%	(0.03)	172.4	23%	(0.04)
Primary education	98.1	26%	(0.03)	64.0	24%	(0.04)	73.0	21%	(0.04)	160.9	21%	(0.02)
Secondary education	215.5	56%	(0.04)	156.0	58%	(0.04)	228.6	67%	(0.05)	427.5	56%	(0.04)
Current residence <1yr	39.5	10%	(0.02)	20.0	7%	(0.02)	25.3	7%	(0.02)	16.1	2%	(0.01)
1-4 yrs	121.4	32%	(0.04)	100.0	37%	(0.04)	150.1	44%	(0.04)	326.0	43%	(0.03)
5-9 yrs	85.0	22%	(0.03)	53.0	20%	(0.04)	82.5	24%	(0.02)	182.8	24%	(0.04)
10-14 yrs	38.1	10%	(0.02)	22.0	8%	(0.02)	19.9	6%	(0.02)	64.8	9%	(0.01)
15+ yrs	98.8	26%	(0.04)	75.0	28%	(0.04)	65.5	19%	(0.04)	171.2	23%	(0.04)
Household level												
Primary source of drinking water: sachet	19.8	5%	(0.02)	1.0	0%	(0.00)	107.7	31%	(0.05)	326.7	43%	(0.05)
Total	382.9	100%		270.0	100%		343.3	100%		760.9	100%	

Weighted n and %; PSU-clustered standard errors

Children born in the 5 years prior to the survey interview

Table 3.3. Ghana life table mortality rates.

Life Table Mortality Risks in Childhood for Period 1999 - 2003

	Non-Slums	Slums
Neonatal Mortality Rate	26	37
Post-Neonatal Mortality Rate	11	17
Infant Mortality Rate (1q0)	37	53
(95% Confidence Limits)	(3.9 to 142)	(8.4 to 166)
Child Mortality Rate (4q1)	29	204
Under-five Mortality Rate (5q0)	65	246
(95% Confidence Limits)	(17 to 161)	(95 to 435)
Weighted n	382.9	270.0

Life Table Mortality Risks in Childhood for Period 2004 - 2008

	Non-Slums	Slums
Neonatal Mortality Rate	27	13
Post-Neonatal Mortality Rate	18	17
Infant Mortality Rate (1q0)	45	30
(95% Confidence Limits)	(6 to 154)	(4 to 108)
Child Mortality Rate (4q1)	15	25
Under-five Mortality Rate (5q0)	60	55
(95% Confidence Limits)	(13 to 163)	(14 to 122)
Weighted n	343.3	760.9

Rates per thousand

Data sources: 2003, 2008 DHS surveys. 2003 UNHABITAT. 2008/9 HAWS.

Table 3.4. Hazard ratios of under-five mortality in the five years prior to the survey.

5q0	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Slum area	0.31**		0.29***	0.65	0.31**	0.29***	0.67
	(0.11)		(0.11)	(0.23)	(0.12)	(0.11)	(0.23)
Sachet water	0.43*	0.43*	0.44*	0.48*	0.45*	0.47+	0.52
	(0.15)	(0.16)	(0.16)	(0.18)	(0.18)	(0.19)	(0.22)
Time of survey (2003 reference)		2.0e-14***	1.4e-14***	4.0e-15***		2.9e-14***	1.6e-15***
		(0.00)	(0.00)	(0.00)		(0.00)	(0.00)
Interaction: Slum X Time				0.016***			0.015***
				(0.01)			(0.01)
Multiple birth					2.86**	2.75**	2.69**
					(1.13)	(1.02)	(0.98)
Birth interval >=24 & <59, first birth					1	1	1
Birth interval <24					1.94	1.95	1.70
					(0.82)	(0.82)	(0.69)
Birth interval >59					1.39	1.39	1.35
					(0.37)	(0.37)	(0.37)
Female					0.96	0.97	0.99
					(0.23)	(0.23)	(0.23)
First birth					1	1	1
Second birth					0.53	0.52	0.53
					(0.21)	(0.21)	(0.21)
Third +					0.28**	0.27**	0.28*
					(0.13)	(0.13)	(0.14)
Mother's height					0.98*	0.98*	0.98*
					(0.01)	(0.01)	(0.01)
Total children ever born					1.25*	1.26*	1.28*
					(0.12)	(0.12)	(0.12)
Mother's age at birth <20yrs					1	1	1
20-39					1.15	1.14	1.04
					(0.46)	(0.46)	(0.42)
40+					0.57	0.56	0.52
					(0.53)	(0.51)	(0.46)
No education (mother)					1	1	1
Primary education					0.66	0.67	0.62
					(0.25)	(0.26)	(0.23)
Secondary edu or above					0.68	0.69	0.62
					(0.21)	(0.21)	(0.18)
Current residence <1yr					1	1	1
1-4 yrs					0.74	0.75	0.73
					(0.31)	(0.31)	(0.30)
5-9 yrs					0.86	0.89	0.87
					(0.38)	(0.39)	(0.39)
10-14 yrs					1.06	1.07	1.10
					(0.55)	(0.56)	(0.57)
15+					1.11	1.13	1.14
					(0.48)	(0.49)	(0.50)
Observations	1627	1627	1627	1627	1627	1627	1627

Exponentiated coefficients; Standard errors in parentheses. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.5. Hazard ratios of infant mortality in the five years prior to the survey.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Slum area	0.77		0.71	0.89	0.79	0.72	0.97
	(0.32)		(0.30)	(0.50)	(0.34)	(0.32)	(0.55)
Sachet water	0.46^{+}	0.47^{+}	0.48^{+}	0.49^{+}	0.46^{+}	0.48	0.49
	(0.19)	(0.20)	(0.20)	(0.20)	(0.20)	(0.21)	(0.22)
Time of survey (2003 reference)		6.3e-17***	4.8e-17***	1.5e-16***		9.5e-20	6.4e-18
		(0.00)	(0.00)	(0.00)		(0.00)	(0.00)
Interaction: Slum X Time				0.65			0.55
				(0.53)			(0.46)
Multiple birth					2.60*	2.43*	2.38*
					(1.13)	(0.98)	(0.96)
Birth interval >=24 & <59, first birth					1	1	1
Birth interval <24					2.53^{+}	2.50	2.42
					(1.43)	(1.41)	(1.34)
Birth interval >59					0.83	0.81	0.80
					(0.38)	(0.37)	(0.37)
Female					0.77	0.78	0.78
					(0.27)	(0.27)	(0.27)
First birth					1	1	1
Second birth					0.22*	0.21*	0.21*
					(0.14)	(0.13)	(0.13)
Third +					0.29	0.28	0.27
					(0.25)	(0.24)	(0.24)
Mother’s height					0.97**	0.97**	0.97**
					(0.01)	(0.01)	(0.01)
Total children ever born					1.33*	1.34*	1.35*
					(0.17)	(0.18)	(0.19)
Mother’s age at birth <20yrs					1	1	1
20-39					0.62	0.61	0.59
					(0.27)	(0.26)	(0.24)
40+					0.51	0.49	0.48
					(0.46)	(0.44)	(0.43)
No education (mother)					1	1	1
Primary education					1.10	1.11	1.08
					(0.54)	(0.54)	(0.53)
Secondary edu or above					1.28	1.30	1.27
					(0.45)	(0.46)	(0.45)
Current residence <1yr					1	1	1
1-4 yrs					2.32	2.36	2.36
					(1.52)	(1.57)	(1.60)
5-9 yrs					2.56	2.68	2.69
					(1.79)	(1.90)	(1.94)
10-14 yrs					2.16	2.17	2.19
					(1.99)	(2.00)	(2.05)
15+					2.31	2.39	2.43
					(1.70)	(1.77)	(1.84)
Observations	1600	1600	1600	1600	1600	1600	1600

Exponentiated coefficients; Standard errors in parentheses. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.6. Hazard ratios of child mortality in the five years prior to the survey.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Slum area	0.36**		0.36**	0.75	0.35**	0.35**	0.73
	(0.14)		(0.14)	(0.27)	(0.13)	(0.13)	(0.26)
Sachet water	0.42*	0.41*	0.42*	0.47*	0.46*	0.46*	0.51+
	(0.15)	(0.14)	(0.15)	(0.17)	(0.18)	(0.18)	(0.21)
Time of survey (2003 reference)		1	1	1		1	1
Interaction: Slum X Time				0.018***			0.017***
				(0.02)			(0.01)
Multiple birth					2.15+	2.15+	2.05
					(0.97)	(0.97)	(0.93)
Birth interval >=24 & <59, first birth					1	1	1
Birth interval <24					2.12+	2.12+	1.89
					(0.91)	(0.91)	(0.78)
Birth interval >59					1.53	1.53	1.51
					(0.43)	(0.43)	(0.44)
Female					0.96	0.96	0.99
					(0.25)	(0.25)	(0.25)
First birth					1	1	1
Second birth					0.84	0.84	0.87
					(0.34)	(0.34)	(0.35)
Third +					0.48	0.48	0.53
					(0.25)	(0.25)	(0.28)
Mother's height					0.98	0.98	0.98
					(0.01)	(0.01)	(0.01)
Total children ever born					1.12	1.12	1.12
					(0.12)	(0.12)	(0.13)
Mother's age at birth <20yrs					1	1	1
20-39					0.88	0.88	0.80
					(0.38)	(0.38)	(0.35)
40+					0.50	0.50	0.47
					(0.49)	(0.49)	(0.46)
No education (mother)					1	1	1
Primary education					0.72	0.72	0.68
					(0.30)	(0.30)	(0.28)
Secondary edu or above					0.73	0.73	0.68
					(0.26)	(0.26)	(0.23)
Current residence <1yr					1	1	1
1-4 yrs					0.78	0.78	0.78
					(0.36)	(0.36)	(0.36)
5-9 yrs					1.00	1.00	0.99
					(0.52)	(0.52)	(0.52)
10-14 yrs					1.31	1.31	1.39
					(0.75)	(0.75)	(0.81)
15+					1.17	1.17	1.19
					(0.57)	(0.57)	(0.59)
Observations	1295	1295	1295	1295	1295	1295	1295

Exponentiated coefficients; Standard errors in parentheses

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.7. Completeness of dates of birth and death for slum and non-slum areas.

	Number of Births			Number with Complete Birth Date			Percentage with Complete birth Date			Sex Ratio at Birth[1]			Calendar Year Ratio[2]		
Calendar Year	**Living**	**Dead**	**Total**	**Living**	**Dead**	**Total**	**Living**	**Dead**	**Total**	**Living**	**Dead**	**Total**	**Living**	**Dead**	**Total**
DHS, non-slum															
1998	11	2	13	11	2	13	100%	100%	100%	83.3	na	62.5	na	na	na
1999	70	6	76	70	6	76	100%	100%	100%	70.7	20.0	65.2	177.2	200.0	178.8
2000	68	4	72	68	4	72	100%	100%	100%	94.3	100.0	94.6	112.4	88.9	110.8
2001	51	3	54	51	3	54	100%	100%	100%	131.8	200.0	134.8	71.3	75.0	71.5
2002	75	4	79	75	4	79	100%	100%	100%	97.4	300.0	102.6	170.5	160.0	169.9
2003	37	2	39	37	2	39	100%	100%	100%	94.7	100.0	95.0	na	na	na
Total	312	21	333	312	21	333	100%	100%	100%	93.8	75.0	92.5	na	na	na
UNHABITAT, slum															
1998	4	0	4	4	0	4	100%	na	100%	300.0	na	300.0	na	na	na
1999	59	4	63	59	4	63	100%	100%	100%	96.7	na	110.0	245.8	133.3	233.3
2000	44	6	50	44	5	49	100%	83%	98%	144.4	50.0	127.3	85.4	200.0	91.7
2001	44	2	46	44	2	46	100%	100%	100%	83.3	na	91.7	90.7	50.0	87.6
2002	53	2	55	53	2	55	100%	100%	100%	112.0	100.0	111.5	111.6	133.3	112.2
2003	51	1	52	51	1	52	100%	100%	100%	88.9	na	92.6	na	na	na
Total	255	15	270	255	14	269	100%	93%	100%	104.0	200.0	107.7	na	na	na

Table 3.7 continued

Calendar Year	Number of Births			Number with Complete Birth Date			Percentage with Complete birth Date			Sex Ratio at Birth[1]			Calendar Year Ratio[2]		
	Living	Dead	Total	Living	Dead	Total	Living	Dead	Total	Living	Dead	Total	Living	Dead	Total
DHS, non-slum															
2003	11	1	12	11	1	12	100%	100%	100%	83.3	0.0	71.4	na	na	na
2004	56	3	59	56	3	59	100%	100%	100%	143.5	0.0	126.9	196.5	150.0	193.4
2005	46	3	49	46	3	49	100%	100%	100%	70.4	50.0	69.0	86.8	85.7	86.7
2006	50	4	54	50	4	54	100%	100%	100%	117.4	100.0	116.0	108.7	160.0	111.3
2007	46	2	48	46	2	48	100%	100%	100%	84.0	100.0	84.6	89.3	66.7	88.1
2008	53	2	55	53	2	55	100%	100%	100%	65.6	100.0	66.7	na	na	na
Total	262	15	277	262	15	277	100%	100%	100%	92.6	50.0	89.7	na	na	na
HAWS, slum															
2004	7	0	7	7	0	7	100%	na	100%	75.0	na	75.0	na	na	na
2005	129	6	135	125	6	131	97%	100%	97%	74.3	100.0	75.3	189.7	200.0	190.1
2006	129	6	135	126	4	130	98%	67%	96%	111.5	na	121.3	93.8	133.3	95.1
2007	146	3	149	144	3	147	99%	100%	99%	117.9	na	122.4	100.3	46.2	98.0
2008	162	7	169	158	7	165	98%	100%	98%	97.6	16.7	92.0	110.2	155.6	111.6
2009	148	6	154	144	6	150	97%	100%	97%	102.7	100.0	102.6	na	na	na
2010	5	1	6	4	1	5	80%	100%	83%	na	na	na	na	na	na
Total	726	29	755	708	27	735	98%	93%	97%	100.6	141.7	101.9	na	na	na

[1] B_m/B_fx100, where B_m and B_f are the numbers of male and female births

[2] $[2B_x/(B_{x-1}+B_{x+1})]$x100 where B_x is the number of births in a calendar year

Unweighted

Figures

Figure 3.1. Ghana early childhood mortality rates by region for the 0-9 year period prior to each survey, DHS data.

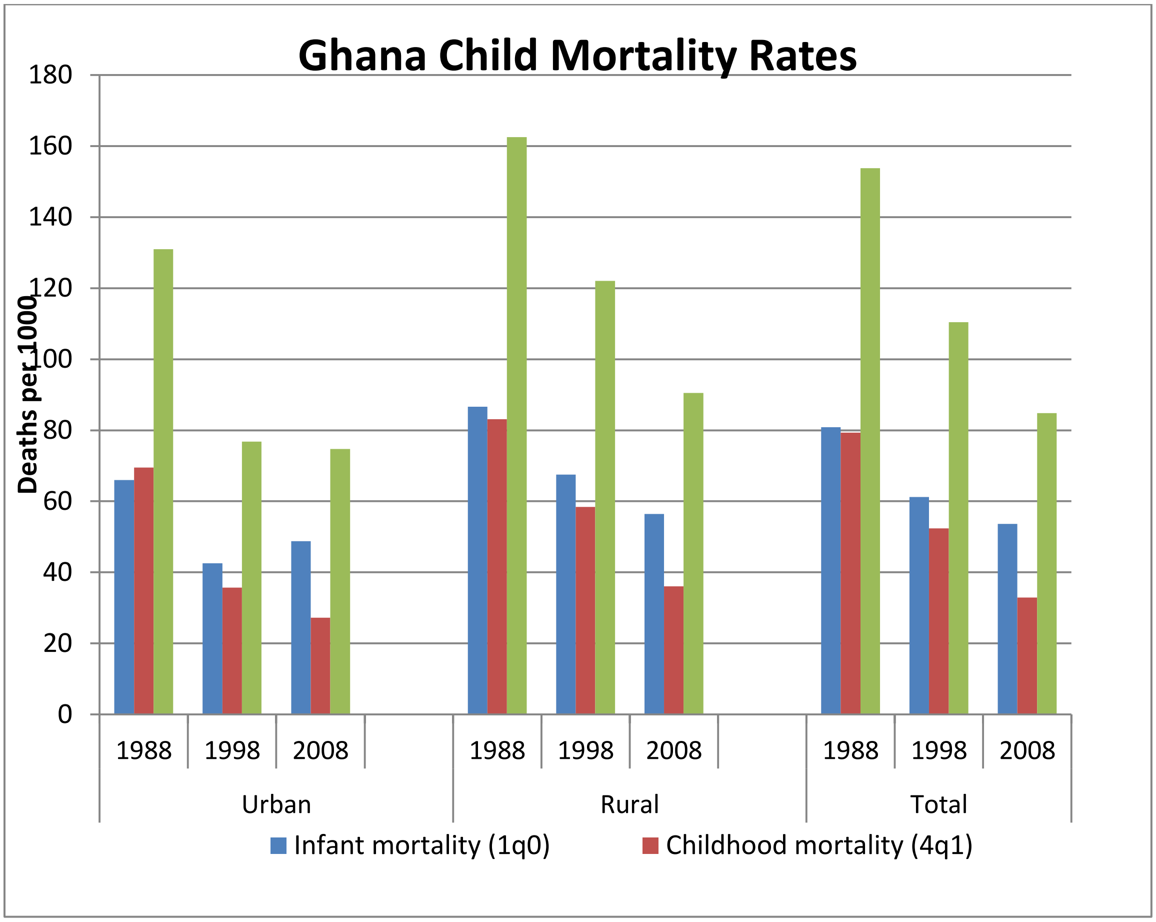


Figure 3.2. DHS, UNHABITAT and HAWS survey locations in Accra, Ghana.

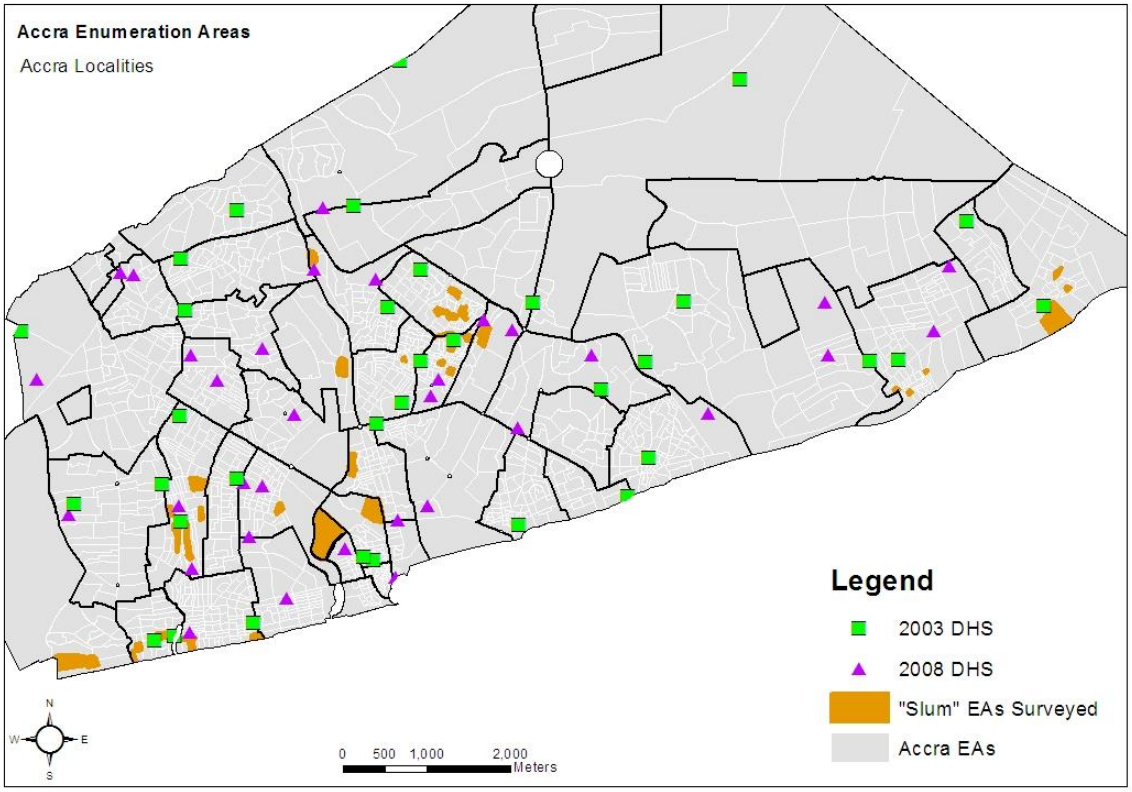


Figure 3.3. Kaplan-Meir survival curves for 1q0 mortality rates among slum and non-slum dwellers, Ghana 2003-2008.

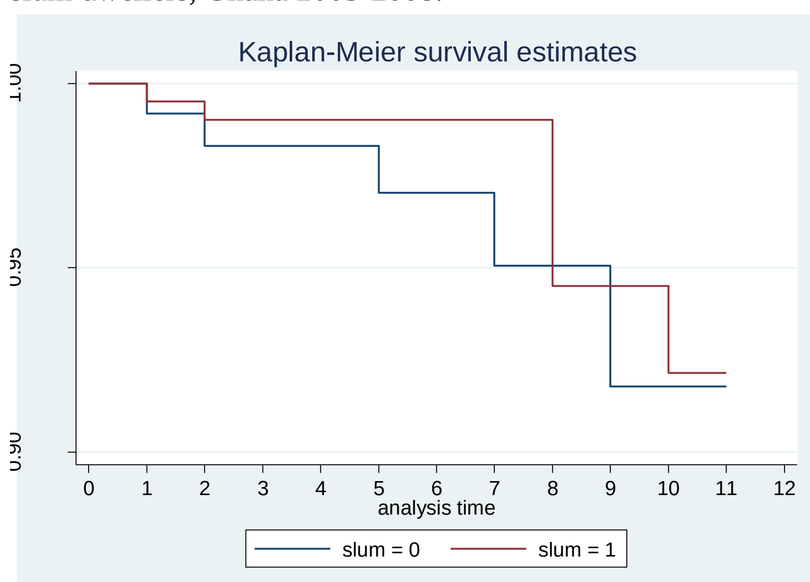
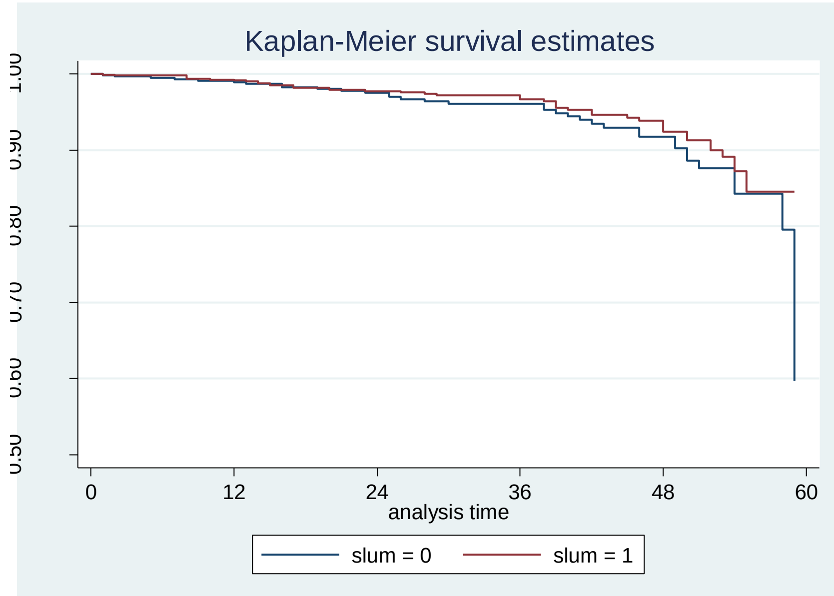


Figure 3.4. Kaplan-Meir survival curves for 5q0 mortality rates among slum and non-slum dwellers, Ghana 2003-2008.



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