URBANIZATION AND DEMOGRAPHIC CHANGE IN SUB-SAHARAN AFRICA: THREE ESSAYS ON FERTILITY AND CHILD MORTALITY DIFFERENTIALS IN A RAPIDLY-URBANIZING CONTEXT

Jamaica Corker

A DISSERTATION

in

Demography

Presented to the Faculties of the University of Pennsylvania

in

Partial Fulfillment of the Requirements for the

Degree of Doctor of Philosophy

2014

Supervisor of Dissertation

____

Michel Guillot
Associate Professor of Sociology

Graduate Group Chairperson

____

Michel Guillot
Associate Professor of Sociology

Dissertation Committee
Michel Guillot Associate Professor of Sociology
Jere R. Behrman William R. Kenan, Jr. Professor of Economics
Emilio A. Parrado Professor of Sociology

URBANIZATION AND DEMOGRAPHIC CHANGE IN SUB-SAHARAN AFRICA: THREE ESSAYS ON FERTILITY AND CHILD MORTALITY DIFFERENTIALS IN A RAPIDLY-URBANIZING CONTEXT

ACKNOWLEDGMENTS

I would like to thank Prof. Michel Guillot, Prof. Jere Behrman and Prof. Emilio Parrado for serving on my dissertation committee and for the excellent guidance they provided me throughout my Ph.D. candidacy. Special thanks to Prof. Deborah Balk for her invaluable assistance with and input on my third chapter, and to the CUNY Institute for Demographic Research for hosting me during numerous trips to NYC throughout 2014. I would like to acknowledge the input of the researchers and colleagues who offered feedback on my second chapter during my research exchange at the Institut National d` Etudes Démographiques (INED) in Paris in the spring of 2014. I am particularly grateful to Rachel Margolis, Apoorva Jadhav and Susan Watkins for reading many versions of the early drafts of my first two chapters and providing me with wonderfully frank and constructive feedback. Finally, I'd like to acknowledge the support provided by my cohort members and the other students of the Graduate Group in Demography at the University of Pennsylvania, all of whom greatly helped to enrich my Ph.D. experience.

ABSTRACT

URBANIZATION AND DEMOGRAPHIC CHANGE IN SUB-SAHARAN AFRICA: THREE ESSAYS ON FERTILITY AND CHILD MORTALITY DIFFERENTIALS IN A RAPIDLY-URBANIZING CONTEXT

Jamaica Corker

Michel Guillot

Nearly all demographic research on sub-Saharan Africa (SSA) utilizes a strict urban/rural dichotomy, which implicitly assumes homogenous demographic outcomes within these categories. In this dissertation, I use data from the Demographic and Health Surveys (DHS) to demonstrate that using an urban continuum reveals substantial differences in the demographic outcomes among SSA's growing urban settlements. In the first chapter, I use event-history analysis to examine whether SSA's long-held urban child survival advantage is diminishing, accounting for differentials in city size and potential bias in survival rates due to migration. I find the overall under-5 survival advantage of urban over rural areas persists but that there is a widening of the advantage in the largest cities over smaller urban areas. In the second chapter, I model annual birth probabilities to examine whether there is a discernible "urban effect" of lower fertility among internal migrants in West Africa. Results suggest an association of urban residence and lower fertility, as women who moved either to or from urban areas have lower annual odds of a birth compared to both rural non-migrants and rural-to-rural migrants. I also find that women who relocate to the largest cities have lower fertility than do women who move to smaller urban areas, suggesting that the influence of urban residence on fertility is

strongest where fertility rates are lowest. In the final chapter, I estimate total fertility rates and under-5 mortality probabilities for cities of different size in West Africa by linking DHS cluster data to census and geographic information systems (GIS) data for four distinct urban sub-categories. Results show a clear gradient in fertility and child mortality in urban areas according to size, with the largest cities most advantaged; this gradient is as steep between the largest and smallest urban areas as it is between the smallest urban and rural areas. I use the findings from this dissertation to argue for wider use of urban continuums in demographic research on SSA instead of the continued reliance on a strict urban/rural dichotomy that obscures important nuances in the interrelationship of urbanization and demographic change in this rapidly-urbanizing region.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 3:

LIST OF ILLUSTRATIONS

PREFACE

Sub-Saharan Africa (SSA) is currently the world's fastest urbanizing region, and is projected to retain that position until 2030 when it will to transition from being predominately rural to predominately urban (UN-Habitat 2010). The United Nations forecasts that between 2005 and 2025, 87% of population growth in Africa will occur in urban areas (UN-Habitat 2003) and while SSA's rapid rate of urbanization is not extraordinary from a global historical perspective, the absolute numbers and the rates of urban growth are unprecedented (National Research Council 2003). Continued rapid urban growth in SSA will likely further strain already over-burdened infrastructure and social services, particularly in the smallest cities which often have the fewest resources available for meeting the needs of growing populations (UN-Habitat 2010; Montgomery 2009).

The dynamics of urbanization and urban growth in SSA are not well understood. In contrast to other regions of the world, the urban transition in SSA has preceded industrialization (Oucho and Gould 1993) and is generally occurring without the concurrent economic growth that accompanied nearly all examples of urbanization elsewhere in the 19th and 20th century (Dyson 2010; Leon 2007). Though the process of urbanization has generally been linked to economic development (Kelley and Williamson 1984b; Davis and Golden 1954), the evidence on the relationship between urbanization and improved living standards, and demographic outcomes, in SSA is less clear. Some research on SSA's current urban transition has voiced concerns over the proliferation of urban slums, declines in urban health indicators and stalls in urban fertility (Gould 1998;

UN-Habitat 2003; Garenne 2008). Yet other studies show that urban dwellers in SSA have better living standards, and higher education levels and enjoy a child survival advantage over their rural counterparts (Brockerhoff 1994; Bocquier 2011), in addition having lower fertility thought to act as the driving force behind the region's fertility transition (Shapiro and Tambashe 2000).

Nearly all demographic research on SSA uses an urban/rural dichotomy, which implicitly assumes that urban areas of vastly different size are undergoing a homogenous process of urban growth. I believe this blunt urban/rural dichotomy may obscure important nuances of the interrelationship of urbanization and demographic change in SSA. I plan to empirically demonstrate this by using more specific urban sub-categories in all three of the chapters in this dissertation.

In the first chapter, I investigate whether rapid urbanization rates in SSA have contributed to a narrowing of the region's historic under-5 urban survival advantage. Using DHS data from ten SSA countries, I measure the aggregate change in this advantage between 1995-2000 and 2005-2010. I find that overall the urban advantage persists and remains virtually unchanged due to similar rates of improvement in child survival in both rural and urban areas. I then examine whether improvements in urban child survival are uniform across urban areas of different sizes by segmenting the largest and fastest growing cities from all other areas defined as urban. Results indicate that there is a widening in the child survival advantage in the largest cities over other urban areas, and that smaller urban areas have seen the slowest improvements in under-5 survival compared to both large cities and rural areas. These findings add support to the literature that finds that rapid urbanization in SSA poses the greatest risk to improvements in child survival in the smaller cities that are likely to see the greatest proportional growth in the coming decades (Brockerhoff and Brennan 1998; Montgomery 2009).

In the second chapter, I seek to determine if there is an “urban effect” on fertility (an association of urban residence and lower fertility exclusive of socio-demographic characteristics) discernable among internal migrants. This chapter uses DHS data from 26 surveys from 11 countries to investigate changes in fertility behavior within the urbanization framework to examine whether residence in a new area following an internal move is associated with changes in fertility behavior, namely lower fertility outcomes. In a departure from most previous research on the fertility/migration residence, I examine whether this effect is strongest among migrants to the largest urban areas, where fertility rates are lowest, and whether an urban effect is also apparent among migrants who move away from urban areas and take up residence in rural areas. I find evidence of reduction in fertility for nearly every migrant group. Analysis in this chapter, however, highlights two methodological issues that challenge research on the migration and fertility literature. First is the difficulty of defining a reference category as counterfactual against which to measure changes in fertility among those who move. Second, models and measurements of fertility among those women who have changed residence type are heavily influenced by natural age patterns of fertility and patterns in the timing of fertility and failing to address these issues can lead to findings that are almost contradictory.

In the third chapter I aim to produce locally informed estimates of fertility and mortality by four categories of city size across West Africa. Chapter 3 extends the work in Chapters 1 and 2 that looks beyond the urban-rural dichotomy by creating a more detailed division of city class sizes inclusive of all urban areas within each country. I find clear evidence of a gradient in urban characteristics and demographic outcomes across urban areas of different size. The largest cities are the most advantaged in terms of access to urban amenities (defined as household electrification, access to improved sanitation and access to safe drinking water), lower fertility and under-5 mortality rates, and the smaller cities most disadvantaged. This chapter has two particularly interesting findings. First, the suburbs (satellite cities) of the largest cities in the region have the lowest fertility and child mortality rates of all urban areas, substantially lower than even those of the largest cities. Second, it is not the category of smallest urban areas but that of the second-smallest category which have the highest fertility and child mortality rates across urban areas. Despite a sharp gradient in fertility and mortality rates as city sizes decrease, even the smallest urban areas have fertility and child mortality that is substantially and significantly lower than those in rural areas; this difference, however, is approximately the same as that between the smallest and largest urban areas. This chapter uses its findings to argue for the need to give greater consideration to using an urban continuum, rather than a simply urban/rural dichotomy, in demographic research in West Africa.

The theme of urbanization in sub-Saharan Africa ties together the three papers presented in this proposal. By examining how changes in fertility, mortality and migration underlie the process of urbanization in SSA, I will explore how the process of urbanization in the region may be influencing and influenced by differential patterns of fertility and child mortality. Through an investigation of the relationship between the urban transition and demographic change, I hope to shed light on the patterns and potential consequences of demographic change for SSA's growing urban settlements. A better and more nuanced understanding of urbanization and differential patterns of child mortality and fertility in SSA is critical for understanding how urbanization may influence demographic outcomes in the region that has the world's highest rates of urbanization, fertility and child mortality.

CHAPTER 1

Under-5 Mortality and City Size in Sub-Saharan Africa: Urban Advantage for All?

Introduction

Sub-Saharan Africa (SSA) is currently urbanizing faster than any other region in the world. From 1990-2010, SSA's average annual urban growth rate was 3.81 per cent, compared with 2.91 for other less developed regions (United Nations 2012). SSA is currently predominately rural but is projected to become majority urban by 2030 (UN-Habitat 2010), during which time continued rapid rates of urban growth are likely to strain already over-burdened urban infrastructure and services throughout the region.

SSA's urban residents, particularly infants and children, have long enjoyed a survival advantage over their rural counterparts. There are indications, however, of recent declines in the urban under-5 mortality advantage that have coincided with rapid rates of urbanization and urban growth throughout the region, though recent literature has provided inconsistent findings (Gould 1998; Fotso 2007; Antai et al. 2010). Several single-country studies suggest that SSA's urban child health advantage is declining (Gould 1998; Macassa *et al*. 2003; Antai and Moradi 2010) but most aggregate or multi-country studies find that the advantage holds (Brockerhoff and Brennan 1998; NCR 2003; van de Poel et al. 2007; Bocquier et al. 2011; Gunther and Harttgen 2012).

This study adds to the growing research that asks whether the under-5 survival advantage of SSA's urban areas is diminishing by accounting for differentials in city size and potential bias in survival rates due to migration during the most recent period of rapid urbanization. Since the 1990s, the majority of research on the under-5 mortality differential in SSA has relied on an urban-rural dichotomy. Combining all urban areas into one category implicitly assumes that changes in child survival chances are uniform across all areas defined as urban and may obscure some of the subtleties of the relationship between residence and child survival in SSA. Additionally, nearly all research on SSA's urban child survival advantage attributes child deaths only to the mother's place of residence at the time of the survey, which can result in biased estimates in areas where migration is high and a considerable proportion of child deaths may have occurred where the child lived before moving.

In this paper, I use Demographic and Health Survey (DHS) data from eleven SSA countries to investigate whether there was an aggregate change in this advantage between 1995-2000 and 2005-2010. I find that the urban advantage persists and remains virtually unchanged due to similar rates of improvement in child survival in rural and urban areas. I then examine whether there is a difference in urban advantage among the largest and fastest growing cities or if improvements are uniform across all areas defined as urban. Results indicate that there is a widening in the survival advantage of children who live in the largest and fastest growing cities over those in other urban areas. To address the potential bias in under-5 survival measurements due to high rates of migration that have accompanied SSA's rapid urbanization, I allocate each migrant child's risk of dying (and, when it occurs, death) to the period of his or her life spent in the place of origin and destination.

Through this analysis I aim to determine whether, apart from individual characteristics, the totality of urban factors offer children a better chance of surviving to age 5 in SSA over time – and whether this geographic advantage differs by city size. I thus focus on comparing averages of under-5 survival probabilities between rural, smaller urban and largest urban areas rather than measuring differences in sub-groups of these populations. These averages no doubt conceal substantial heterogeneity within these populations, particularly intra-urban disparities of child mortality between the poor and non-poor, but the aim here is to explore the combined effect of geographically specific variations in health outcomes on survival probabilities for children in SSA. In a cross-country study aimed at identifying overall patterns and trends, is not possible to account for all the different contextual country- or city-specific factors, particularly those related to urban policies and management, which might explain the child mortality differential across a pooled sample of countries. It is possible, however, to gauge whether there is an overarching pattern in urban and rural mortality rates at the aggregate that is associated with the consequences of continued rapid rates of urbanization and population growth throughout the region.

An accurate accounting of child survival risks by residence is particularly important for SSA because of the massive demographic shift from rural to urban that the region will continue to undergo in the coming decades. SSA's rapid urbanization and population growth, coupled with its high fertility rates and young age structure, mean that any changes in urban child survival probabilities will impact two of the fastest-growing segments of the region's population: children under five and urban residents.

Understanding how urbanization is related to geographic patterns of child mortality in SSA is crucial for informing policies that will influence the geographic distribution of resources to fight the region's high child mortality rates.

Background

Rural-urban mortality differentials

Historically, European and American cities were characterized by an "urban penalty" (Kearns 1988) with mortality rates substantially higher in cities compared to rural areas, particularly for infants and children (Preston and Haines 1991). This was due primarily to the spread of communicable diseases resulting from overcrowding and unsanitary conditions in cities, despite the greater availability of health facilities and higher overall incomes compared to rural areas (Gould 1998). By the twentieth century, however, improvements in public health and sanitation had largely transformed this urban mortality penalty into an urban survival advantage (Preston and Haines 1991; Haines 1995).

Conversely, African cities in the nineteenth and twentieth centuries generally experienced an urban mortality *advantage*. Many of contemporary Africa's largest cities were designated as colonial centres in the nineteenth century with health-related infrastructure and services established for the colonial settlers but with positive spillover effects for local urban populations, which contributed to substantially lower mortality in cities (National Research Council 2003). Studies documenting health differentials in SSA in the mid-twentieth century are few, but show urban survival advantages for infants and children in Zambia (Mitchel 2009) and Sierra Leone (Kandeh 1989).

More recently, several single-country studies using time series data show evidence of a narrowing of the urban child mortality advantage in SSA, notably in Senegal in the 1970s (Antoine and Mbodji 1991) and in Mozambique from 1992[1] (Macassa et al. 2003), while increases in under-5 mortality rates in Nairobi have been cited as an indication of a reversal in Kenya's urban mortality advantage (Gould 1989). Though these studies suggest an erosion of the urban child mortality advantage, each is limited to the experience of a single country at different time points and it is not clear if they represent the current overall trend throughout the region.

Alternatively, a handful of recent multi-country studies have found that SSA's overall urban child mortality advantage persists. Though some of these studies used cross-sectional data (van de Poel et al. 2007; Bocquier et al. 2011), and thus do not measure changes in this advantage, several studies used time series data from across the region and generally find that the urban child survival and health advantage holds, but with some variation in the findings. Fotso et al. (2007) found that urban child mortality in the majority of SSA countries remained unchanged or declined only slightly (although five countries showed sharp declines and three sharp increases) but did not directly compare these with changes in rural rates. Fotso's (2007) investigation of child

[1] The decrease in urban under-5 mortality rates coincided with the end of Mozambique's civil war in 1992 and may have been impacted by the post-conflict environment and higher than normal levels of rural-to-urban migration by those displaced by the conflict.

malnutrition in SSA showed that the urban advantage in child malnutrition had declined notably in six countries, due to increases in urban malnutrition rates, and widened notably in three countries. These and most similar studies look at individual countries to comment on regional trends, rather than measuring changes in the region as a whole. One exception is Gunther and Harttgen's 2012 study which looked at the region as a whole –but not at individual countries– and found that the overall child survival advantage in urban over rural areas holds. The other notable exception is Brockerhoff and Brennan's 1998 study, which looked at child mortality across different world regions disaggregated by city size category. They found that from the 1970s through the early-1990s, SSA had substantial improvements in child survival in rural areas and towns and modest improvements in the largest cities, but declines in overall child survival probabilities in smaller urban areas.

This analysis builds off these previous studies, combining different aspects of several of them and using the most recently available data, but differs from them in two respects. First, it moves beyond the urban/rural dichotomy used in nearly all these studies (with the exception of Brockerhoff and Brennan's 1998 study) by separating the largest and fastest growing cities from all other areas defined as "urban", using a standard cross-country definition. Second, it accounts for the potential bias introduced by migration in cases where a child's mother moved before the child's fifth birthday. With the notable exception of Bocquier et al. (2011), most studies have overlooked the potential migration bias of measuring child mortality rates, despite high rates of internal migration in the region. Failure to account for migration status can introduce bias into estimates of mortality rates if residence at the time of survey is assumed to apply to the entire life span of the child in question, even if the child moved during the exposure period. Here, in cases where a child moved before turning five, his or her risk of dying is divided between previous and current place or residence and death, when it occurs, is attributed to the child's place of residence at that time, which would be different from the mother's residence at the time of survey if the child died before his or her mother's migration.

Explanations for changes in SSA's urban advantage

Recent declines cited in the urban survival advantage in SSA have generally been attributed to stalls or declines in urban under-5 survival rates, rather than to the improvements in rural health that narrowed the mortality gap in the second half of the twentieth century (Gould 1998; UN-Habitat 2003; Fotso et al. 2007). SSA's high rates of urbanization and urban growth are thought to threaten the urban health advantage as increasingly crowded and polluted cities are often unable to provide adequate housing, water and sanitation for their growing populations (Faye et al. 2005; Dyson 2010).

Much of the concern over potential declines in urban child health outcomes is focused on the changing composition of urban dwellers, specifically the growth in the proportion of the urban poor and migrants, and the proliferation of slums throughout the region. The urban poor generally have child health outcomes that are worse than the urban non-poor and, in some cases, worse than their rural counterparts (National Research Council 2003; van de Poel et al. 2007; Montgomery 2009), suggesting that the urban child mortality advantage could narrow if the proportion of urban poor increases. Children of migrants in SSA are usually thought to have worse child health outcomes than those of non-migrants (Brockerhoff and Yang 1994; Brockerhoff 1995; Antai et al. 2010), though more recent work by Bocquier et al. (2011) has questioned whether this is always the case. Low child survival rates among in-migrants could contribute to declining aggregate under-5 survival rates in cities and narrow the urban-rural mortality differential, as was found to be the case in post-war Mozambique (Macassa et al. 2003). Not surprisingly, children in city slums generally have higher mortality rates than those in non-slum areas (UN-Habitat 2003) but it is uncertain whether they face higher mortality risks compared to children in rural areas (Gunther and Harttgen 2012; Fotso et al. 2007). Cities in SSA already have the largest proportion of slum dwellers globally (UN-Habitat 2003), and the continued growth of slums could diminish the urban survival advantage if child mortality rates in slums reach rates that are higher than in both non-slum urban and rural areas.

After controlling for demographic and socio-economic correlates of under-5 mortality, several recent studies have found that the urban child survival advantage decreases or disappears, most notably among the urban poor (Van de Poel et al. 2009; Bocquier et al. 2011). This implies that the urban advantage is primarily a factor of differences in urban-rural population characteristics, primarily greater levels of wealth and higher education in cities, and not due to factors specific to living in an urban area. Yet other research has found the urban child survival advantage is related not to compositional differences in urban and rural populations but to advantages offered by the urban environment, including greater immunization rates, improved infrastructure and better access to health services (National Research Council 2003; Faye et al. 2005). This presents two possible scenarios as they relate to the urban child survival advantage. If access to basic health services and sanitation infrastructure remains superior in cities, despite the strains of rapid population growth, the urban under-5 mortality advantage will hold. Alternatively, the advantage will narrow if there were a greater overall deterioration of living conditions in cities compared to rural areas.

City Size and the Urban Health Advantage

Where a historic urban survival penalty has been identified, there is some evidence that mortality rates have been highest in the largest cities (Cain and Hong 2009), particularly for infants and children (Williamson 1982). More recently, child mortality rates were found to be nearly 20 per cent higher in Nairobi than in other urban areas of Kenya during a period that coincided with particularly rapid population growth in the city (Gould 1998). Mortality rates for children of urban in-migrants in less developed countries were found to be higher in larger compared with smaller cities (Brockerhoff 1995), suggesting an association between the size of an urban area and decreased under-5 survival chances, at least for migrants.

In contemporary SSA, however, it may in fact be smaller cities that face the greatest risks for stalls or declines in child health outcomes. Smaller cities in SSA tend have the greatest proportional growth but often have the fewest resources available for meeting the needs of growing populations (Montgomery 2009; UN-Habitat 2010) and are often relatively underserved by government services, particularly health and hygiene related services, compared to the biggest cities (National Research Council 2003). In contrast to other developing regions of the world, infant mortality rates in SSA from the 1970s to the early 1990s were found to be higher in smaller cities (with populations of 50,000 to 1 million) than in larger urban areas (Brockerhoff and Brennan 1998). With nearly two-thirds of SSA urban dwellers estimated to currently live in cities of fewer than 500,000 (National Research Council 2003) and the majority of urban growth in the coming decades in SSA projected to occur in small- and medium-sized cities (UN-Habitat 2010), this is an alarming finding.

Data

This analysis uses data from eleven SSA countries that had a Standard Demographic and Health Survey (DHS) carried out between 1995–2000 and again between 2005–2010 (Table 1), and which included data from respondents on both migration and type of previous place of residence. Only countries that had surveys carried out during both of these periods were included, in order to use the same number of repeated observations per country and to measure period effects of mortality over a standard time frame. I used these two time periods in order to consider the most recent regional trends[2] (from 2005-2010) and to compare these to trends from approximately ten years prior in the same countries.

The DHS collects nationally representative data in less developed countries

[2] The vast majority of DHS from 2010 forward do not include questions on migration so these surveys are the most recent which can account for respondents' migration.

through household sample surveys that measure health, population, and socioeconomic indicators, with a focus on maternal and child health (Rutstein and Rojas 2006). DHS surveys use standardized variables across surveys in order to be easily comparable across countries. The DHS are cross-sectional surveys and so the time trend analysis in this study is at the aggregate as different areas, but not individual respondents, can be linked between the two surveys.

Table 1: Description of DHS datasets in the analysis

Country	Year of Survey 1 (1995-2000)	Children under 5	Year of Survey 2 (2005-2010)	Children under 5
Benin	*1996*	5,214	*2006*	16,312
Ghana	*1998*	3,342	*2008*	3,032
Kenya	*1998*	5,774	*2008*	6,145
Mali	*1996*	10,403	*2006*	14,462
Niger	*1998*	6,352	*2006*	29,027
Nigeria	*1999*	8,124	*2008*	9,316
Senegal	*1997*	7,482	*2005*	11,129
Uganda	*1995*	7,268	*2006*	8,478
Zambia	*1996*	7,334	*2007*	6,477
Zimbabwe	*1999*	7,394	*2006*	10,680

The two key variables for analysis are child survival and urban/rural residence. The dependent variable is survival from birth to age five for all children born in the five years preceding the survey. Child survival here is measured by under-5 mortality, a combination of infant (0-1 years) and child (1-4 years) mortality, to provide a longer exposure period to conditions that influence determinants of rural-urban disparities in survivorship. Child survival rates are calculated from the birth histories collected from all women surveyed in the DHS. These birth histories include information on parity, month and year of birth, child survivorship status and age at death for children who died. For the latter, age of death is recorded in months for the first two years and then only in years. I limit my analysis to children born within five years of the survey because a) reporting on children born in the recent past tends to be more accurate and reliable than for those born further in the past and b) I aim to capture the most recent trends in under-5 mortality for direct comparisons across the two time periods with no overlap.

The analysis is segmented by residence at two levels: 1) stratified by urban and rural areas and 2) stratified within urban areas by: a) rapidly-growing large cities (RGLCs) and b) all other areas designated as urban in the DHS (see Table 2). This division of urban areas is theoretical as well as practical. Theoretically, if rapid increases in urban population are associated with declining survival outcomes for children under five (Fotso et al. 2007), then the effects would be most evident in the cities experiencing the fastest and/or greatest absolute growth. The practical reasons are factors of data reliability and comparability: although the majority of urban residents in SSA live in small to mid-sized cities, information on the populations or growth of these cities is far less reliable given the variability in quality of country-level data (National Research Council 2003; Montgomery 2009), rendering meaningful cross-country comparisons nearly impossible.

Urban and rural areas, for which there is no standard international definition[3], are identified in the DHS according to each respective country's definition of what constitutes rural or urban residence, and are categorized using the dichotomous variable for urban or rural residence (v102). I also identify a third category of residence: rapidly-growing largest cities (RGLCs), defined here as cities with populations over 750,000 in 2009 that also experienced an average annual growth rate of 2.5% or greater from 1995-2010 (United Nations Population Division 2010) (Table 2). For this third category I use the variable for hierarchy of city type (v026 – which distinguishes between "countryside", "town", "small city" and "capital/large city") and GPS coordinates provided by DHS to spatially locate which clusters correspond to RGLC[4]. Although this allows for an accurate categorization of current place of residence for those living in RGLCs, it is not possible to classify previous place of residence with the same precision; thus respondents who migrated and whose previous place of residence is listed as "capital/large city", are classified as having moved from an RGLC. It is also worth noting that while this categorization allows for a clear identification of RGLCs, "other urban" areas here are still subject to the limitations of the urban/rural dichotomy.

---

[3]There is no international or standardized definition of urban and rural. The designation of an area as urban or rural is often based on administrative boundaries and/or population size, not necessarily on population density or other criteria that may more accurately differentiate urban from rural areas http://unstats.un.org/unsd/demographic/sconcerns/densurb/densurbmethods.htm

[4] Variable v026 was used in the first step to identifying RGLCs. I then used the Global Urban-Rural Mapping Project's (GRUMP) Nighttime Lights database in ArcGIS and Google Earth imaging to verify that all clusters categorized as "capital/largest city" corresponded to RGLC areas. With the exceptions of Nigeria, Ghana and Kenya there is only one RGLC per country and the vast majority of DHS clusters categorized as "capital/largest city" correspond to the RGLC area; only 26 clusters were reclassified. Nigeria, Ghana and Kenya all have more than one urban area classified here as an RGLC but identified by v026 as "small city", so in these cases clusters were individually coded as RGLCs. Ghana 2008 and Nigeria 2008 did not include the variable v026 but did provide cluster GPS coordinates, so for these surveys clusters were individually matched to RGLC areas. For the Benin 2006 DHS neither v026 nor cluster GPS coordinates were provided, so clusters for Cotonou were identified using the variable for "region" (v024) and for urban or rural residence (v025).

All control variables refer to the mother; as the majority of children under five in SSA live with their mothers, any potential bias from separate mother-child residence is believed to be small (Bocquier et al. 2011). Control variables are broadly categorized using the Mosley and Chen (1984) conceptual framework, which outlines the main proximate and socioeconomic determinants of child survival. Proximate determinants are primarily the “biological risk factors” (such as mother’s age, birth interval length and parity) that directly affect child mortality and are also the factors through which socioeconomic determinants impact child survival. Socio-economic factors are distinguished at the individual, household and community levels. Although community-level factors have been shown to play a role in explaining urban/rural child survival differentials (van de Poel et al. 2009), this analysis controls for individual and household determinants only. This paper works off the assumption that there is likely substantial variation in community characteristics within any particular urban area, but that health and infrastructure variables related to child health are generally better at the aggregate in urban compared to rural places.

Individual level controls include: mother’s age at the time of the birth, length of the previous birth interval, parity and mother’s education. Mother’s age at birth is categorized as 19 or younger, 20-35 and 35 or older. A birth interval is considered short if it was less than 24 months after the previous birth and parity is measured for whether or not the child was the firstborn. Educational attainment of mothers is coded as the highest level of education completed: no education, primary, secondary, or higher.

Household level controls include: wealth, main source of drinking water and toilet facility. To approximate household wealth, I create an index using a principal component analysis of common household assets, instead of using the standard DHS wealth index, in order to account separately for two household infrastructure variables, water source and toilet facility, which are strongly associated with child survival and are usually included as factors within the DHS wealth quintiles. I use six household assets (radio, television, bicycle, refrigerator, motorcycle, and car) in addition to the type of flooring in the household, the number of people per room and whether the household has electricity. The first principal component was used to categorize households into thirds (poor, middle and wealthiest). Household wealth was estimated first at the country level (and shown in the descriptive statistics), then separately for the urban and rural samples for each country, and again separately for RGLCs and all other non-RGLC urban areas (used in the multivariate analysis). Dummy variables for a household's access to improved water and type of toilet facility[5] are included as separate variables in order to investigate whether these measures of infrastructure, more commonly found in urban areas, have an impact on under-5 survival independent from that of household wealth.

Migrants are defined here as respondents who have moved within the five years before the year of the interview and are identified using information on current and last place of residence from DHS surveys which includes the respondent's current place of

[5] Categories for improved and unimproved water source and sanitation are based on categories provided by the WHO and UNICEF Joint Monitoring Program for Water Supply and Sanitation (WHO/UNICEF JMP website 2013).A household is considered to have access to safe water if its primary source of drinking water comes from: a private or public tap, a protected well or spring, bottled water or a tanker. A household is considered to have access to improved sanitation if its toilet type is flush or an improved latrine (ventilated, covered with a slab or flush); in many surveys it is not possible to distinguish between private and shared latrines so access to any improved latrine is considered improved access.

residence and how long she has lived in this location. Women who do not respond "always" for the length of time lived in the location of the interview are asked to identify when they moved to their current location. Although this information does not provide a comprehensive migration history, it does identify those who have moved at least once before the survey and accounts for how long they have lived in their current place of residence. Last, a dummy variable was included for the two time periods under consideration, coded as 0 for the earlier period (1995-2000 and 2005-2010).

Methods

First, I show descriptive statistics for the pooled sample, with adjusted weights for country population size at the regional level.

Next, I estimate Kaplan-Meier survival curves to test whether there are differences in survival to age 5 by residence. This provides a nonparametric estimate of the survivor function *S(t)*, the probability of survival past time *t* (Cleves et al. 2010). All children born within the five years preceding the survey are included, with children considered at risk of death until age 5 and then left-censored. One advantage of using the Kaplan-Meier method is that it can produce survival estimates to age five for the most recent time period (i.e. the past five years), rather than only for those children who were born more than five years before the survey. This permits calculating under-5 survival probabilities for the five years preceding each survey without any overlap within a country's surveys.

Last, I use Cox proportional hazards models to examine the relationship between survival to age 5 by residence and a set of demographic and socio-economic variables known to be associated with under-5 mortality. The outcome variable is the risk of death from birth to age five. The proportional hazards model assumes a baseline hazard that is constant (in this case a baseline hazard for dying before age 5) with a similar underlying shape across a population, and calculates a hazard rate as a factor of a baseline hazard and included covariates (Cleves et al. 2010). The regression combines the pooled country sample from both time periods and controls for country and time period. I estimate five models in the Cox regression. Model 1 uses residential status as the only covariate. Model 2 includes residential status and the main socio-demographic variables: mother's age at birth, length of the previous birth interval and whether or not the child was the firstborn. Model 3 adds the socio-demographic variables: highest level of education attained and asset third. Model 4 adds the two infrastructure variables: main source of drinking water and whether the household uses a flush toilet or improved latrine. Model 5 adds the dummy variable for time period. All models include country-specific sample weights, country-level fixed effects and robust standard errors calculated at the sample cluster level.

The use of Kaplan-Meier survival curves and Cox regression allows for a more accurate attribution of a child's death among migrants to the place of residence at the time of death. Instead of attributing a child's death to the residence category of the mother at the time of the survey, these methods allow for a child's death to be attributed to the residence category where the child was living at the time of his or her death

(Bocquier et al. 2011). By permitting both right and left censoring, the Kaplan-Meier method can attribute any deaths that occur to the residence at the time of death and can likewise attribute a child's exposure to the risk of dying to both the place of residence before and after the move; children whose mothers move during their life time are right censored from that residence category at the time of move and left censored into the new residence category. The Cox proportional hazards model likewise allows for residence to be a time-varying covariate and can divide analysis between a child's pre-and post-migration exposure in cases where the child moved before reaching age five or, when it occurred, death. The pooled data used for the Kaplan-Meier estimates and Cox regression is weighted by population size.

Table 2: Average annual growth rate of rapidly growing large cities in sub-Saharan Africa by country from 1995 to 2010

No.	Country	Major cities[a]	Average annual city growth rate (%) 1995-2010[b]
1	Benin	*Cotonou*	**2.53**
2	Ghana	*Accra*	**3.35**
		Kumasi	**4.68**
3	Kenya	*Nairobi*	**3.75**
		Mombasa	**4.65**
4	Mali	*Bamako*	**4.16**
5	Niger	*Niamey*	**4.40**
6	Nigeria	*Abuja*	**8.88**
		Benin City	**2.88**
		Lagos	**3.82**
		Ogbomosho	**2.54**
7	Senegal	*Dakar*	**3.52**
8	Uganda	*Kampala*	**3.74**
9	Zambia	*Lusaka*	**3.17**
10	Zimbabwe	*Harare*	***1.75***

[a] Urban agglomeration with 750,000 or more inhabitants in 2009 (United Nations Population Division 2010)

[b] Average annual rate of change of urban agglomerations with 750,000 inhabitants or more in 2009 (United Nations Population Division 2010)

Results

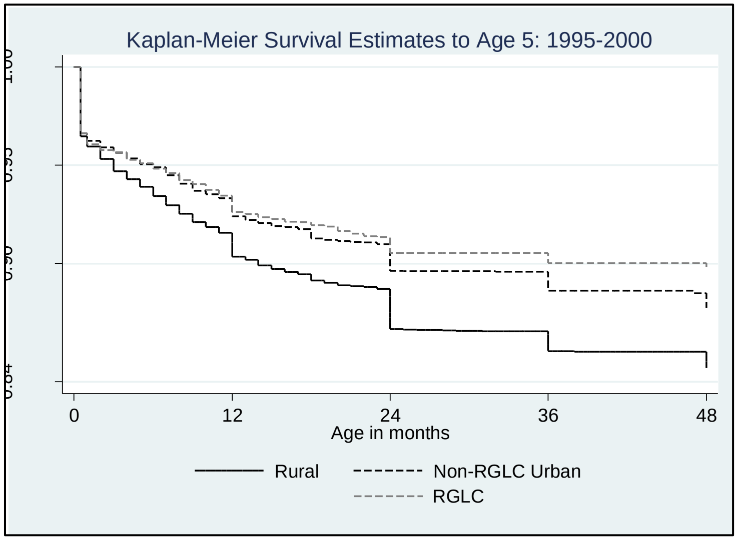
Table 3 shows the mean values or proportion of the variables used in the analysis for the pooled sample for both time periods combined. Just under a third of respondents live in urban areas, and approximately one-third of these live in the RGLCs. About 20-30 per cent of all respondents have moved in the five years before the survey in both periods, with recent migrants making up a higher proportion of respondents in urban areas. Migrants who have changed their place of residence (e.g. from a smaller urban area to an RGLC) account for 9 per cent and 14 per cent of all respondents in the first and second survey periods, respectively – small but not negligible proportions. Approximately twice the proportion of respondents in urban compared to rural areas has changed residence type within the past five years.

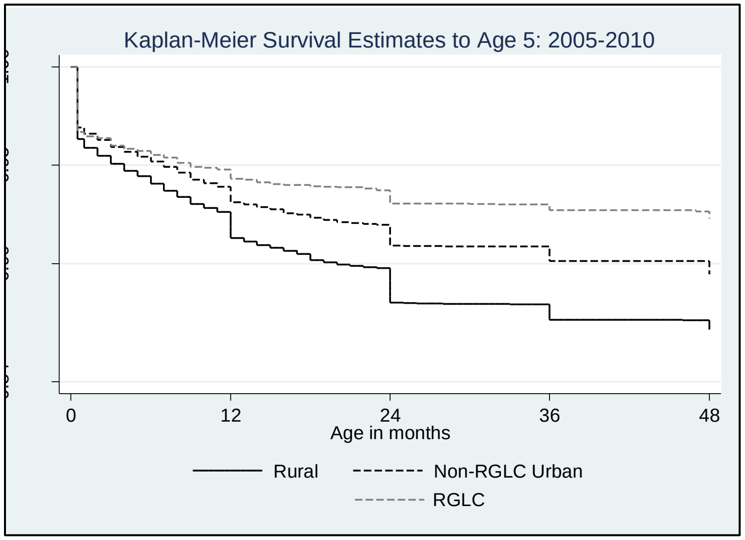
Table 3: Descriptive statistics by mothers' residence type for ten sub-Saharan African countries

Mothers' characteristics by residence: urban and rural & within-urban	1995-2000				2005-2010			
	Rural	All Urban Areas	Inter-urban		Rural	All Urban Areas	Inter-urban	
			Urban *(non-RGLC)*	RGLCs			Urban *(non-RGLC)*	RGLCs
Residence (%)	72.4	27.6	68.4	31.6	70.7	29.3	74.9	25.1
Highest education level (%)								
no education	57.47	36.5	38.4	31.6	60.3	39.1	42.9	26.6
primary	31.4	32.4	31.3	35.2	27.1	26.5	25.5	29.9
secondary	10.6	28.4	27.8	29.9	11.86	28.7	26.9	34.7
higher	0.6	2.7	2.5	3.3	1.06	5.76	4.73	8.8
Household Assets (%)								
poorest	45.3	15.1	18.2	7.3	48.8	14.9	18.0	5.72
middle	37.9	21.2	24.0	14.0	35.1	26.7	29.0	20.2
richest	16.9	63.7	57.9	78.7	16.0	58.5	53.3	74.1
Moved in past 5 years (%)	21.0	27.1	27.7	25.5	19.2	27.5	25.9	33.4
changed residence type (%)	5.3	14.1	14.6	20.2	8.0	16.1	14.2	23.0
Improved source of drinking water (%)	31.6	80.9	82.6	92.3	51.6	84.1	79.8	96.9
Improved toilet (%)	25.6	55.7	55.0	57.2	30.26	69.7	65.5	74.1
N (intra-urban)			*8,230*	*3,610*			*15,785*	*5,296*
N	31,664	11,840			53,098	20,999		

Source: Demographic and Health Surveys 1995-2010

Graphs 1 & 2: Kaplan-Meier survival estimates by residence for ten sub-Saharan African countries : 1995-2000 and 2005-2010





Source: Demographic and Health Surveys (1995-2010); calculations by author

Table 4: Changes in under-5 survival estimates by residence type in ten sub-Saharan African countries

Time Period	Rural	Urban (Non-RGLC)	RGLC
1995-2000	0.847	0.878	0.897
2005-2010	0.867	0.895	0.923
Difference	0.020	0.016	0.025
Percentage change (Period 1 to Period 2)	2.33%	1.93%	2.92%

Source: Demographic and Health Surveys (1995-2010); calculations by author

Kaplan-Meier Survival Estimates

Kaplan-Meier survival curves for data pooled at the regional level are displayed for both periods (Graphs 1 and 2) and show clear overall improvements for all residence types. However, there are differences in the rates at which these improvements have occurred: they are greatest in RGLCs (2.92 per cent), followed by rural areas (2.33 per cent) and slowest among non-RGLC urban areas (1.93 per cent) (Table 4).

Urban-Rural Dichotomy

Table 5 shows probabilities of surviving to age 5 for the rural and urban dichotomy at the aggregate and country-specific levels. Average under-5 survival chances have improved noticeably across the board between the two time periods. Increase in survival estimates for both urban and rural areas are practically universal, with the exceptions of urban Ghana and rural Nigeria which show slight declines. At the regional level, the urban under-5 survival advantage remains virtually unchanged, decreasing in absolute terms by only 0.001.

There is substantial variation among countries in both survival probabilities and changes in the differential. Rural survival chances range from as low as 0.748 in rural Niger in the earlier period to 0.934 for urban Kenya in the second. The likelihood of surviving to age 5 is higher for urban than rural residents in all countries in both periods, with the exceptions of Ghana and Zambia which both have higher under-5 survival probabilities in rural areas in the 2005-2010 period. The log-rank test for equality was significant for both periods for the pooled data at the regional level and for the majority of the individual countries in each period.

Countries are fairly evenly split between those whose urban advantages have narrowed and those whose have widened: of the ten countries, six show a decline in the urban advantage (Benin, Ghana, Niger, Senegal, Uganda and Zambia) and four have an increase (Kenya, Mali, Nigeria and Zimbabwe). The two countries with the largest changes in the urban advantage, Ghana and Niger, showed declines in the advantage. Ghana's declining urban advantage may be particular to its unusually high under-5 survival for RGLCs in the earlier period and its subsequent decline (see page 16 below). Niger's narrowing urban advantage, on the other hand, appears to be a positive outcome of substantial gains in child survival with greater improvements in rural survival rates. Niger's experience is more indicative of the general pattern in countries with declines in the urban advantage that resulted from greater increases in rural under-5 survival, rather than to declines in urban survival rates.

Table 5: Kaplan-Meier survival estimates to age five for ten sub-Saharan African countries by urban/rural residence

	1995-2000				2005-2010				Change in absolute difference *diff 2000s - diff 1990s*	Change in relative risk (u) / (r) *diff 2000s - diff 1990s*
Country	All Urban Areas (u)	Rural (r)	Absolute difference (u) - (r)	Relative risk (u) / (r)	All Urban Areas (u)	Rural (r)	Absolute difference (u) - (r)	Relative risk (u) / (r)		
All Countries	**0.882**	**0.847**	**0.035**	**1.042***	**0.903**	**0.868**	**0.035**	**1.040***	**-0.001**	**0.998**
Benin	0.876	0.841	0.035	1.042*	0.908	0.882	0.025	1.029*	-0.010	0.988
Ghana	0.930	0.899	0.031	1.035*	0.925	0.929	-0.004	0.996	-0.035	0.962
Kenya	0.921	0.891	0.030	1.034*	0.934	0.926	0.008	1.009	0.022	0.975
Mali	0.841	0.766	0.075	1.098	0.885	0.813	0.072	1.088*	-0.003	0.991
Niger	0.845	0.748	0.098	1.131	0.892	0.830	0.062	1.075*	-0.035	0.951
Nigeria	0.883	0.845	0.038	1.045*	0.896	0.839	0.057	1.068*	0.019	1.022
Senegal	0.901	0.854	0.047	1.055*	0.926	0.884	0.042	1.042*	-0.005	0.992
Uganda	0.877	0.858	0.019	1.022*	0.895	0.891	0.004	1.004	-0.015	0.983
Zambia	0.827	0.811	0.016	1.020*	0.880	0.896	-0.016	0.982	-0.032	0.962
Zimbabwe	0.913	0.896	0.017	1.019*	0.931	0.916	0.014	1.016*	-0.002	0.997

* Difference between urban and rural survival estimates we significant at the .05 level
Source: Demographic and Health Surveys 1995-2010. Time between surveys per country ranges from 6-11 years, with an average of 9 years.

Table 6: Kaplan-Meier survival estimates to age five for ten sub-Saharan African countries by urban residence

Country	Rapidly-growing large cities (RGLCs)	1995-2000 RGLCs (rg)	1995-2000 Other Urban (o)	1995-2000 Absolute difference (rg) - (o)	1995-2000 Relative risk (rg)/(o)	2005-2010 RGLCs (rg)	2005-2010 Other Urban (o)	2005-2010 Absolute difference (rg) - (o)	2005-2010 Relative risk (rg)/(o)	Change in absolute difference *diff 2000s - diff 1990s*	Change in relative risk (r) / (o) *diff 2000s -diff 1990s*
All Countries	**Cities**	**0.897**	**0.878**	**0.019**	**1.022**	**0.923**	**0.895**	**0.028**	**1.032***	**0.009**	**1.010**
Benin	*Cotonou*	0.860	0.882	-0.021	0.976	0.935	0.898	0.034	1.038*	0.055	1.063
Ghana	*Accra, Kumasi*	0.990	0.907	0.083	1.092*	0.941	0.907	0.029	1.031	-0.054	0.945
Kenya	*Mombasa, Nairobi*	0.938	0.896	0.042	1.047	0.935	0.938	0.001	1.001	-0.042	0.956
Mali	*Bamako*	0.873	0.819	0.053	1.065*	0.909	0.870	0.041	1.047*	-0.013	0.983
Niger	*Niamey*	0.876	0.830	0.046	1.055*	0.900	0.893	0.013	1.014	-0.033	0.961
Nigeria	*Abuja, Lagos, Benin City, Ogbomosho*	0.899	0.881	0.018	1.020	0.928	0.888	0.041	1.046*	0.023	1.025
Senegal	*Dakar*	0.893	0.911	-0.018	0.980	0.921	0.928	-0.010	0.989	0.008	1.009
Uganda	*Kampala*	0.899	0.864	0.035	1.041	0.910	0.892	0.021	1.024	-0.014	0.984
Zambia	*Lusaka*	0.816	0.832	-0.016	0.981	0.869	0.889	-0.016	0.982	-0.000	1.001

* Difference between urban and RGLC survival estimates were significant at the .05 level
Zimbabwe not included since Harare is not considered an RGLC since it did not have an annual growth rate of 2.5% over the analysis period.
Source: Demographic and Health Surveys 1995-2010. Time between surveys per country ranges from 6-11 years, with an average of 9 years.

Rapidly-growing large cities and other urban areas

Table 6 displays Kaplan-Meier estimates of survival to age 5 within urban areas only. The RGLC survival advantage over other urban areas has increased over the two periods by .009, or just less than one per cent, with a change in the relative risk between the first and second period of 1.01. The log-rank test for equality was significant for both periods for the pooled data at the regional level but only for three of the ten individual countries in each period. The improvement is only slight but is both greater in magnitude than and in the opposite direction from the change in the urban/rural differential.

In general, under-5 survival rates are higher in RGLCs than in other urban areas. Only Senegal and Zambia have lower under-5 survival rates in RGLCs than in other urban areas in both periods, and Benin for the first period only. There is again variation in changes to the RGLC advantage at the country level. Four countries (Benin, Nigeria, Senegal, Uganda) show a slight widening in the RGLC survival advantage, while the other five (Ghana, Kenya, Mali, Niger, and Zambia) show a narrowing of this advantage. The largest change is the substantial increase for Benin, which transitioned from an RGLC penalty to an advantage. The second largest change is for Ghana, with a reversal of its RGLC advantage, though this may be a unique case. Ghana's RGLC under-5 survival estimate in the first period, at 0.990, was substantially higher than for any other country and at an a highly unusual rate for SSA; in the second period, its RGLC survival estimate had declined to 0.940, more in line with other countries in the region and now second-highest after Kenya. Ghana's earlier exceptionally high RGLC survival rates did not have a strong influence on aggregate rates as calculating both Kaplan-Meier estimates and Cox models without Ghana had no discernible impact on regional estimates. The next two biggest changes at the country level, for Mali and Niger, are more typical of the majority of countries with a decline in the advantage, due to greater relative improvements in more disadvantaged areas (here, non-RGLC urban areas compared to RGLCs), rather than an indication of stalling or worsening survival chances in previously advantaged areas.

Cox Proportional Hazards Models

Results from Cox proportional hazard models show whether the urban child health advantage persists after adjusting for individual and household level characteristics. The parallel shape of the Kaplan-Meier under-5 survival curves by residence in Graphs 1 and 2, with only minimal crossover of the urban/RGLC curves in the first couple of months, indicates that the proportional hazards assumption is reasonable here.

Table 7: Cox proportional hazards model for survival to age 5 for ten sub-Saharan African countries from 1995 to 2010

	Model 1	Model 2	Model 3	Model 4	Model 5
Residence (ref: rural)					
Urban	0.762***	0.778***	0.842***	0.860***	0.847***
RGLCs	0.629***	0.658***	0.755***	0.787***	0.772***
Mother's age at birth (ref: 20-35)					
<20 years		1.328***	1.247***	1.245***	1.243***
>35 years		1.275***	1.220***	1.223***	1.225***
Short birth interval (<24 mo.)		1.700***	1.686***	1.694***	1.686***
First born		1.108***	1.180***	1.183***	1.179***
Mother's education (ref: no education)					
Primary			0.900***	0.898***	0.901***
Secondary			0.722***	0.726***	0.728***
Higher			0.466***	0.458***	0.462***
Wealth (ref: poorest third)					
Middle third			0.980	0.973	0.971
Richest third			0.879***	0.880***	0.871***
Water source (ref: unimproved)				0.926***	0.957
Toilet type (ref: unimproved)				0.959	0.983
Later time period (2005-2010)					0.882***
Country-level fixed effects	Y	Y	Y	Y	Y
N	184,206	184,204	183,155	178,182	178,183

Exponentiated coefficients; * p<.05, ** p<.01, *** p<.001
[a]Source: Demographic and Health Surveys 1995-2010 (Benin, Ghana, Kenya, Mali, Niger, Nigeria, Senegal, Uganda, Zambia, Zimbabwe)

Results from the Cox model confirm initial findings from the Kaplan-Meier survival estimates that showed an aggregate urban child survival advantage – and one that is most pronounced in RGLCs. Table 7 shows results for the pooled sample for all three residence types at both time periods. When only residence is included in the model, living in RGLCs and other urban areas decreases the hazard of dying before age five by 37 per cent and 24 per cent, respectively. The hazard is attenuated but does not disappear after controlling for all covariates.

As would be expected, children who were born to mothers at higher-risk ages, born after a short interval, or who are firstborns have a greater relative risk of dying before the age of five. The relative risk ratios for these variables change only slightly when the socioeconomic covariates are added. Mother's education is strongly and monotonically associated with improved child survival chances. The association of wealth and child survival is not as straightforward nor as strong as that for education: children who live in households in the richest third are approximately 12 per cent more likely to reach age five than those in the poorest third, but there is no significant difference in survival chances between the middle and poorest third. Access to an improved source of drinking water decreases the hazard of dying before age 5 by about 7 per cent, but become insignificant when controlling for the time period, and toilet type is not statistically significant in either model.

The dummy variable for time period confirms the upward trend in child survival suggested by the Kaplan-Meier analysis: children born in the later time period are approximately 12 per cent more likely to reach their fifth birthday. Even after including all variables in the full model, children in RGLCs and those in other urban areas have a hazard of dying before age five that is approximately 23 per cent and 15 per cent less, respectively, than their rural counterparts. An interaction term for both time periods and all residence types (rural, urban or RGLC) was also included in the full model but was not statistically significant, suggesting that while differences in the under-5 survival advantage by residence types are significant in both periods, changes to the differential between the two periods are not.

Table 8: Cox proportional hazards models for survival to age 5 by resident type dichotomies for ten sub-Saharan African countries

	Model 1	Model 2	Model 3	Model 4	Model 5
All types (ref: Rural) - From Table 7					
Urban	0.768***	0.773***	0.824***	0.860***	0.834***
RGLC	0.643***	0.655***	0.731***	0.778***	0.758***
Urban/Rural Dichotomy					
Urban (ref: Rural)	0.732***	0.752***	0.820***	0.843***	0.828***
Urban Comparison					
RGLC (ref: Urban)	0.816**	0.839**	0.944	0.971	0.969

Exponentiated coefficients; * p<.05, ** p<.01, *** p<.001
Model 1: Residence only
Model 2: Adds age at birth, length of birth interval and parity
Model 3: Adds education and household wealth
Model 4: Adds access to improved water and toilet
Model 5: Controls for time period (reference: early period 1995-2000)

Table 8 shows the full Cox model for the urban/rural dichotomy (with both RGLCs and all other urban areas included the urban category) and the urban-only comparison (RGLCs compared to all other urban areas). It shows that the urban advantage over rural areas is significant across all models, and that in full model urban children are still approximately 17 per cent more likely to reach age five than their rural counterparts. The RGLC advantage over other urban areas is significant only in the first two models but becomes insignificant once socio-economic variables are added, suggesting that the intra-urban difference is largely compositional.

Discussion

This analysis finds that the urban under-5 survival advantage in SSA holds. Overall under-5 survival probabilities in the region mirror the hierarchy of city size: survival chances are highest in the largest and fastest growing cities, next highest in other urban areas, and lowest in rural areas. Nearly every country shows fairly substantial improvements in child survival across both urban and rural areas. These findings concur with the most recent research on SSA's child survival differential (Gunther and Harttgen 2012) which also found a positive trend in raw estimates of rural child survival from the 1990s and 2000s. Among the largest and fastest-growing cities, there were notable increases in under-5 survival probabilities for all but one country (Ghana), implying that more rapid rates of urban growth are not necessarily associated with declines, stalls or relatively slower increases in under-5 survival chances – at least for the fastest-growing largest cities.

At the regional level, the urban survival advantage over rural areas holds and remains practically unchanged. The variation among individual countries with respect to a widening or narrowing of the urban advantage is similar to that found in comparable studies which have found differences in both the direction and magnitude of the urban child health advantage among different countries, rather than an overarching trend across countries (Fotso et al. 2007; Bocquier et al. 2011).

Half of the countries in this analysis had declines in the urban/rural differential, but these nearly always resulted from greater relative improvements in rural compared to urban child survival. This implies that stalls or declines in the urban *advantage* are not necessarily cause for concern if they result from overall encouraging improvements in child survival instead of declines in urban survival rates. This in turn suggests that rather than repeating the pattern of nineteenth century industrialized countries where the urban advantage transformed into an urban penalty, we may instead see trends similar to mid-twentieth century Africa, when rapid increases in rural child survival led to overall decreases in the urban advantage but not to a relative urban disadvantage.

The slower relative improvements in child survival rates in smaller cities compared to both rural areas and RGLCs, on the other hand, may be reason for concern. Greater relative improvements in rural over urban areas could be explained in part by the lower baseline survival rates in rural areas. But the lags in child survival improvements among smaller urban areas lend support to the view that with continued urbanization in SSA the greatest threats to continued improvements in child health will likely be in smaller cities (Brockerhoff and Brennan 1998; Montgomery 2009). However, the analysis here can only be considered an early indication of this potential trend as for the majority of countries the survival advantage of RGLCs over other urban areas were not statistically significant.

The overall survival advantage for children in the largest and fastest growing cities seen here concurs with earlier work by Brockerhoff and Brennan (1998), who also found that the largest cities in SSA had the highest rates of child survival from the 1970s to mid-1990s. In contrast to their findings, however, I do not find evidence of declines in child survival rates among smaller cities. This discrepancy could be washed out by the broader "other urban area" category used here (as Brockerhoff and Brennan defined small cities as those with populations of 50,000 to 1 million and towns as below 50,000) but it may also simply reflect changes in child survival patterns from the earlier time period in their analysis. The more favourable child survival probabilities in SSA's biggest cities may reflect the tendency in poorer countries for infrastructure and services to be concentrated in the largest cities (National Research Council 2003) and the strains of greater *rates* of population growth among smaller urban areas. This also suggests that in contemporary SSA, again in contrast to the early experiences of European and American cities, better under-5 survival chances in the largest cities play a key role in the persistence of this urban advantage.

Controlling for known individual and household level covariates of under-5 mortality attenuates but does not erase the overall urban advantage, although there is variation at the country-level (Appendix A). For half the countries, the association of urban or RGLC residence with under-5 survival becomes insignificant after controlling for demographic and socio-economic variables. This confirms analysis from comparable studies which find that the urban/rural child mortality and health differential often disappears after controlling for individual and household variables (Fotso et al. 2007; van de Poel et al. 2007; Bocquier et al. 2011). Findings here differ from these studies because in no case do I find that controlling for all covariates leads to a statistically significant reversal in the advantage.

The analysis of changes in SSA's urban under-5 survival advantage at the regional and country-specific levels tells different but not necessarily contradictory stories about current trends. When measured at the aggregate, the urban advantage for raw estimates of under-5 survival holds, and the advantage of RGLCs over other urban areas appears to be widening. Controlling for household variables decreases the magnitude of the urban advantage over rural areas and makes the RGLC advantage over other urban areas insignificant. On the other hand, there is substantial variation between countries in the magnitude and direction of changes, with some countries showing an increase in their advantage and others a narrowing. This difference among countries within in the region found in the analysis presented here is in agreement with other recent research (Fotso 2007; Gunther and Harttgen 2012), which showed substantial variation in current changes in SSA's urban child survival and health advantage, rather than a definitive and overarching trend across the region at this time.

This study has several limitations that should be acknowledged. First, this analysis focuses on the combined effect of geographically specific variations in under-5 mortality but does not account for environmentally specific factors. Available data does not allow for a comparable assessment of many of the geographic specific factors – including city-level infrastructure, sanitation services and government policies– that may explain some of the rural-urban under-5 mortality differential when pooling countries at the regional level. More localized or country-specific research on the under-5 health advantage in SSA is more appropriate for further investigating how best to account for the effects of these geographic-specific factors on rural-urban mortality differentials. Second, this study does not control for cause of death and thus does not investigate if and to what degree these might differ, however this is not considered a major drawback as this analysis focuses on the event of death rather than the cause. Third, restricting surveys to only those which fall within the two designated time periods reduces the sample of countries and surveys and results in a relatively short time period in which to observe changes. There is a trade-off, however, for widening the analysis to cover a greater period of time, as the comparability over a longer standardized period means a reduction in countries with the same number of surveys conducted at comparable times.

Conclusion

The combined effect of urban living in SSA continues to offer urban children better chances of surviving to age five. Current under-5 survival probabilities in SSA mirror the hierarchy of residence size: they are highest in the largest cities, next highest in other urban areas, and lowest in rural areas. Controlling for socio-demographic indicators attenuates but does not erase this advantage at the regional level, although the advantage of the largest and fastest growing cities over other urban areas becomes insignificant after controlling for socioeconomic variables. Among the individual countries in this analysis, I do not find evidence that controlling for household characteristics reverses the urban under-5 survival advantage.

With few exceptions, improvements in child survival chances by residence type were found across the region. The rate of improvement to under-5 survival chances, however, did not correspond to city size category: rapidly-growing large cities showed the greatest improvements followed by rural areas, with the slowest improvements in smaller urban areas. The slower rate of increase found for child survival among the smaller cities lends support to concerns that rapid urbanization in SSA may pose the greatest risk to improvements in child survival among the smaller urban areas that are likely to see the greatest growth in the coming decades. It also suggests that in contemporary SSA the better chances of surviving to age five in the largest cities may have played a key role in the persistence of the overall urban under-5 survival advantage.

CHAPTER 2

Not Just When but Where: Investigating internal migration fertility decline in West Africa

Introduction

Despite the importance of both urbanization and rural-urban migration throughout sub-Saharan Africa (SSA), research on the relationship between migration, urbanization and fertility remains limited. This is particularly true with regards to gaps in our knowledge about whether the experience of residence in new areas impacts the fertility behavior of internal migrants (National Research Council 2003; Beauchemin and Bocquier 2004; White, Muhidin, Andrzejewski et al. 2008). In this study, I seek to determine if there is a discernable "urban effect" on fertility among internal migrations in SSA. I define the "urban effect" here as an association of urban residence and lower fertility that is exclusive of socio-demographic characteristics. In a departure from most previous research on the fertility/migration residence, I also ask if an urban effect is found among migrants who move away from urban areas and take up residence in rural areas. This study is also the first to examine differences in fertility following residence in new areas in SSA by looking beyond the urban/rural dichotomy and considering the difference in this relationship in cities of different sizes.

Understanding the relationship between urban migration and fertility decline is particularly relevant for sub-Saharan Africa (SSA), as the region is expected to see continued high rates of internal migration, including urban-to-rural and horizontal migration, and is projected to have the world's fastest rates of urbanization and highest fertility in the coming decades. An investigation of differences in migration and fertility outcomes is particularly relevant for West Africa, which has the continent's highest fertility rates and highest projected rates of urbanization and population growth for the next two decades and is predicted to have more cities with over a million people than any other region in Africa by 2025 (United Nations 2012). Though the majority of urban growth in most developing countries is due to natural increase (Chen et al. 1998), the growing proportion of young and female migrants throughout SSA (Brockerhoff and Yang 1994) means that in the coming decades a larger number of migrants will spend their reproductive years in cities, contributing to urban population growth indirectly through their reproductive behavior. A more nuanced understanding of migrant fertility behavior is thus relevant for projections of urban growth rates and can contribute to the unresolved debate on whether internal migration is likely to make a positive contribution to fertility decline throughout West Africa and, if so, whether this would be driven predominantly by migration to largest cities.

Theoretical Background

Throughout SSA, as in much of the contemporary developing world, fertility has consistently been found to be substantially lower in urban compared to rural areas (Kirk and Pillet 1998; Shapiro and Tambashe 2000; Shapiro and Tambashe 2002; Chattopadhyay, White and Debpuur 2006). Lower-fertility urban areas are believed to play a key role in driving overall fertility decline at the national level in SSA (Shapiro and Tambashe 2002) , and are considered leaders in any country-wide fertility decline (Romaniuk 2011). It is unclear, however, whether and to what extent this may be influenced by internal migration (migration within a country's boarders) to and from urban areas. Though there is a healthy literature on the migration/fertility relationship, very little has focused on internal migration (migration within a country's borders) and urbanization, most likely because of the added difficulties in measuring or accounting for domestic migrations.

Broadly speaking, the lower fertility in urban areas is believed to result from a combination of factors related to the costs of raising children, ideational change about family size and/or access to family planning. In cities, housing, schooling and the overall cost of living tends to be higher than in rural areas, generally making the cost of raising a child more expensive (Easterlin 1975). Even in SSA, the traditional desire for large families in SSA may be off-set by the higher costs of child rearing in urban setting. Furthermore, compared to those in rural areas, children in cities do not usually contribute to agricultural production (Shapiro and Tambashe 2000; Shapiro and Tambashe 2002) and are less likely to provide other forms of household production (White, Muhidin et al. 2008). City residents in SSA are also more likely to have favorable views on smaller family size, often associated with higher levels of socio-economic development and female education (Cleland and Wilson 1987), as urban areas provide greater opportunity for social interactions that encourage the diffusion of this ideational change (Bongaarts and Watkins 1996). Not insignificantly, urban residents in SSA are far more likely to have access to reproductive health services and modern birth control, particularly through the private sector (Cleland, Bernstein, Ezeh et al. 2006), making it easier for urbanites who wish to limit their fertility to do so.

Although urbanization is generally associated with lower fertility, the relationship between migration and fertility is less clear, particularly how the process of a change in residence type impacts the fertility behavior (National Researc Council 2003; Beauchemin and Bocquier 2004; White, Muhidin et al. 2008). Migrant adaptation to new residence areas is not well understood, particularly with regard to changes in fertility outcomes post-migration. Unfortunately, the lack of adequate data on internal migration in SSA (Schoumaker, Vause and Mangalu 2010) poses a particular challenge to producing evidence on the consequences of migration on fertility throughout SSA, which may account for the dearth of research on the migration-fertility relationship at the regional level.

Evidence to date on the association between urbanization, migration and fertility in SSA is mixed and results from most studies on migration and fertility show considerable variation (Brockerhoff and Yang 1994). Some studies find urban migration is positively associated fertility decline (Omandi and Ayiemba 2005; Brockerhoff 1998; Brockerhoff 1995) for the migrants themselves in the new place of residence (Brockerhoff and Yang 1994) and for subsequent generations born in the urban place of destination (White, Tagoe, Stiff et al. 2005), with two recent studies of migration and fertility in Ghana using longitudinal data finding evidence of lower fertility among rural-to-urban migrants (Chattopadhyay, White et al. 2006; White, Muhidin et al. 2008). On the other hand, other studies of SSA have found no association or migration and fertility decline or even an association of migration with increased fertility (Cleveland 1991; Lee 1992).

Research on the interrelationships between migration and fertility has been guided by three main theoretical approaches: 1) the selection hypothesis; 2) the adaptation and/or socialization hypothesis; and 3) the disruption hypothesis. The selection hypothesis proposes that those who migrate are a specific group whose fertility preferences are closer to those at the destination location prior to migration (Kulu 2005). According to this theory, lower fertility preferences are part of the motivation to move to a new area, so urban migrants are thus a self-selected group, based partly on their lower fertility desires.

The socialization hypothesis argues that migrant fertility behavior will primarily reflect fertility preferences dominant in their place of origin, even after relocation (Kulu 2005). Any changes in fertility behavior among migrants, presumably a decrease since most migration studied in the literature is from high to low fertility regions, will only occur over the longer-term, for example among not first but second generation migrants (White, Tagoe et al. 2005). The adaptation hypothesis, on the other hand, is based on the idea of a faster re-socialization and adaptation to fertility behaviors dominant at the destination. Like the socialization theory, adaption theory implies that the fertility behavior of migrants will eventually come to resemble the dominant patterns of the destination location (Kulu 2005). According to this theory, convergence to fertility levels of the destination location will be seen among the migrants themselves. The adaptation theory generally assumes improved knowledge of sources of family planning in urban areas (Brockerhoff 1995), and, accordingly, that fertility rates would be lower in urban areas following migration because of the increased acceptance of and access to contraception and abortion in urban areas (Shapiro and Tambashe 1994).

Finally, the disruption hypothesis proposes that migrants' fertility behavior will change in the period immediately prior to and/or following a residential change, primarily as a result of the disrupting factors associated with the process of migration itself (Kulu 2005). This theory is built on the idea of a disruption in economic and social support as part of the relocation process. Interestingly, the disruption hypothesis has been used to explain both relative increases and decreases in the fertility rates of migrants: although the disruption hypothesis is generally believed to act to lower fertility, largely due to spousal separation (Kulu 2005) it has also been used to explain situations where fertility has increased following migration, as a result of disruption to breastfeeding and/or lack of or failure to access family planning services (White, Tagoe et al. 2005).

Evidence has been found in support of each approach, and often of several concurrently. For example, migrant selectivity has been suggested as the reason that migrants to urban areas have fertility behavior similar to that in destination cities in Ghana (White, Muhidin et al. 2008) and Thailand (Goldstein 1973), with limited evidence was found in support of the disruption theory. Alternatively Brockerhoff's 1995 study of thirteen SSA countries found that fertility declined among most rural-urban migrants declined immediately after migration and remained low, supporting the adaptation hypothesis. These theoretical approaches can be contradictory or complementary, and the inconsistent evidence on migration and fertility patterns highlights the complexity of the migration-fertility interaction and the difficulty of fitting all experiences under one theoretical framework, (Kulu 2005). The inconsistent research findings suggest that outcomes are heavily context dependent (Brockerhoff and Yang 1994; Kulu 2005) and not necessarily generalizable from one area or region to another. Here, I propose to investigate the relationship between residence in new areas post-migration and changes in fertility in the West African context by employing both descriptive and event-history methods using the latest demographic data on internal migration and fertility for West Africa.

The West African Context

Urban/rural fertility differential in contemporary SSA are well established (Cohen 1993). Urban areas are not only where fertility is lowest but are also the places where experiencing more rapid declines in fertility. In fact, there has been a widening differential between urban and rural areas, as fertility decline has accelerated in most urban areas and stalled in rural ones, within the past few decades (Kirk and Pillet 1998; Shapiro and Tambashe 2002). This means that investigating the migration and fertility interplay in SSA also means this relationship must be considered within the context of a region currently experiencing the fertility transition. Specifically, this means that rural-to-urban migrants are moving to locations that not only have lower relative fertility, but which are also currently experiencing accelerated declines in fertility. This makes the reference category for fertility akin to a moving target with regard to measuring differentials in fertility changes among those who move to new areas. This is also true for those who move out from urban areas where fertility is not only lower but rapidly declining. It also precludes reliance on completed fertility or limiting the analysis to women towards the end of their reproductive years because in many cases this may fail to capture the full extent of recent urban/rural fertility differentials and under-estimate an "urban" effect.

Urban areas throughout SSA are not homogeneous, and there are stark differences in fertility by city size. Throughout SSA, fertility is not only lower in most urban areas, but it is also lower in the largest cities compared to other urban areas (Cohen 1993), often by more than one child (Shapiro and Tambashe 2002). Despite this fact, scant attention has been paid in the literature to fertility differentials by city size in SSA. Accordingly, there is also no research to date on differences in migrant fertility behavior disaggregated by city size for the region. By relying on the common urban/rural dichotomy, which combines all urban areas together in one category, studies on internal migration and fertility behavior implicitly make the interrelationships between migration and fertility uniform across all areas defined as urban. This may obscure important subtleties of the relationship between residence/migration and fertility decline in SSA. More generally, this implies that research on the region may be overlooking the role that that geographic mobility may be playing, directly or indirectly, in diffusing fertility decline at the national and regional levels.

Furthermore, the literature on the linkages between urbanization, migration, fertility in SSA has focused almost exclusively on an upward rural-to-urban trajectory (Goldstein 1973; Brockerhoff and Yang 1994; White, Muhidin et al. 2008), with only a few studies also considering urban-to-rural migrants (Chattopadhyay, White et al. 2006). This nearly- singular focus on upward migrants essentially assumes that any impact of urban migration on fertility is found exclusively in urban areas. Notably, it also fails to account for the growing importance of other streams of migration within SSA which are expected to be more important as the continent continues through the demographic transition. Although the data needed to estimate rates and levels of internal migration is sorely lacking in most of SSA, there is some evidence of increases in urban out-migration and return migration from urban to rural areas (Beauchemin and Bocquier 2004), circulatory and temporary migration and intra-rural and intra-urban migration within the region (Oucho and Gould 1993). Notably, rural areas were found to be the principal destination among internal migrants in at least two studies looking at SSA (Chattopadhyay et al. 2006, Oucho and Gould 1993). The potentially high level of migration to and within rural areas implies that focusing exclusively on city-ward migration may result in an incomplete and overly simplistic explanation of the relationship of migration and fertility.

Accounting for circular or temporary migration, however, poses a specific challenge to examining the longer-term effect of migration on fertility, both theoretically and practically. Theoretically, the mechanisms by which migration may influence fertility could be different among circular or temporary migrants. This may be particularly true for adaptation, which is usually a gradual process and may not impact migrants who stay for shorter periods. It may also be that rural women migrate temporarily or seasonally to urban areas have lower motivation for adaptation (Chattopadhyay, White et al. 2006). Alternatively, disruption may have a bigger impact on migrants who know a move (or one in a series of seasonal moves) is temporary. It may also be that exposure to lower fertility norms in urban areas –however temporary– may affect fertility behavior of rural return migrants, although they will be seen in most surveys to be downward urban-to-rural migrants, rather than returning migrants. More practically, most demographic data, including DHS used here, does not directly account for these types of migration. Without comprehensive migration histories, it is extremely challenging, if not impossible, to parse out the circular and temporary migrants from long-term or permanent migrants. Using DHS data (see Data section below), I am not able account for circular migration but instead try to separate out more temporary from permanent (or more long-term) migrants by including length of time at destination place in several aspects of the analysis.

The Present Study

In this analysis, I first investigate whether internal migration is associated with changes in fertility behavior (among all origin/destination combinations of rural, small urban and large urban areas). I then measure whether the association of relocating to an urban area (with lower fertility) is greatest among those who move to the largest cities (where fertility rates are lowest); I also look at differences in fertility outcomes of downward migrants, to see if previous residence in an urban area is associated with different fertility outcomes. Last, I compare fertility behaviors of all migrants in the short- and medium-term, to discern if fertility patterns in the period immediately following migration change with increased duration in destination.

This study has three hypotheses. First I hypothesize that (internal) migrant women in West Africa will exhibit fertility behavior that differs from non-migrants in their places of origin; with the exception of urban-to-rural migrants, for whom migrant fertility outcomes are expected to be lower. Second, compared to rural non-migrants, I expect to find a general negative association of migration with fertility for both upwards (rural-to-urban) and downward (urban-to-rural) migrants. Relatedly, I also anticipate that horizontal migrants (within the same residence type, e.g. rural-to-rural) will have similar fertility rates as non-migrants in these residence areas. Third, I propose that the association of rural-to-urban migration and lower fertility will be strongest among rural migrants who move to the largest cities, where fertility is lowest, than among migrants who move to smaller urban areas.

My aim in this study is to assess how residence in new areas alters the longer-term fertility behavior of migrants, rather than how the process of migration impacts fertility outcomes around the time of the move. Thus, while the different mechanisms at play in altering post-migration fertility (disruption, adaptation and/or selectivity) will be investigated, my primary interest is in longer-term fertility outcomes of more permanent migrants (whether due to adaptation or selectivity), not temporary changes in fertility outcomes due to process of migration itself (due to disruption).

This paper is a departure from most previous studies of the migration-fertility interrelationship in SSA in two important ways. First, it is the only study on migration and fertility to consider both upward and downward migration across the region and the first to examine the impact of residence in new areas on fertility among urban-to-rural migrants at a regional level. Though at least one other recent study has included urban-to-rural migrants (Chattopadhyay, White et al. 2006) for a single country (Ghana), none have looked at the relationship of downward migration in multiple countries. Second, this study is the first of its kind to look at the relationship of new residence and fertility change by employing a division of urban areas by size. By doing this, I seek not only to determine if there is a discernable impact of migration on fertility behavior but also whether it shows a higher magnitude with an increase in the differential in fertility regimes between the place of origin and destination.

Data

DHS

I use 26 Demographic and Health Survey (DHS) datasets carried out between 1990-2008 from eleven countries in West Africa (Table 1). Only surveys up to 2008 are included in this analysis because as of 2009 the DHS core questionnaire (the model questionnaire designed by DHS on which the country-specific questionnaires are based) no longer includes questions related to migration and residence changes. Though there are discussions currently underway about reinserting these variables in the next round of surveys' core questionnaire[6], if these variables are not replaced in future DHS, these datasets represent the last opportunity to account for migration and fertility analysis using DHS data for the foreseeable future.

The DHS collects nationally representative data in less developed countries through household sample surveys that measure health, population, and socioeconomic indicators, with a focus on maternal and child health (Rutstein and Rojas 2006). All surveys include a representative stratified probability sample of all women of reproductive age (15-49)[7], though most surveys also now include samples of men. For all women surveyed, DHS collect detailed data on maternal and child health, fertility, and family planning. This includes a complete birth history for each woman, detailing the month and year of birth, sex, age and survival status of every child a woman has had.

[6] Personal email correspondence with DHS on 11 March 2013.
[7] Some DHS only include married women aged 15-49, not all women in this age group. However, all surveys included here are samples of all women in the age group, regardless of marital status.

The DHS also obtains data on the demographic characteristics of respondents (including age, level of education, employment and marital status) and respondents' household characteristics (including household infrastructure, electrification, access to safe water and sanitation). To approximate a relative measure of wealth at the household level, the DHS creates a wealth index and household wealth index based on a principal component analysis of common household assets. Households within a country are then divided into five quintiles, calculated as the deviation of a household's wealth relative to that country's mean wealth (Rutstein and Johnson 2004). Both the wealth index measure and wealth quintiles have been standardized across DHS countries and are widely used measurements of relative wealth for DHS survey countries.

Table 1: DHS datasets included in the analysis

Country	Year	Women 15-49
Benin	1996	5,488
Benin	2001	6,219
Benin	2006	17,794
Burkina Faso	1993	6,354
Burkina Faso	2003	12,477
Ghana	1993	4,562
Ghana	1998	4,841
Ghana	2003	5,637
Ghana	2008	4,878
Guinea	2005	7,951
Liberia	2007	7,018
Mali	1996	9,704
Mali	2001	12,849
Mali	2006	14,336
Niger	1992	6,503
Niger	1998	7,575
Niger	2006	9,021
Nigeria	1990	8,781
Nigeria	1999	9,805
Nigeria	2003	7,620
Nigeria	2008	32,856
Senegal	1993	6,310
Senegal	1997	8,592
Senegal	2005	14,181
Sierra Leone	2008	7,283
Togo	1998	8,569
Total		246,894

Cote d'Ivoire (all surveys), Guinea (1999) and Burkina Faso (1998-99) are not included because those surveys did not contain migration-related variables.

The DHS also includes a series of questions related to current place of residence that can be used to identify migrants. Migrants here are defined as respondents who have lived in their current place of residence for fewer than 9 years. DHS includes data on current (v106) and last place (v105) of residence. Respondents are first asked "Have you always lived in this place" (v106)? Those who answer no are then asked, "How long ago did you move to this place" (v104), which is recorded in years. These same respondents are then asked "What was the type of place in which you previously lived" (v105), usually coded as "capital/large city", "small city", "town" or "countryside". This does not provide a comprehensive migration history –and does not account for multiple moves or circular migration– but nonetheless identifies those who have moved at least once and when, allowing for a category of lifetime migrants.

DHS also includes a question on "type of place of childhood residence" (v103), in which respondents specify what type of place (city, town or countryside) they spent most of their childhood in until they were aged 12; however this variable is excluded from nearly half of the surveys and is subject to both greater recall bias and inaccuracies due to reclassification of areas in the time since respondents' lived in these areas. For these reasons, I create migrant categories based on current and last place of residence and include v103 only as a control variable.

The DHS also collects data on whether respondents are married at the time of the survey and, if so, the date of their first marriage – allowing for information on the timing of births and (first) marriage to be linked to a respondent's last move (migration). All other socio-economic variables used in this analysis (including highest level of education, measurements of household wealth), however, are only measured at the time of the survey. This permits socio-demographic descriptions of the sample respondents' characteristics at the time of the survey but makes these variables less reliable in analysis of the relationship to fertility and migration.

Migrant Stream Categories

To examine intra-urban differences in overall fertility levels and any fertility changes among migrants, I divide residence area types into three categories. I first use the urban and rural designations from the DHS, which are based on each country's definition of urban and rural[8]. I then further segment "largest cities," defined here as those having populations of one million or greater at the time of each DHS, using the United Nations Population Division population estimates (identified using v026 in combination with regional/provincial identifiers). Despite the fact that many of the urban areas with populations of fewer than a million are still quite large, for simplicity I refer to them throughout this analysis as "smaller cities".

I then create twelve migrant categories, defined by place of origin (type of place of previous residence) and destination (current residence). These include three categories of non-migrants (rural, small urban and large urban) and all nine origin/destination combinations of these residence categories, including horizontal migrants within the same residence area type (e.g. rural-to-rural migrants) (Table 2). Only internal migrants are accounted for in these categories and in this analysis, since those who have moved internationally have their place of origin listed only as "abroad" (without any information on the country or residential type).

---

[8] There is no international or standardized definition of urban and rural (unstats.un.org/unsd/demographic/sconcerns/densurb/densurbmethods.htm). The DHS relies on each country's administrative definition for designating areas as urban or rural.

Table 2: Migrant categories for women in the sample

Migrant category*	All women n	All women %	Migrants only n	Migrants only %
Rural Non-migrant	109,080	*45.2*		
Small Urban Non-migrant	36,238	*15.3*		
Large Urban Non-migrant	17,498	*7.0*		
Rural → Rural	29,135	*12.1*	29,135	*37.2*
Small Urban → Rural	13,689	*5.7*	13,689	*17.5*
Small Urban → Small Urban	12,121	*5.0*	12,121	*15.5*
Small Urban → Large Urban	7,894	*3.2*	7,894	*10.1*
Rural → Small Urban	6,530	*2.7*	6,530	*8.3*
Rural → Large Urban	3,043	*1.3*	3,043	*3.9*
Large Urban → Rural	2,457	*1.0*	2,457	*3.1*
Large Urban → Small Urban	1,998	*0.8*	1,998	*2.6*
Large Urban → Large Urban	1,443	*0.6*	1,443	*1.8*
N	**241,126**	*100.0*	**78,310**	*100.0*

Source: Demographic and Health Surveys (1990-2008)
*Migrants who have relocated from abroad are not included (as neither the country of origin nor the type of previous residence in these countries can be identified and out-migrants abroad are not accounted for in the DHS).

Methods

Descriptive analysis

I first provide a descriptive overview of socio-demographic characteristics for all respondents. Results are presented first for non-migrants in rural are urban areas (largest/capital cities and smaller urban areas), and then disaggregated for all migrant categories. The descriptive overview includes counts and proportions of all migrant and non-migrant categories and descriptive statistics of socio-demographic variables of respondents at the time of the survey. In cases where more than one survey per country is included in the analysis, only the most recent survey is used. Descriptive statistics are presented for the pooled sample of all women and are weighted at the country level to account for the multistage sampling design and by country population at the regional level.

Analysis of Fertility Outcomes

Age-specific fertility rates (ASFR) and Total Fertility Rates (TFR)

As a descriptive overview of fertility across the regions, I first calculate age-specific fertility rates (ASFR) by migrant stream, to determine whether different migrant categories have distinct age-specific fertility patterns. ASFRs are calculated by dividing the number of births to women in a specific age group (usually five-year age groups from 15-49) by the number of person-years lived by all the women in that age group. Here, ASFRs are calculated for the three year period preceding each survey. These results are presented in the form of a graph for all ages and all migrant categories. ASFRs are then aggregated to produce the total fertility rate (TFR), which is the average number of children a woman would have over her lifetime if she experienced the prevailing ASRFs and survived to the end of her reproductive years. The TFR is thus a synthetic measurement since no cohort will realistically experience the current ASFRs for the entirety of its reproductive years, which means there will inevitably be disparities/discrepancies between TFR estimates and actual completed fertility. All ASFRs and TFRs here refer to period rates, as the birth histories used for these calculations are from a particular period rather than following a birth cohort through their reproductive years. Although there is some variation in the years during which surveys were carried, I do not believe there is enough of a lag between different survey years to result in different period effects across the surveys and countries.

Cumulative Fertility

For a more detailed multivariate fertility overview, I use Poisson models of cumulative fertility comparisons by migrant category. The outcome variable is children ever born (at the time of the survey) and I control for age, age squared, education level, wealth quintile, marital status and childhood type of place of residence. I then run the Poisson model for the different migrant categories based on length of duration in place of destination.

These estimates of ASFR/TFR and Poisson regression of cumulative fertility serve largely as a descriptive overview of migrant fertility. This is because while ASFRs (and TFR) can provide a snapshot of fertility for a particular period, they are highly susceptible to changes in the age patterns and timing of childbirth, and can differ substantial from lifetime fertility measures when there are shifts in the age-patterns of fertility over time. Cumulative fertility likewise only measures fertility at the time of the survey, and may misrepresent overall fertility levels if there are different age patterns of childbearing (even when controlling for age).

It would be ideal to use a more accurate measurement of lifetime fertility such as the completed fertility rate (CFR), which is the average number of births by a cohort of women at the end of their reproductive lives, to compare differences in completed fertility between migrants and non-migrants (or among different migrant streams). The CFR, however, reflects the past experiences of older women and largely neglects current fertility trends as it does not measure the fertility of younger women (Parrado 2011). This means the CFR may fail to accurately capture current trends in the interrelationship of migration and fertility in areas. This is particularly true in a region like West Africa, which is not only experiencing rapid urbanization but which has also seen a concurrent widening of urban/rural fertility rates in recent decades (Kirk and Pillet 1998; Shapiro and Tambashe 2002). Furthermore, calculating CFR from the DHS will lead to inadequate sample sizes for most migrant stream categories, since the DHS only interviews women of reproductive ages and CFR could thus be calculated from only the small proportion of the oldest women in the survey (who would technically still be of childbearing age).

Discrete time logit and conditional logit models

Last, I use two discrete time event history models to investigate the relationship of the timing of residence in new areas and changes fertility outcomes. Here the dependent variable is whether or not a woman gives birth in a particular year, and control variables are the same as those used in the Poisson regression. The DHS allows information on fertility to be linked to the timing of migration, by matching birth histories with the calculated year of migration (year of survey minus years lived in current place of residence for migrants). Measuring fertility rates pre- and post-migration, and at different time periods following migration will allow for an exploration of which mechanisms/theories of fertility change (disruption, adaptation or/or selectivity) may be at play among migrants in their new places of residence.

To measure the effect of new residence (in rural, small urban or large urban areas) on fertility, I estimate discrete-time hazard models using a discrete-time framework with a person-year data structure. Each person-year for the ten years prior to the year to the survey year forms a record, allowing me to estimate annual birth probabilities using logistic regression. This produces 2,411,260 records for 241,126 individual women (once those moving from abroad are removed). The DHS interviews women aged 15-49, but the creation of person-year files for the ten years previous to the survey means that in some cases there are person-year files for women as young as 5. While there are certainly instances in which women give birth prior to 15, this is relatively rare (even in SSA) and does not factor into the ASFR calculations. As a result, those below age 15 for any parts of the ten years prior to the survey are left-censored into the data set when they reach age 15. This reduces the total number of records in the dataset to 1,856,512 person-year records.

Each record contains a set of both constant and time-varying co-variates. Constant variables included in the regression are those only measured at the time of each survey that do not contain information necessary to evaluate any changes over time: highest level of completed education and household wealth. The time-varying covariates, which can change from record to record for each individual, are: residences, year of migration, marital status, whether a woman gave birth that year and her parity. Parity is broken down into three categories: no births, first birth and all higher order births. Parity is also lagged by one year so that a woman's parity only increases the year after she gives birth. The DHS data on last move is collected by asking a respondent how many years she has lived in her current place of residence. This results in "fuzzy" rather than exact timing of both first marriage and births around the time of a residence change. As a result, findings here are not measurements of potential interactions of the exact timing of events. Nonetheless, this will help tease out whether and to what degree selection, disruption and/or adaption may be at play with regard to fertility behavior changes with residence in new areas and in the shorter- and longer-term.

Accurately measuring the impact of residence in a new place following migration requires identifying the following counterfactual: what would a woman's fertility *have been* had she *not* changed residence? Since we can never know what a particular migrant's fertility would have been had she not changed residence, we are faced with two options for approximating this counterfactual: comparing her with women of similar socio-demographic profiles who did not move (and assuming that her fertility would have been similar to theirs) or comparing an individual woman's fertility before and after her move (assuming that any changes in her fertility following migration are due to influences in her new place of residence). The advantages and disadvantage of each approach our explained below.

A discrete time logit model permits estimating fertility among different migrant and non-migrant categories. This allows for comparison of fertility outcomes of migrants and non-migrants (but for annual birth probabilities rather than cumulative fertility), so that the fertility of migrants in their places of destination can be compared with that of non-migrants from their places of origin. This provides a more direct comparison of actual fertility rates in places of origin and destination among migrants and non-migrants, with non-migrants serving as the counterfactual for fertility in the absence of a change of residence. To compare fertility outcomes prior to and following a move (and the subsequent residence in a new area), I also run discrete-time models for migrants for the periods before and after migration, and compare the results to see if those who do move exhibit higher or lower fertility prior to moving, which could reflect either anticipatory fertility, disruption or selection. Although this model provides a comparison of fertility differences for migrants in their new places of residence with non-migrants from their places of origin, it does not provide a direct comparison of an individual's fertility before and after changing residence because the model does not allow for fixed effects while accounting for complex survey design.

Discrete time conditional logit models, on the other hand, can include fixed effects with complex survey data, thus essentially providing a more direct comparison of fertility changes following a change of residence while controlling for unobserved individual-level characteristics. Specifying individual-level fixed effects in the model automatically controls for all unobserved differences between individuals that are stable (time-invariant), regardless of whether or not these differences are related to the likelihood of an event occurring (Allison 1994). In this case, the event is moving to a new residential area (migration), and the model allows for residence to be a time-varying covariate that can occur at different time periods for different individuals. Because the outcome is dichotomous in each person-year file (0=no birth in that year, 1= a birth), I use a conditional likelihood logit.

Relying solely on the results from this method, however, is complicated here by two factors. First, while the discrete-time conditional logit model can control for both constant and time-varying covariates, it can only produce estimates for those variables that change over time. As a result, it cannot provide estimates of fertility for non-migrants, eliminating them as a reference category for those who do not change residence. Second, and perhaps most important, the age pattern of fertility questions the accuracy of comparing a woman's fertility pre- and post-migration to measure the impact of residence in a new area may have on fertility, as most respondents who change residence do so when they are young, before the peak childbearing years. So while a discrete-time conditional logit may capture differences in fertility outcomes prior to and following a residential change, it may also be confounding these changes with both overall age patterns of fertility and changes in the tempo of fertility (particularly if women who delay their first birth ultimately have fewer children on average than those who begin childbearing earlier). However, by comparing the *changes* in fertility among migrant groups with fertility outcomes of non-migrant groups as estimated with a logit regression, we may be able to comment on the estimated differences in fertility among individuals who take up residence in new areas.

While neither the discrete time logit nor the discrete time conditional logit model can provide an actual counterfactual, I argue that by using them together I may be able to create a more complete counterfactual for what migrant fertility would have been for women who change residence type in the absence of this change. As a result, I run both logit and conditional logit models and use results from both models to form both population profile and individual-level counterfactuals against which to compare post-migration fertility among women who have changed residence.

Both the Poisson and the discrete-time logit and conditional models are run first for all migrant categories and then separately by length of time in current residence (0-2 years, 3-5 and 6-8). All regression models are run for the pooled sample of all women and include country-level fixed effects. The pooled sample includes weights at the country level, to account for the multistage sampling design (using the *svy* setting in Stata), and by country population at the regional level.

Results and Discussion

Descriptive statistics

Sample characteristics are of respondents are given for, age, education, children ever born and marital status are given for non-migrants (Table 3) and by all migrant categories by length of duration in place of destination (Table 4). Recent migrants are on average younger, more likely to be childless and have fewer children than migrants who have lived in their place of destination for longer. Newer migrants are slightly better educated than longer-term migrants, probably a reflection of increased levels of female education across the region. Somewhat surprisingly, rural women who move to large cities have among the lowest average number of children ever born and are more likely to be childless and unmarried than most other migrant categories (including rural-to-small urban). Women who move from urban areas (large or small) to rural areas have lower levels of education, more children and are more likely to be married than urban women who migrate to other urban areas. Migrants who make horizontal moves between small urban areas have higher cumulative fertility than those moving from small to large urban areas. There is some change in the profiles and ordering of migrant categories across different duration periods, indicating a timing element (and perhaps high proportion of circular or return migration) may be at play.

Table 3: Descriptive statistics for non-migrants for eleven West African Countries

Non-Migrants	**CEB (mean)**	**Age (mean)**	**Educ. (mean)**	**Parity=0 (%)**
Rural Non-migrant	3.83	30.4	0.6	21.1
Large Urban Non-migrant	2.02	28.7	1.5	37.4
Small Urban Non-migrant	2.89	29.0	1.2	32.9
Average	2.91	29.4	1.1	**30.5**

Source: Demographic and Health Surveys (1990-2008)
Education levels: no education=0, primary school=1, secondary school=2, higher=3

Table 4: Descriptive statistics by migrant category for eleven West African Countries

	6-9 years since migration				**2-5 years since migration**				**0-1 years since migration**			
Migrant Category	**CEB (mean)**	**Age (mean)**	**Educ. (mean)**	**0 parity (%)**	**CEB (mean)**	**Age (mean)**	**Educ. (mean)**	**0 parity (%)**	**CEB (mean)**	**Age (mean)**	**Educ. (mean)**	**0 parity (%)**
Rur → Rur	3.40	27.5	0.40	17.8	2.40	25.2	0.50	14.6	1.70	23.7	0.70	36.4
Sm Urb → Rur	2.72	28.1	1.00	44.3	1.90	25.1	0.90	32.0	1.30	24.1	1.10	56.0
Rur → Sm Urb	3.00	27.8	0.90	30.4	2.20	25.7	1.10	29.7	1.70	24.7	1.20	42.6
Lg Urb → Rur	2.23	30.1	1.70	38.1	1.80	28.5	1.80	37.2	1.50	26.6	1.70	44.2
Sm Urb → Sm Urb	2.64	28.6	1.50	33.7	2.10	27.3	1.60	31.8	1.60	25.8	1.70	41.0
Lg Urb → Lg Urb	1.92	26.7	1.10	34.5	2.40	28.3	0.90	29.8	1.30	26.6	0.99	43.8
Rur → Lg Urb	2.40	28.7	1.00	35.3	1.80	27.0	1.10	34.1	1.70	25.8	0.99	42.9
Lg Urb → Sm Urb	2.85	27.7	0.60	30.3	1.90	25.1	0.50	27.2	1.30	22.7	0.60	42.6
Sm Urb → Lg Urb	3.14	28.9	0.90	25.7	2.30	27.2	1.20	24.7	1.70	25.6	1.38	35.6
Average	2.70	28.23	1.01	2.70	2.40	25.2	0.5	24.3	1.53	25.07	1.15	42.8

Source: Demographic and Health Surveys (1990-2008)
Education levels: no education =0, primary school=1, secondary school=2, higher=3

ASFRs

Figure 1 illustrates variation in ASFRs across migrant and non-migrant categories. Migrants to and non-migrants in urban areas tend to have lower ASFRs at all ages. Generally speaking, migrants to rural areas and non-migrants in rural areas have the highest ASFRs – with the important exception of rural-to-large urban migrants, who show much lower ASFRs than all other groups that originate in or migrate to rural areas. Urban non-migrants and large-to-large urban migrants show slightly later fertility peaks than most other migrant categories. Rural-to-rural horizontal migrants show the highest fertility at younger ages and small-to-large urban migrants have lowest the ASFR of any group, including non-migrants in the largest urban areas, at nearly every age. While these ASFRs are largely descriptive and cannot give us substantial insight into lifetime fertility outcomes, but they nonetheless show that are is substantial variations in the age patterns of fertility by migrant category and suggest these differences warrant further investigation.

Figure 1: Age-specific fertility rates by migrant category (0-8 years in place of destination)

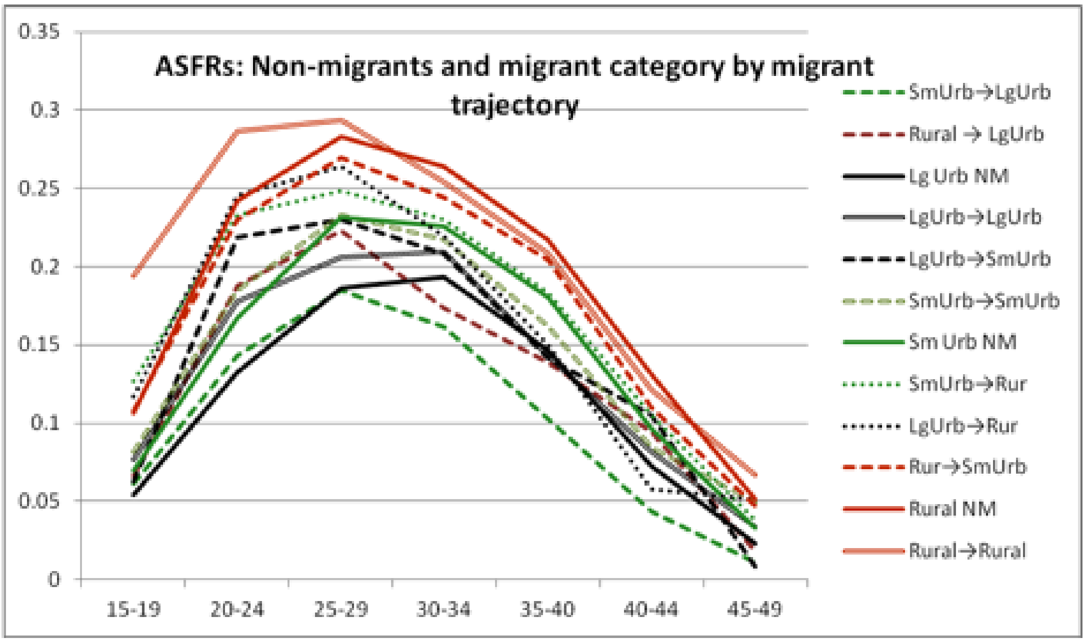


Table 5 displays results from the Poisson model for cumulative fertility for all migrant categories (migrants and non-migrants). Model one includes only age and age squared. Model two adds socio-demographic variables known to be associated with fertility: education, wealth and marital status. The third model adds the childhood type of place of residence. Table 5 seems to confirm the ASFR patterns seen in Figure 1. Small-to-large urban migrants show the lowest cumulative fertility of all migrants. Migrants with the lowest cumulative fertility are those that move to or from the largest cities - with the exception of large urban-to-rural downward migrants. In the third model, we see that childhood residence in a large city has statistically significant effect on cumulative fertility compared to childhood residence in a rural area, although living in a small city as a child is not statistically significant. Adding this variable to the model, however, does not change the direction of any of the coefficients for residence and only alters slightly the magnitude of some. Due to the relatively small influence this variable has on the estimated outcomes, combined with the problematic nature of this variable and the limited number of surveys in which it is included, I do not include it the following steps of the analysis.

Table 5: Poisson model of cumulative fertility by migrant status (0-9 years since last move)

	Model 1		Model 2		Model 3	
Migrant category (ref: rural non-migrant)						
Large Urban Non-migrant	-0.390	***	-0.117	***	-0.122	***
Small Urban Non-migrant	-0.162	***	-0.017		-0.030	*
Rural → Rural	0.024	*	-0.062	***	-0.059	**
Rural → Small Urban	-0.152	***	-0.063	**	-0.084	*
Small Urban → Rural	-0.179	***	-0.108	***	-0.102	***
Large Urban → Rural	-0.185	***	-0.127	***	-0.094	***
Small Urban → Small Urban	-0.360	***	-0.137	***	-0.166	***
Rural → Large Urban	-0.329	***	-0.147	***	-0.213	***
Large Urban → Large Urban	-0.482	***	-0.243	***	-0.220	***
Large Urban → Small Urban	-0.428	***	-0.201	***	-0.190	***
Small Urban → Large Urban	-0.554	***	-0.267	***	-0.273	***
Age	0.355	***	0.256	***	0.266	***
Age-squared	-0.004	***	-0.003	***	-0.003	***
Education level			-0.140	***	-0.130	***
Household wealth			-0.025	***	-0.024	***
Marital status			2.125	***	2.414	***
Childhood residence (ref: rural)						
Small urban area					0.004	
Large urban area					-0.048	**

Source: Demographic and Health Surveys (1990-2008)
All models include country-level fixed effects
Coefficients; * p<.05, ** p<.01, *** p<.001

Table 6 runs the full model from Table 5 for migrants only, by migrant category and by duration in current place of residence. All models control for age, age squared, education, household wealth quintile and marital status and parity; but these coefficients are not reported as they are in the expected direction across the three groups. Results displayed in Table 6 suggest that the association of migration and lower fertility generally increases with time for some migrant groups but not for most. This could be the result of greater adaptation to lower fertility with increased time spent in cities. It could likewise represent fertility disruption around the time of migration – or again circular migration by younger women who move to cities temporarily for work and then return to their places of origins to start families.

Table 6: Poisson model of cumulative fertility for migrants by duration at destination

	Number of years since last migration					
	0-1 years		2-5 years		6-9 years	
	Coef.		Coef.		Coef.	
Migrant stream (ref: Rural to Rural)						
Rural → Small Urban	0.026		0.055		0.002	
Rural → Large Urban	-0.036		-0.000		-0.084	
Small Urban → Rural	-0.004		-0.032		-0.001	
Large Urban → Rural	-0.013		-0.028		-0.015	
Small Urban → Small Urban	0.016		0.017		-0.073	*
Large Urban → Large Urban	-0.074		-0.053		-0.040	
Large Urban → Small Urban	0.101		-0.020		-0.179	***
Small Urban → Large Urban	-0.158	*	-0.127	***	-0.165	***
Age	0.281	***	0.231	***	0.161	***
Age squared	-0.003	***	-0.002	***	-0.001	***
Education	-0.187	***	-0.151	***	-0.149	***
Wealth level	-0.044	**	-0.044	***	-0.017	*
Married (ref: no)	1.565	***	2.153	***	2.164	***

Source: Demographic and Health Surveys (1990-2008).
All models control for age, age squared, education, household wealth, marital status and type of place of childhood residence and include country-level fixed effects

Coefficients: * p<.05, ** p<.01, *** p<.001

Discrete time logit model of fertility

Table 7 displays results of three discrete-time logit models of the annual probability of a birth by migrant and non-migrant categories, based on residence location at the time of the survey. Model one includes migrant category and age and age squared. Model two adds two time-varying covariates: marital status (moving from never-married to ever-married) and parity. The third model adds highest level of education achieved and household wealth (as measured at the time of the survey).

Table 7: Discrete-Time Logit Model for Fertility (annual probability of a birth)

	Model 1		Model 2		Model 3	
	Odds Ratio		*Odds Ratio*		*Odds Ratio*	
Migrant status *(Ref: rural non-migrant)*						
Small urban non-migrant	0.711	***	0.845	***	0.917	***
Large urban non-migrant	0.513	***	0.717	***	0.817	***
Rural → Rural	1.108	***	0.957	**	0.989	**
Rural → Small urban	0.857	***	0.917	***	0.993	
Rural → Large urban	0.614	***	0.807	***	0.916	*
Small urban → Large urban	0.563	***	0.780	***	0.920	**
Small urban → Small urban	0.712	***	0.900	***	1.003	
Large urban → Large urban	0.545	***	0.743	***	0.890	**
Large urban → Small urban	0.626	***	0.820	***	0.907	*
Large urban → Rural	0.801	***	0.881	***	0.901	***
Small urban → Rural	0.869	***	0.924	***	0.965	*
Age	0.975	***	0.915	***	0.918	***
Age squared	1.001	***	1.000	***	1.001	***
Married (ref: unmarried)			16.167	***	15.494	***
Parity (ref: 0)						
1			1.167	***	1.159	***
2 and higher			1.270	***	1.237	***
Education (ref: no education)						
Primary					1.031	*
Secondary					0.948	***
Higher					0.835	***
Household wealth *(ref: poorest)*						
Poor					0.982	
Middle					0.940	***
Rich					0.901	***
Richest					0.824	***
Intercept	0.422	***	0.120	***	0.125	***

Source: Demographic and Health Surveys (1990-2008).
All models include country-level fixed effects
* p<.05, ** p<.01, *** p<.001

When controlling only for age and aged squared, every migrant category has annual birth probabilities that are statistically significantly different (p<.001) from the reference category of rural non-migrants. With the exception of rural-to-rural migrants, annual odds of a birth are lower for all migrant categories compared to rural-non-migrants. The differences are attenuated some with the addition of two time-varying covariates: marital status and parity, both of which substantially increase the likelihood of a woman giving birth in a particular year. The effect of being married is particularly strong, suggesting that few births happen (or that are reported to happen) out of wedlock. When a woman's highest level of completed education and her household's wealth quintile (at the time of the survey) are added to the model, rural-to-small urban and small urban horizontal migrants' annual birth probabilities are no longer significantly different from that of rural non-migrants. For all other categories, however, annual birth probabilities are lower than for rural non-migrant reference category, with the largest differences are for large urban non-migrants and large urban horizontal migrants. It is noteworthy that among women who migrated upwards to the largest cities, those from rural areas have lower annual birth probabilities than those from small urban areas, though the difference is slight.

<u>Table 8: Discrete-time logit model for migrants: comparison of birth probabilities in year *t* before and after migration</u>

Migrant category		Pre-migration *(origin)*		Post-migration *(destination)*	
Ref: Rural	*→ Rural*				
Rural	→ Small urban	1.043		0.965	
Rural	→ Large urban	1.036		0.811	***
Small urban	→ Large urban	0.896	*	0.822	***
Small urban	→ Small urban	1.024		0.938	
Large urban	→ Large urban	1.002		0.831	***
Large urban	→ Small urban	1.066		0.842	***
Large urban	→ Rural	1.000		0.950	
Small urban	→ Rural	0.971		0.962	

Source: Demographic and Health Surveys (1990-2008).
Models control for age, age squared, education, household wealth, marital status, and parity (first and higher order births) and include country-level fixed effects
Odds ratios; * p<.05, ** p<.01, *** p<.001

Table 8 uses the full model from Table 7 above to compare the annual birth probabilities among the different migrant groups in the period prior to and following their migrations, in an attempt to determine whether there is a discernable selection effect (for higher or lower fertility) among those who change residence prior to their move. Since I am now looking at only migrants, the reference category is no longer rural non-migrants but is instead rural-to-rural migrants. Both the descriptive overview and results from Table 7 suggest that fertility of rural horizontal migrants is the closest of all categories to that of rural non-migrants, making it a reasonably similar comparison as a reference group.

Only migrants from small-to-large urban areas show annual odds of having a birth prior to migration that are statistically different from rural-to-rural migrants. Their lower birth odds could indicate a potential selection effect among this group, but not among any other. When we look at the post migration period, however, small-to-large urban migrants have even lower odds of having a birth in a given year than prior to the move. Three other migrant categories show statistically lower annual odds of having a birth, all of which include a large urban area as origin or destination. With the exception of those who move from large-to-small urban areas, respondents who migrated to a small urban or rural areas, downward or horizontally, have annual odds of having a birth that are not significantly different from that of rural-to-rural migrants. This finding seems to contradict somewhat those of the most comparable study of migration in SSA that measured pre-migration fertility (Brockerhoff and Yang 1994) and found that rural-to-urban and urban-to-urban migrations had higher fertility than non-migrants in the years just prior to migration.

Table 9: Discrete-time logit model of odds of a birth in year *t* for all migrant categories by duration at place of destination

Migrant Category	0-1 years		2-5 years		6-9 years	
	Odds Ratio		*Odds Ratio*		*Odds Ratio*	
Ref: Rural → Rural						
Rural → Small urban	0.847		1.049		0.917	
Rural → Large urban	0.750		0.880		0.852	
Small urban → Large urban	1.013		0.864	**	0.855	**
Small urban → Small urban	1.212		1.001		0.893	**
Large urban → Large urban	1.062		0.908		0.862	*
Large urban → Small urban	1.376	*	0.966		0.777	**
Large urban → Rural	1.075		0.987		0.962	
Small urban → Rural	1.263	*	0.996		0.957	

Source: Demographic and Health Surveys (1990-2008)
Models control for age, age squared, education, household wealth, marital status, and parity (first and higher order births) and include country-level fixed effects
Odds ratios; * p<.05, ** p<.01, *** p<.001

Table 9 breaks down annual birth probabilities by migrant group by duration in the place of new residence, to determine whether there are markedly different patterns over time, primarily to see if there is a bump in the odds of giving birth in the period immediately following migration. If so, this would make a strong case for the disruption hypothesis, and catch-up fertility due to marriage-related migration or reuniting of spouses. This, in turn, would suggest that residence the (new) place of destination has less of an impact on fertility than does the process of, and disruption around, migration itself. We do see some evidence of increased birth odds in the two years immediately following migration but only for two groups – notably, the only two downward migration categories (large-to-small urban and small urban-to-rural). There is no convincing time trend across migrant groups, although intra-urban migrants (to, from and between small and large urban areas) do show greater decreases in (significant) annual birth odds among those who have resided in their places of destination the longest.

While this model seems to provide a good approximation for measuring the effect of new residence on fertility outcomes, it does not measure this change directly for individuals. Instead, this is done in Table 10, which shows results from a conditional logit model with individual-level fixed effects. In theory, this measures any change in the outcome (annual probability of a birth) following the event (migration and residence in a new area), since the individual-level fixed effects are designed to control for all stable differences across individuals, and any changes in fertility should be attributable to the event of migration and subsequent residence in the (new) place of destination.

Table 10: Discrete time conditional logit model (probability of a birth in year *t*) with individual level fixed effects

Migrant Category	Odds Ratio	
Rural → Rural	1.615	***
Rural → Small urban	1.417	***
Rural → Large urban	1.124	
Small urban → Large urban	1.442	***
Small urban → Small urban	1.498	***
Large urban → Large urban	1.312	
Large urban → Small urban	1.463	**
Large urban → Rural	1.462	***
Small urban → Rural	1.542	***
Age	0.977	***
Married	17.567	
Parity *(reference: 0)*		
1	0.479	***
2 or greater	0.192	***

Source: Demographic and Health Surveys (1990-2008)
Model also controls for but does not calculate coefficients for the following constant (time-invariant) variables: age squared, education and household wealth
Odds ratios; * p<.05, ** p<.01, *** p<.001

Results from the discrete time conditional logit model with individual fixed effects (Table 10) suggest that for nearly all migrant categories, the period following a residence change leads to significantly higher fertility. The only exceptions are for the two groups that had among lowest relative fertility as estimated in the logit models: rural-to-large urban migrants and large urban horizontal migrants, though neither are statistically significant. All other groups have odds of more than 40 percent of having a birth in a given year than they did in their place of origin prior to the move. These results suggest that migration and residence in new areas dramatically increases fertility for nearly all women.

The findings from the conditional logit model with individual-level fixed effects in Table 10 seem somewhat puzzling. They seem to run counter to what we would expect given the descriptive characteristics and earlier Poisson models of fertility, and seem to run directly counter to the results from the logit models. However, I suspect that rather than controlling for unobserved differences across individuals, the fixed-effects models are reflecting the intersection of the age patterns of fertility and age patterns of migration. In fact, among all migrant categories, women who migrate do so on average more than year before mean age of childbearing for that category, suggesting that most women have the majority of their children after migration – regardless of their overall level of fertility (Table 11). Furthermore, migrants a combined group and each individual migrant category have their first births later than non-migrants (from the places of origin). As a result, women with lower lifetime fertility but who have most or all of their children following their change of residence would appear to have higher fertility as a direct result of their move and of living in a new environment – be it in rural, small urban or large urban areas. As a result, I contend that the discrete-time logit model, though it does not measure changes in an individual's fertility against herself, is a more appropriate measure of the counter-factual for migrant fertility outcomes in the absence of a change in residence.

Table 11: Mean age at first birth, all births and migration for migrants and non-migrants

Migrant category	Mean age at first birth	Mean age at birth	Mean age at migration
All migrants combined	19.55	28.98	27.96
All non-migrants combined	18.88	32.31	--
Rural non-migrants	18.51	32.70	--
Small urban non-migrant	19.00	32.70	--
Large urban non-migrant	19.75	32.45	--
Rural → Rural	18.81	27.89	26.64
Rural → Small urban	19.45	29.06	27.43
Rural → Large urban	19.58	29.77	27.01
Small urban → Large urban	21.24	30.80	29.79
Small urban → Small urban	20.45	29.84	28.28
Large urban → Large urban	20.89	30.71	28.91
Large urban → Small urban	20.53	29.08	28.33
Large urban → Rural	19.46	28.29	25.96
Small urban → Rural	19.73	29.72	28.44

Though this analysis here does not delve into the various reasons behind residence change among women in SSA, it is worth commenting briefly on how different motivations for migration and relocation may work to influence fertility. For example, pursuing higher education or employment may drive urban-ward migration among many young women. Continued education and access to higher levels is a major determinant of migration in SSA, and students who are successful in school are more likely relocate to the larger cities where higher education institutions are concentrated. Rural to small urban migration tends may likewise coincide with success at primary school and relocating to attend high school, while a move from small-urban to large urban consecrates access to higher education. Marriage and family formation are likewise strong drivers of migration, and relocating from urban to rural areas may be largely driven by divorce and return home, while rural-to-rural migrations are more likely to be for nuptial purposes, not for education or work. These differences could explain differentials in annual birth probabilities between these two groups but research into the motivations and specific timings of residential relocation of women in SSA are better suited for future studies which can utilize detailed longitudinal data.

Conclusion

Results from this study suggest a discernable "urban effect" associated with internal migration and fertility outcomes. This is evident first in the descriptive overview, which includes descriptive statistics of the profile of all migrant categories and initial Poisson regression analysis of fertility as measured by children ever born. Notably, ASFRs are generally lower among migrants and non-migrants, and are particularly low for migrants from small-to-large urban areas and higher among women who have relocated to rural areas. Poisson regressions of children ever born likewise suggest that women who relocate to the largest cities (from rural areas and smaller cities) have lower fertility than do women who move to smaller cities (from rural areas or other small cities), suggesting that the influence of urban residence on fertility is strongest where fertility rates are lowest.

Results from the discrete time logit model of annual birth probabilities show that with the exception of the two years immediately following a change in residence, all migrant categories have annual odds of a birth that are lower than those for rural-to-rural migrants – though these differences are only statistically significant for migrants moving to, from and within the largest urban areas. Including individual-level fixed effects in the final discrete time conditional logit model allows for a more direct measurement of the fertility of women who move before and after a change of residence. Results from this model diverge from that expected from the descriptive overview and found in the logit model, and indicate instead that all women from all migrant categories have substantially and significantly higher fertility following residence in new areas. However, I contend that this fixed-effects model is reflecting the intersection of the age patterns of fertility and age patterns of migration and thus do not provide an accurate counterfactual. Most women who move do so before their peak age of childbearing, suggesting that individual-level fixed effects confound overall age patterns of fertility with individual increases in fertility. As a result, I argue that the discrete-time logit model is a superior approximation of the counter-factual for fertility outcomes in the absence of a change in residence, and I use the results from this model to argue that residence in new areas among all migrant groups demonstrate apparent reductions in fertility attributable to the "urban effect." This, in turn, suggests that in West Africa, high rates of migration both to and from urban areas may contribute positively to declines in fertility at the national levels.

CHAPTER 3

Urban Fertility and Child Mortality in West Africa: Are all cities created equal?

Introduction

This chapter aims to produce locally informed demographic estimates of fertility and under-five mortality by city size category at the regional level in West Africa. I argue that with the large-scale process of urbanization facing sub-Saharan Africa (SSA), and in particular West Africa, it is essential to consider urban and rural areas as a continuum, rather than simply a dichotomy. This is particularly true given that SSA's rapid urbanization is happening in tandem with overall declines in fertility and child mortality. The continued reliance on the urban/rural dichotomy in demographic research may be obscuring important interrelationships between urbanization, on the one hand, and fertility and mortality changes, on the other, that are currently underway throughout SSA.

The analysis here focuses on a more detailed spectrum of "urban" areas, by giving specific consideration to the small- and medium-sized cities that tend to be overlooked in the demographic literature on urbanization in developing countries (Montgomery 2009; Potts 2008). This chapter extends earlier work in Chapters 1 and 2 of this dissertation, which looked beyond the urban-rural dichotomy in demographic research in SSA, by expanding intra-urban definitions to include four city size categories. This analysis also includes a substantial geographic information systems (GIS) element, because creating more accurate estimates of urban differentials in fertility and mortality requires precise spatial location of urban settlements and correctly matching these locations with available demographic data. By linking local demographic data to specific urban sub-categories, I hope to determine whether urban areas of different sizes with different characteristics show significant enough differences in fertility and child mortality rates to warrant more standard divisions of cities in demographic research– or whether, conversely, urban areas of different sizes have fertility and mortality rates that are similar enough to justify the continued use of the urban/rural dichotomy.

Background/Motivation

Beyond the urban/rural dichotomy

Urbanites in SSA, as throughout most of the developing world, are generally believed to better off than their rural counterparts. Most studies show that urban dwellers in developing countries enjoy superior living standards, better access to infrastructure and health services, and higher education levels than their rural counterparts (Montgomery 2009), including in SSA (Brockerhoff and Yang 1994; Bocquier, Madise and Zulu 2011). While there is some debate about intra-urban disparities (Montgomery 2009; Van de Poel 2009) and whether the urban child health advantage is declining (Gould 1998; National Research Council 2003; Woods 2003; Gunther and Harttgen 2012), at the aggregate in SSA child survival remains higher and fertility lower in urban compared to rural areas.

But are all urban dwellers equally well off? Does the urban advantage –be it for living standards, education, or fertility rates– apply uniformly across areas considered urban? Demographic research on SSA almost universally uses an urban/rural dichotomy that defines urban and rural areas in contrast only to one another: that which is not urban is rural and vice versa. This oppositional definition implicitly assumes that characteristics found in one category are absent from the other and that urban and rural areas are easily and clearly distinguishable from one another. By lumping together all areas considered urban in one category, the dichotomous urban definition may obscure important nuances in intra-urban differences in the demographic impact of SSA's urban transition, including whether cities of different sizes have different rates of fertility and mortality that show a common pattern across the region.

For example, SSA is known to have substantial urban/rural fertility differentials, but we know next to nothing about whether there are fertility differentials within the "urban" category, despite substantial variation in the size and characteristics of different cities. Urban areas are believed to be the driving force behind the SSA's fertility transition (Cohen 1993) , and throughout the region fertility is substantially lower in urban compared to rural areas (Brockerhoff and Yang 1994; White, Muhidin et al. 2008). Yet little attention has been paid to differentials in fertility outcomes disaggregated by size beyond segmenting the capital cities from all other urban areas(Cohen 1993; Shapiro and Tambashe 2002). This leaves great uncertainty over whether cities of all sizes will contribute equally to the region's fertility decline – or whether declines in overall fertility (when they occur) are due almost entirely to low fertility in the largest cities, with smaller cities may have a negligible role in influencing fertility decline across the region. Likewise, though research has shown that urban areas in SSA generally have distinct under-5 survival advantage over rural areas, we know little about whether this advantage is bestowed on all urban areas, big and small, simply by virtue of being designated urban or whether the advantage is greater among cities of different sizes. To date, there are no detailed studies of differential fertility outcomes regionally in SSA by city size beyond segmenting the largest cities, and few studies that examine child mortality differentials among urban areas of different sizes (Brockerhoff and Brennan 1998; National Research Council 2003).

In addition to obscuring potentially important intra-urban differences in demographic outcomes, relying on the urban/rural dichotomy also leads to the implicit assumption that urban areas of vastly different size are undergoing a homogenous process of both demographic change and urban growth. Population projections, both for overall population growth and for urban populations and urban growth, are usually carried out at the country-level, particularly in countries that lack comprehensive demographic data. In such cases, one urban growth rate is applied to all urban areas in a country. Previously, a dearth of reliable data on fertility and mortality in the vast majority of SSA countries made it nearly impossible to incorporate location-specific estimates within a country. The proliferation of nationally representative demographic surveys in SSA over the past few decades (most notably DHS but also MICS and more reliable census data), however, now provides information on urban fertility and mortality rates that can produce more localized estimates and could be incorporated directly in city growth estimates (Montgomery and Balk 2011). Micro data from the DHS can now be used to give estimates fertility and child mortality rates at the subnational levels (and, at least for the largest cities, at the city-scale), which can be incorporated into urban growth projections[9].

Estimates and West Africa

This study focuses specifically on West Africa. Improving our understanding of the interrelationship between urbanization and fertility and child survival outcomes is particularly relevant for West Africa, given the region's persistent high rates of fertility and child mortality, and substantial urban/rural differentials for both. Even within SSA, which has among the highest fertility rates and lowest child survival probabilities in the world, West Africa stands out. The United Nation's estimates that the total fertility rate (TFR) for West Africa is 5.63 and under-five mortality is 120/1,000, compared to 5.10 and 110/1,000 for SSA as a whole[10] (United Nations 2013). Furthermore, West Africa is projected to have the highest rates of urbanization and urban growth in SSA in the coming decades, and the United Nations forecasts that by 2025 West Africa will have more cities with populations of over a million people than any other region in Africa (United Nations 2012).

Additionally, West Africa's sharp urban/rural differentials in fertility and child mortality outcomes make it easier to identify an urban gradient, if it exists, for these demographic outcomes. Urban areas in SSA in general, including in West Africa, have had a long-held child survival advantage in urban over rural areas (Kandeh 1989, Gould

---

[9] The data available from the DHS on migration, however, is much less complete and –at best– can give only an approximation of in-migration rates, which cannot be directly incorporated into growth estimates without more information on circular and out-migration from the same cities.

[10] Estimates from the United Nations put TFR and under-five mortality highest in Middle Africa, at 5.58 and 159/1,000 respectively, but the low number of DHS carried out and census data available for this region make it difficult to produce meaningful finding for this region as a whole.

1998, Mitchel 2009), and while there are questions over whether that survival advantage is narrowing (Fotso et al. 2007, Antai and Moradi 2012), recent studies have found that at the aggregate level the overall urban advantage persists (van de Poel et al. 2007; Bocquier et al. 2011, Gunther and Harttgen 2012). Likewise, though fertility remains stubbornly high throughout West Africa, overall fertility rates are lower in urban than rural areas and nearly always much lower in the largest cities compared to other urban areas (Cohen 1993; Shapiro and Tambashe 2000). These stark overall urban/rural differences make the West African sub-region a particularly good setting for investigating whether urban areas of different sizes also have discernable differences in fertility and child mortality outcomes.

Last, West Africa is facing rapid urbanization and both population and urban growth, making the ability to produce accurate population projections of at both local and national levels all the more pressing. Projections of national and local population size are the basis for determining future population needs, including infrastructure, housing, education, transportation and health care needs - and are particularly important in areas like West Africa which are experiencing particularly rapid population growth. Population growth, urban growth and urbanization are the direct results of the three components of demography: fertility, mortality and migration. Projecting population growth, including urban growth, requires making informed estimates of future population using models based most generally on assumptions on the future course of fertility, mortality and migration (Preston et al. 2001). Assuming that rates of fertility and mortality (and migration, which is more difficult to estimate and not directly measured here) are constant across all urban areas may lead to erroneous projections of urban growth, with major implications for policy and planning in West Africa's rapidly growing urban areas.

Contributions of this chapter

Persistent use of the urban/rural dichotomy in demographic research of SSA and the rigid divide this dichotomy imposes may obscure important nuances in the relationship between urbanization and fertility and mortality outcomes. This chapter aims to fill the gap in the understanding of intra-urban patterns and differentials of fertility and mortality in West Africa as the first study to measure these demographic outcomes – fertility and child mortality– using an urban continuum. By employing an urban continuum, rather than a single category for all areas considered urban, I hope to determine whether fertility and child mortality rates vary enough by cities of different size to require a reconsideration of the appropriateness of continuing to apply a simple rural/urban dichotomy to health measurements in a region, such as West Africa, undergoing rapid urbanization and demographic change. Disparities identified in health outcomes between urban and rural areas (as well as between the poor and non-poor in large urban areas) have been driving forces in allocating resources and designing policy and programming aimed at improving child survival and access to voluntary family planning; if urban areas show the similar levels of intra-urban variation in fertility and child mortality outcomes, there is no reason that similar consideration should not be given for differential policy approaches to different urban areas. This chapter aims to be the first step in examining whether differentials in fertility and child mortality across urban areas of different sizes requires a more nuanced approach when considering what is "urban" across SSA.

The analysis here also hopes to address in part the critique of the United Nation's failure to take into account region- or city-specific demographic data in its urban growth projections. The United Nations Population Division produces the most comprehensive international data on urban areas and urban growth in its biennial publication *World Urbanization Prospects* (Cohen 2004), which includes estimates and projections of urban and rural populations for each country, as well as for the largest cities (those with populations greater than 750,000), derived from country-level estimates of total population, proportions urban and rural, and standard rates of fertility, mortality and migration for urban and rural areas[11]. The United Nation's approach to urban growth projections has come under criticism for neglecting to directly incorporate fertility, mortality or migration estimates (Montgomery 2011), as well as for a systematic bias that produces growth rates that are too high (Bocquier 2005, Cohen 2004, National Research Council 2003). UN often uses city-specific data for urban growth rates of the largest/capital city, but otherwise applies uniform estimates of urban growth across all other areas of a country considered "urban", essentially assuming that urban areas of vastly different size within a country are undergoing a homogenous process of urban growth. Such an assumption of homogenous rates of urban growth applies in particular to SSA, where an estimated two-thirds of urbanites live in cities of 500,000 of less (N.R.C.

[11] It also includes estimates on total urban population by city size classes, but with a lower bound category of urban areas with populations of 500,000 or less[11] (United Nations Population Division 2012). Other categories are: 500,000 to 1 million, 1 to 5 million, 5 to 10 million and greater than 10 million.

2003). For West Africa, the overwhelming majority of urban areas in West Africa fall under the UN's lower-bound category of "fewer than 500,000", with only a handful of cities across the region falling in the higher-order categories. By matching demographic micro-data to specific categories of urban areas by size, I hope to determine whether discernable differences in these rates across West Africa warrants the consideration of city-specific or city-size specific fertility and mortality estimates in urban growth estimates.

Data

Correctly defining and identifying urban areas, coupled with precise matching of micro-data to these areas, is critical for accurately integrating data from different sources to produce fertility and under-5 mortality estimates for city-size categories that are standardized across a region. I seek here to match demographic data collected at the administrative level (from household surveys) with data on spatial identifiers (for categorizing survey clusters by city size). This involves linking information on city size from data sources on population size, geo-locating these areas using a second source indicating administrative and/or population extent boundaries, and matching micro-data by verifying the location of survey clusters.

In this chapter I combine data from four sources in order to identify and categorize urban areas and link them with demographic survey data. First I take census data from each country to categorize specific cities by population size. Then I use the

Demographic and Health Surveys (DHS) for estimating fertility and child mortality rates. The Global Rural-Urban Mapping Project (GRUMP) satellite data is next used to help for spatially locating and delineating urban boundaries. Last, I incorporate the National Oceanic and Atmospheric Administration's (NOAA) DMSP-OLS nighttime lights time series data is used to identify any spatial expansion of urban areas since the GRUMP measurements. Details on each data source and how it is used in conjunction with the other data sources is described in turn below.

Census Data

Information on the estimated populations of urban areas comes from individual country census data and is accessed from the *citypopulation.de* website. This website compiles data on national and urban populations for all countries that have made their census findings public. Information on populations of the largest cities is also available in the cities database published annually in the United Nations Demographic Yearbook, which also takes its data directly from country censuses, and is often considered the international standard for urban statistics. For my purposes, however, the *citypopulation.de* website offers three distinct advantages over the United Nations data. First, while the United Nations cities database only lists urban areas with populations greater than 100,000, the *citypopulation.de* website lists census data on all areas classified as "urban" within a country, including those with populations less than 100,000. Second, the *citypopulation.de* website directly compares data from multiple censuses, unlike the United Nations cities database which lists only data from a country's most recent census at the time of publication. Last, *citypopulation.de* provides direct links to each country's original census data, so that data can be directly verified with the original country source if necessary. For these reasons, I use the *citypopulation.de* website as the primary source of country census data for this study. To ensure the accuracy the data from the website it was also compared with data listed for the largest cities in the United Nations Demographic Yearbook. City population estimates used here are those on city proper estimates as defined in and provided by census, rather than urban agglomerations (which are only available for only some countries).

Table 1: Data sources in the analysis

Data Source	Data	Use
Individual Country Censuses	Urban area populations	Classifying urban areas by population size
Demographic and Health Surveys (DHS)	Individual demographic and socio-economic variables	Calculating household characteristics, fertility rates and child mortality rates
GRUMP	Global urban extent boundaries	Mapping and matching DHS clusters to urban areas
NOAA nighttime lights	Nighttime light series data	Identifying spatial expansion of urban areas since GRUMP measurements

Demographic and Health Surveys (DHS)

The data on fertility and child mortality and other socio-demographic characteristics for this study comes from the Demographic and Health Surveys (DHS). The DHS collects nationally representative data in less developed countries through household sample surveys that measure health, population, and socioeconomic indicators, with a focus on maternal and child health (Rutstein and Rojas 2006). To date, the DHS has carried out over 300 surveys in more than 90 countries. DHS use standardized variables across surveys in order to be easily comparable across countries and over time within the same country (DHS 2014).

All DHS employ a two-stage stratified cluster random sample within each country to choose households: the sampling frame is first stratified by urban and rural areas and then by geographic or administrative regions within a country. Clusters of houses, from a list of census enumeration areas, are randomly selected from within in each stratified area, with these households randomly selected with equally probability and each individual is assigned a sampling weight (Macro International 1996). All women of reproductive age (15-49) within each selected household are interviewed. The surveys collect detailed data on maternal and child health fertility, family planning. In addition, the DHS collects demographic characteristics of the respondent (including age, level of education, employment and marital status) and household characteristics (including infrastructure and proxies for household wealth).

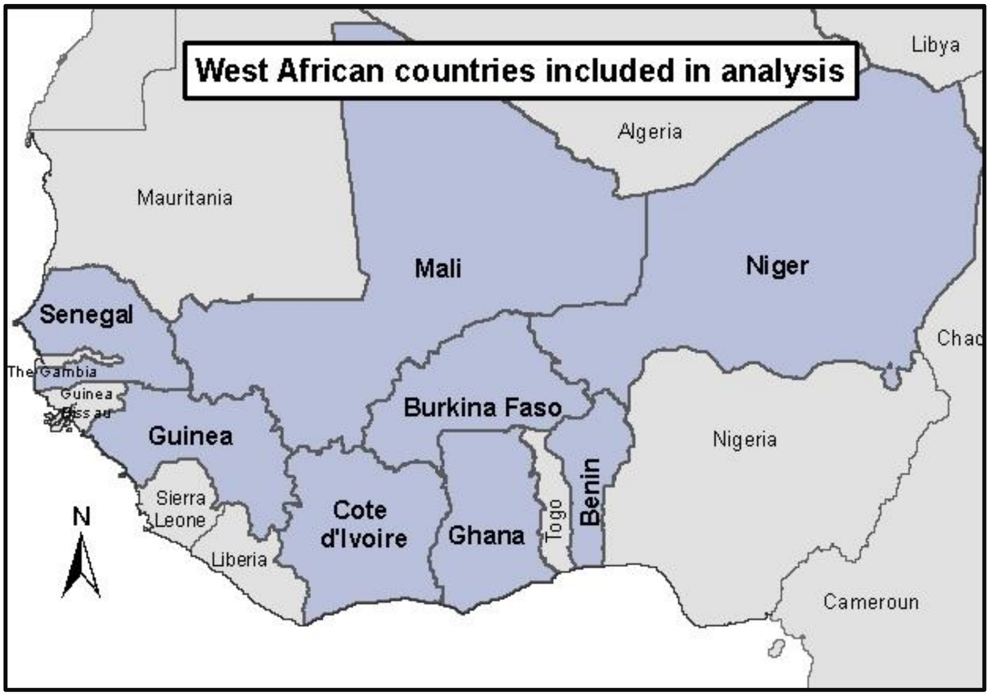
Birth histories are collected from all women surveyed in the DHS, and include data on the month and year of birth, parity and sex of each child ever born to a respondent (not including current pregnancies). Fertility rates are calculated from these birth histories, as are child survival rates since the DHS include data on whether or not a child is alive and age at death for children who died. For those children who died, the age of death is recorded in months for the first two years and then only in years.

The DHS data also includes information on three variables commonly used as measures of urbanness and poverty: household electrification, access to an improved source of drinking water and access to improved toilet facilities (sanitation). These indicators are used to measure access to urban amenities and, by extension, to serve as a functional measure of urbanness (Dorelien, Balk and Todd 2013). These three variables are also known to be correlated with child survival, though with some variation in the associations across different contexts (Mosley and Chen 1984; Wang 2002; Fink, Gunther and Hill 2011). Household electrification, in the developing world in general, and SSA in particular, is highly concentrated in urban areas (Doll and Pachauri 2010) and economic activity usually concentrated in urban areas is highly correlated with nighttime lights (Henderson, Storeygard and Weil 2012). Improved water and sanitation also tend to be concentrated in urban areas, particularly as toilet facilities are often related to better infrastructure generally available in cities. Here, indictors for access to improved and unimproved water source and sanitation are based on categories provided by the WHO and UNICEF Joint Monitoring Program for Water Supply and Sanitation (WHO/UNICEF JMP website 2013): a household is considered to have access to safe water if its primary source of drinking water comes from a private or public tap, a protected well or spring, or rainwater. Improved sanitation includes a private or shared flush toilet or an improved latrine (ventilated, covered with a slab or flush).

The DHS also includes data on respondents that can be used to identify which are migrants. The DHS asks respondents how long they have lived in their current place of residence; women who do not respond “always” are asked to identify how many years ago they moved to their current location. In some surveys, a woman's type of previous place of residence (which corresponds loosely to v026: capital/large city, small city, town, countryside – see next paragraph) is also listed – although the specific location is not given. While this information does not provide a comprehensive migration history, it does identify those who have moved at least once before the survey and accounts for how long they have lived in their current place of residence and, in some cases, the type of place from which they moved. Migrants are defined here as women who have changed location within the five years before the year of the interview.

All DHS surveys identify each cluster as either "urban" or "rural" (v025). Some, but not all, surveys also include the variable v026, which in most cases further classifies clusters as "capital/large city", "small city", "town", or "countryside", and provides a general segmentation of urban areas according to size. Relying on the DHS intra-urban classifications (with variable v026, when it is included in a survey) to create sub-categories of urban settlements, however, is problematic for three reasons: 1) it is based on individual country definitions of urban categorization, which varies across countries, 2) it does not identify specific cities within a DHS region, often making it impossible to determine to which of many cities in a region a cluster classified as "small city" corresponds, and 3) some of the surveys which do include variable v026 have only three classifications (the capital city, "small city" and "countryside") instead of four, or specify the categories specifically by cities ("Abidjan") rather than broad categories. These issues render cross-country comparisons using v026 city class sizes impossible even for the minority of surveys that include this variable.

Map 1: Map of West African countries included in the analysis



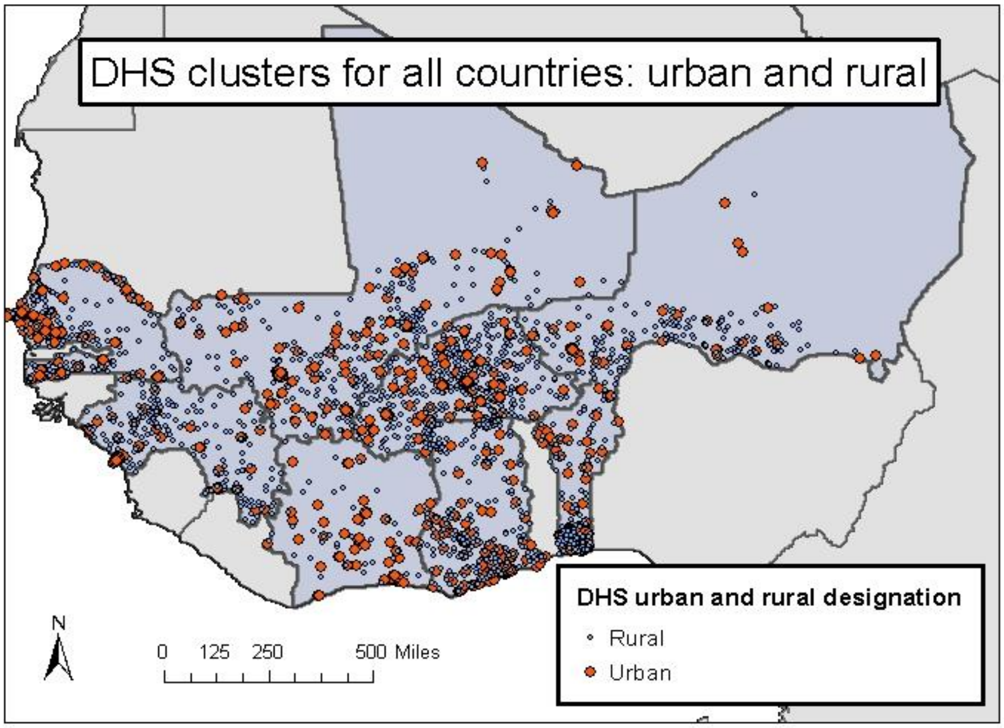
The majority of DHS surveys since the 1990s contain geo-referencing information (longitude and latitude coordinates) for all survey clusters, allowing for the visual identification of their location. Most DHS clusters have a GPS reading that is estimated to be accurate within 15-20 meters. In order to guarantee respondent confidentiality, however, all clusters are randomly displaced in the publically available datasets, with urban clusters displaced up to two kilometers and rural clusters up to five kilometers (DHS 2014). As a result, cluster placements when mapped are very close but not exact locations of the clusters.

In this analysis I use data from eight West African countries with a Standard Demographic and Health Surveys (DHS) that were carried out between 1992 and 2010 and that included GPS cluster coordinates. 1992 is the earliest year in which cluster GPS coordinates were collected in any West African survey. Only DHS conducted within five years before or after a census are included to allow for more accurate classifications of city size in a region undergoing both rapid urbanization and rapid urban growth.

Table 2: DHS Surveys included in the analysis

DHS		Nearest census
Country	Year	
Benin	2001	2002
Burkina Faso	2010	2006
Côte d'Ivoire	1998	1998
Ghana	2008	2010
Guinea	1999	1996
Mali	2006	2009
Niger	1998	2001
Senegal	2011	2010

Map 2: Mapping of all DHS-designated urban and rural clusters for analysis countries



The Global Rural-Urban Mapping Project (GRUMP)

The Global Rural-Urban Mapping Project (GRUMP) data is used to spatially identify urban boundaries and for subsequently matching DHS clusters with corresponding urban areas. GRUMP is a global database that approximates the extent of urban areas using a combination of nighttime lights satellite data and administrative information on population sizes of settlement areas, allowing for a more standard identification of urban extents globally than from comparisons of individual country-level administrative data (Balk et al 2005). Using GRUMP data in combination with DHS allows for a more nuanced definition and measurement of urban than relying on the country-specific definitions of the urban/rural dichotomy in the DHS (Dorelien et al. 2013).

GRUMP initially identifies urban areas by their night-time stable lights "footprint" using the 1994-95 stable city lights dataset from the National Oceanic and Atmospheric Administration (NOAA). This measurement of permanent nighttime lights is then matched with information on city name and population size from national statistics offices (NSOs) and other sources, and an urban area is calculated as a propensity of the lights-based extents. In some cases, particularly in less developed regions including SSA, the nighttime lights data does not detect known cities or smaller urban areas. While electricity is not necessarily absent from all rural areas, where it is present it is not generally strong enough to be detected by the satellite imagery of nighttime lights (Dorelien, Balk et al. 2013). In these instances, urban areas are estimated using administrative population data. These imputed urban areas are designated with fictive lights in the shape of a circle, which can be easily differentiated from the satellite data polygons that represent areas captured by the nighttime stable lights. The final assignment of urban extents with GRUMP involves several levels of cross-validating data from local administrative sources on population and settlement sights with the satellite data (Balk 2009; Dorelien, Balk et al. 2013), and results in crude but still accurate representations of urban extents associated with human settlements (Balk et al. 2005).

DHS data are spatially liked to GRUMP for two main reasons. First, to verify that clusters are accurately coded as urban or rural. In instances where urban or rural clusters appear to be miscoded, particularly when urban and rural clusters overlap, linking these clusters to GRUMP can indicate whether they fall under a permanent nighttime light extent – and, by extension, an urban settlement area. Dorelien et al. (2013) found that GRUMP urban extents identified as urban many clusters designated as rural by the DHS. They also found that DHS clusters –urban and rural– that fell within the GRUMP extents were far more likely to have urban characteristics (i.e. household electrification and access to improved water and sanitation) than those that fell outside of the lights[12]. As GRUMP satellite imagery is primarily based on the 1994-95 stable city-lights dataset and conversely may fail to represent emergent urban areas, the second-step of matching the nighttime lights to GRUMP areas is designed to control for some of this.

Second, linking DHS geocoding information facilitates a more accurate placement of clusters along the urban continuum. Rather than relying on the urban-rural dichotomy using country-specific definitions of urban, as reflected in the DHS, this analysis builds off of work by Dorelien et al. (2013) which showed that using GRUMP in tandem with DHS geocoding of clusters allowed for a better identification of a continuum of urbanness compared to the use of either dataset on its own. While census data provides the basis of the definition of urban categories here by population and for preliminary categorization of clusters based broadly on mapping cluster coordinates, GRUMP allows for a more accurate placement of clusters that do not fall clearly within an administrative area but which may more accurately fall within a particular urban extent. This is particularly important for identifying peri-urban areas, which may be identified in DHS

[12] DHS clusters are also verified using Google Earth, this can only link data to current satellite imagery, which is problematic for matching clusters from earlier surveys, as clusters which fall in areas that were previously rural but are now urban would be mistakenly classified as urban at the time of the survey.

as rural but are adjacent to urban areas, and for determining whether small urban areas that surround the larger urban areas are distinct cities or whether they are essentially linked suburbs of the larger city. Details on the specific city size categories used here are explained in the methods section below.

Stable time-series light data

As GRUMP was developed using the NOAA stable city-lights dataset from 1994-95, it thus does not capture areas that became electrified after this period. Since all of the DHS surveys used here were carried out after this period (some as many as 15 years later), I also use the stable nighttime lights time series produced by NOAA annually to determine whether discernable new areas of electrification have emerged since 1995 – and in turn to verify whether GRUMP accurately captures electrified areas in later years. I use the NOAA nighttime lights dataset for the same year a DHS was carried out in a particular country, to verify that they correspond to the areas identified as GRUMP. In general, there is strong agreement between those areas, with no major inconsistencies between the 1994-95 GRUMP data and more recent nighttime lights measured by NOAA (with a greater proportion of areas identified as urban by GRUMP, which incorporates information beyond satellite data to identify urban extents). It is important to bear in mind that this indicates only that there has been little change in the way of the level of electrification across the region (not too surprising given the generally low level of electrification across SSA), but not necessarily little change in population growth or distribution.

Methods

Mapping

City class categories

Estimates of fertility and under-5 mortality are calculated by city class at the regional level. The reasons for analyzing differences in fertility and mortality by city size regionally, rather than by individual country, are both theoretical and practical. Theoretically, creating city class categories allows for systematic and regionally consistent measures of city size. This is important for this analysis as it aims to examine dominant patterns and produce generalizable findings of fertility and mortality differentials across West Africa, rather than country- or city-specific trends. Additionally, the DHS is not intended to for producing cluster-level rates or estimates, and although prior studies have done this (Balk et al. 2009), and was instead designed more generally for aggregating clusters (for example at the national- or regional-level). Practically, the issue of inadequate sample sizes for city-specific or even city-class specific estimates within many countries renders estimates at the individual country level impossible in many cases; it is not uncommon for some of the smallest urban areas to have only one survey cluster and for many of the largest urban areas to include only a handful of clusters that are often not enough with which to make meaningful fertility and mortality estimates. To overcome this issue of small sample sizes, measurements of fertility and infant mortality estimates are be produced across the entire region for cities classified by size. Survey clusters are then be grouped under city-size category and analyzed at the regional level.

<u>Table 3: City class categories for urban areas in West Africa</u>

Classification	**Population size**
Class 1	> 1million
Class 2	150,000 – 1 million
Class 3	50,000 – 150,000
Class 4	< 50,000

Just as there is no universal definition of “urban”, there is likewise no universal definition for what constitutes a large, medium or small city. Other studies which categorize cities by size in SSA have often used a 1 million as the population threshold for the largest cities and/or the 750,000 population threshold (Brockerhoff and Brennan 1998) that is the lower-bound for which the United Nations gives individual population estimates for cities in its *World Population Prospects* publication. On the lower end of the spectrum, most studies seem to use “less than 50,000” (Brockerhoff and Brennan 1998) or “under 100,000” (National Research Council 2003) as the threshold for smallest urban areas with a middle category as 50,000 to 1 million. Including another category threshold of 500,000 between 100,000 and 1 million, as done elsewhere in studies of child mortality across different world regions (Brockerhoff and Brennan 1998, National

Research Council 2003) [13] is problematic because so few West African cities fall into this category.

Here, I define the largest cities (Class 1) as those that had a population of over 1 million and the smallest (Class 4) as those areas considered urban in each DHS but which had a population of less than 50,000 at the census carried out within five yeas of the DHS data used. I then use a threshold of 150,000 to differentiate the two city class categories in between: Class 2 (150,000 to 1 million) and Class 3 (50,000-150,000) (Table 4). 150,000 was chosen as the cut-off between Class 2 and 3 because using a higher threshold resulted in a very small number of cities and clusters in Class 2 (as West Africa has few secondary cities) and a lower bound made Class 3 quite restricted (50,000-100,000) and resulted in DHS clusters that were not as evenly distributed across analysis countries. The DHS often defines only one city as “capital/largest city”, which in most cases is the capital city regardless of its population and excludes any secondary cities with large populations (e.g. Kumasi in Ghana). Here, cities are classified solely based on population size, with only two capital cities (Cotonou and Niamey) falling in the Class 2 category.

[13] For the countries included in this analysis, only three cities have populations between 500,000 and 1 million (Cotonou in Benin, Niamey in Niger and Touba Mosque in Senegal), although two more come close with populations of just over 400,000 (Bobo Diaoulasso in Burkina Faso and Bouake in Cote d’Ivoire).

Table 4: Cities and clusters per class size (all countries pooled using the most recent DHS per country) for countries in the analysis

Class Category	*n* cities	*n* DHS clusters	Proportion of urban clusters
1	7	297	28%
2	23	174	16%
3	70	198	18%
4	317	406	38%
Total	416	1,075	100%

I then create a fifth sub-category of urban areas, which I call here “suburbs” and which are defined as cities which administratively fall into Classes 2, 3 or 4 but are adjacent to a Class 1 city (population > 1 million). There is reason to suspect that these cities may have urban characteristics less like stand-alone smaller cities and more like the largest cities to which they are attached; in many cases these smaller cities are more akin to extensions of the largest urban areas than to separate cities, even if they are considered administratively separate entities, with distinct population counts in censuses and official data. In fact, in most cases, these smaller cities would be considered part of the “urban agglomeration” of the largest cities, because they are administratively separate but fall within a contiguous territory of urban density levels and are adjacent to the larger city boundaries (United Nations Population Division 2012) but are not categorized as “capital/large city” by the DHS. In fact, these “suburbs” might be more aptly described as “satellite cities”, since they may be more self-contained that most “suburbs” in the North American sense. For simplicity, and because it is difficult to get reliable detailed geographic information on these satellite cities, in this analysis I use “suburb” as shorthand for these outlying areas that are in fact distinct cities. Only a small proportion of all urban clusters fall into this category (and only from Benin, Cote d'Ivoire, Ghana, Mali and Senegal) (Table 5), though this may reflect DHS sampling more than actual population distribution. The standard analysis here is run for the four city class categories defined by population size, and this fifth segmented "suburban" category is only included where indicated in the analysis.

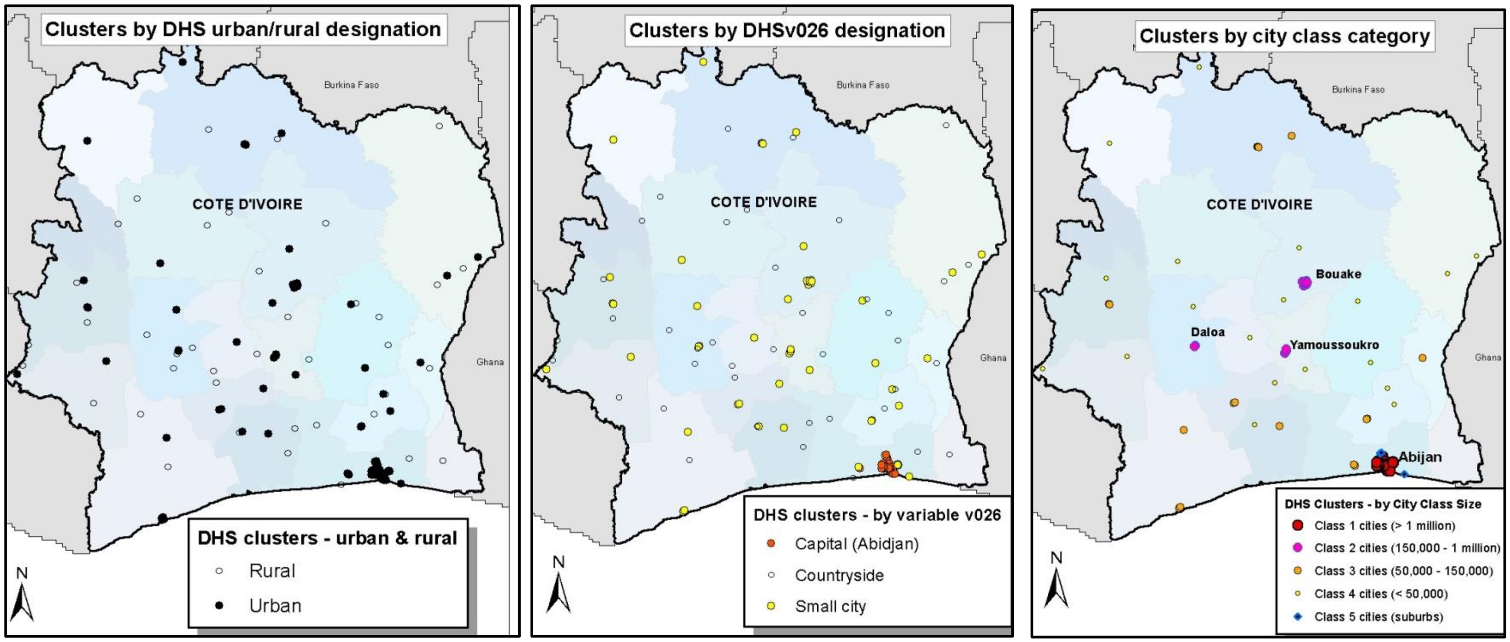
Table 5: Suburban cluster categories

Reclassified "suburb" clusters (Class 5)	*n* clusters	Proportion of total urban clusters
City Class 1	--	
City Class 2	5	0.47%
City Class 3	16	1.49%
City Class 4	--	
Total suburban clusters	21	1.96%

Cluster mapping

To properly categorize all urban DHS survey clusters within the appropriate city class, all clusters are initially spatially located on country maps using ArcMap 10.1. Once mapped, the DHS clusters are matched to administrative areas for all cities with populations of more than 50,000 listed in each country's respective census (within in 5 years of the survey) using GRUMP urban extents data and, when necessary, verified in Google Maps. Identification of urban areas in the lower bound (those with populations of fewer than 50,000), however, is less precise than for the larger urban areas and relies more heavily on DHS classifications of urban areas. This is due largely to the difficulty of accurate identification of the precise location of the smallest urban areas (particularly for later surveys for which urban areas that have emerged since 1995 would not be captured by GRUMP; relying entirely on night-time lights in these cases is likewise problematic because smaller cities may be less electrified, while some well-lit areas that show up may represent industry or mining, rather than human settlements). As a result, not all of the urban areas that fall under Class 4 can be fully verified there is thus a leap of faith in many instances in assuming that the smaller "urban" areas are accurately defined as urban according to each country's definition of urban in respective DHS surveys.

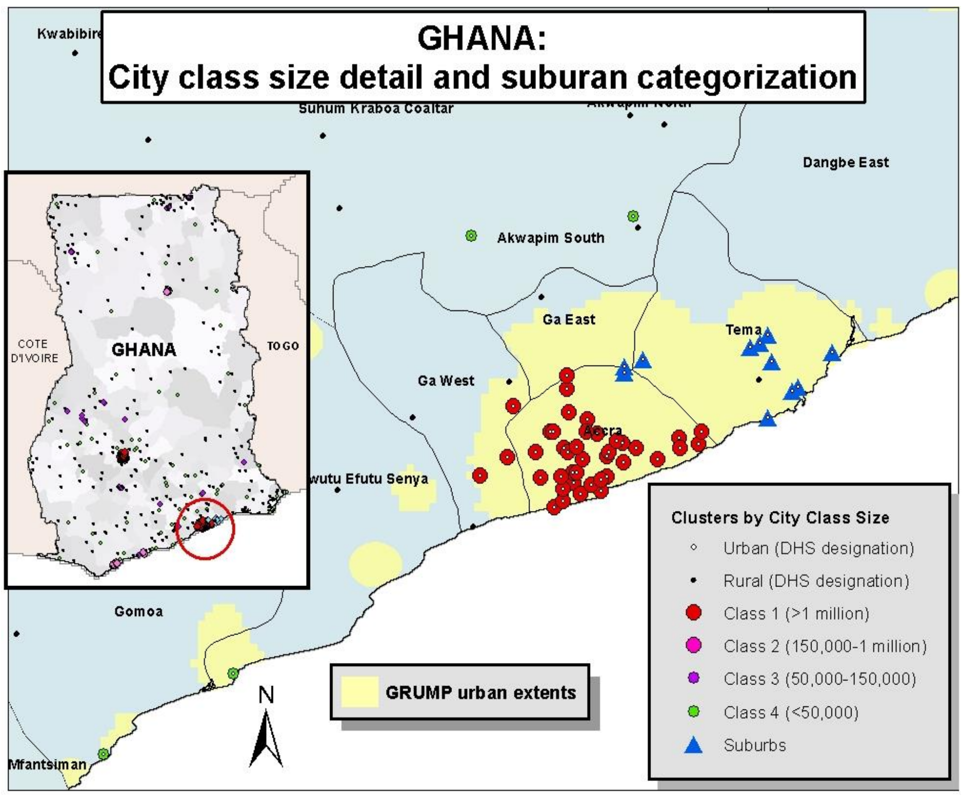
Map 3: Cote d'Ivoire 1999: Clusters mapped by DHS urban/rural designation, variable v026, and city class size categories



Source: DHS clusters from Cote d'Ivoire 1999 DHS survey; urban/rural and v026 clusters from DHS and City Class Size clusters designated by the author. Cote d'Ivoire's fourteen regions (the second-level administrative division after districts) indicated by blue background shading.

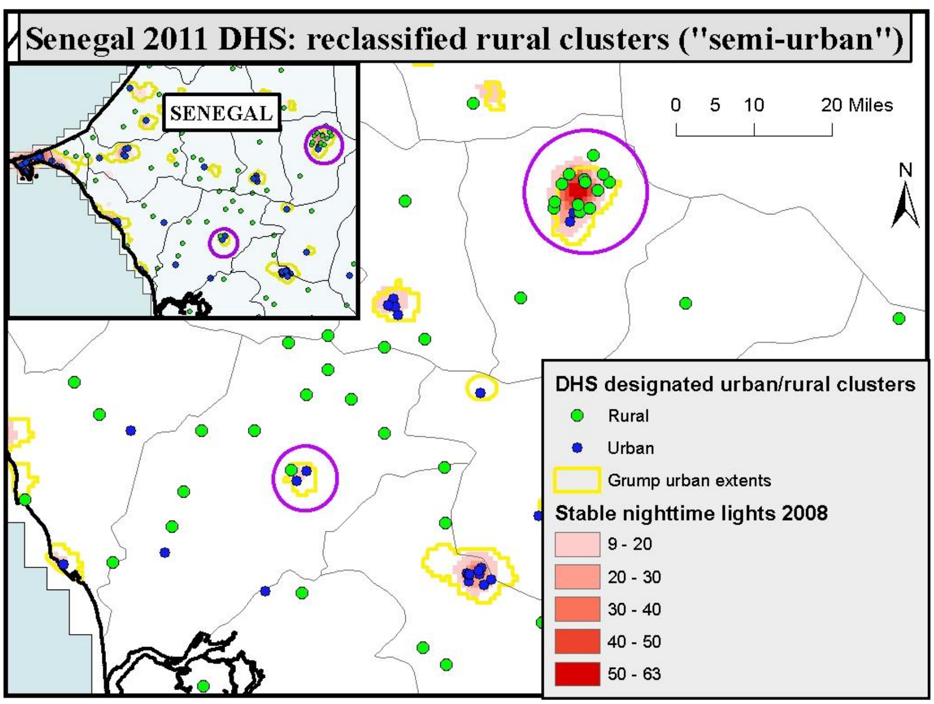
I spatially identify clusters that fall into the Class 5 "suburb" category by outlining suburban areas and determine which clusters fall within these areas. To be considered "adjacent" to a largest city, these suburban areas must be within 20 kilometers from the administrative boundary of a Class 1 city and within a contiguous GRUMP or nighttime lights extent. Map 4 illustrates this process for Ghana.

Map 4: "Suburban" category mapping for Ghana using DHS 2008 clusters



Finally, previous research has shown that DHS clusters are sometimes misclassified as urban or rural and vice-versa (Dorelien et al. 2013). To verify that all remaining non-urban clusters designated as rural in the DHS are accurately categorized as such, I highlight rural clusters that fall within the administrative boundaries of urban areas in the first step of the mapping process. The DHS cluster data is then combined with GRUMP data, to see whether these clusters fall within the GRUMP urban extents; those that do are designated as "semi-urban", since they appear to be urban but are not necessarily clearly adjacent to identified urban centers (which would be "peri-urban"). Map 3 illustrates this process for the interior of Senegal. These re-categorized rural clusters are initially included in the analysis as rural but subsequently analyzed separately under the "semi-urban" category to investigate whether they have urban characteristics and demographic outcomes more similar to urban or rural areas – and whether there is a difference in these characteristics and outcomes by semi-urban sub-category.

Map5: Illustration of rural clusters re-categorized to semi-urban category from the Senegal 2011 DHS



If there is a gradation in urban fertility and child mortality rates, we would also expect to see a similar gradation among semi-urban clusters that are located in or near cities of different sizes. Analyzing rural clusters associated with these smallest urban areas separately may give an idea of whether there is a difference in rural proximity to larger or smaller urban areas and whether clusters in this category in fact share have characteristics closer to those of rural areas. Reclassified rural clusters associated with urban Classes 1, 2 and 3 are combined into one category. This is one primarily because of the small number of clusters that fall into each of these categories and the assumption that these city classes are more easily considered “urban” because of the downward limit of a population of 50,000. Semi-urban clusters found within the GRUMP urban extents of Class 4 cities are a unique category because there is both a substantial number of clusters in this individual category and because it is the most nebulous “urban” category (as it relies on each individual country’s definition of a lower threshold of urban). Last, rural clusters that fall within the GRUMP imputed circles make up the third and final sub-category. These clusters are also considered separately because this group represents a slightly different measurement of urban (imputed rather than identified by electrification), and including them as a unique sub-category may give an indication as to whether these imputed circles are capturing areas with substantial urban characteristics. For these reclassified clusters in particular, it is important to keep in mind that the displacement of rural DHS clusters by up to 5 kilometers means some rural clusters that are truly rural will be displaced into urban light extents, while some rural clusters which fall within these extents will be displaced outside of them. For categorization purposes, however, I assume that clusters are accurately matched and that the noise of the displacement will be washed out.

Table 6: Rural DHS clusters that fall within GRUMP urban extents

Reclassified "semi-urban" rural clusters	***n* clusters**	**Proportion of total rural clusters**
City Class 1, 2 & 3	32	1.93 %
City Class 4	19	1.15 %
Within imputed circles	20	1.21 %
Total	71	4.29 %

It should be acknowledged that these city class categories are defined based solely on population estimates (with the exception of the "large city suburban" category, which includes a geographic element) within administrative boundaries, or what is generally considered the "city proper" (United Nations Population Division 2012). While this allows for the creation of standard definitions of city size for cross-country comparison, it does not incorporate other criteria used to define or characterize urban areas elsewhere in the literature, which include delineation of extents of urban areas, urban expansion, urbanicity indexes (Van de Poel et al. 2009, Smith and Popkin 2010), population density and other aggregate measures of urban conditions. Instead, city class categories here are based solely on population estimates because of the difficulty of creating more complicated definitions of urban conditions beyond the household level with DHS and because of data limitations in general in most of West Africa, particularly for the smaller urban areas for which localized data is often non-existent.

Descriptive Statistics

I provide descriptive statistics for the pooled sample by residential type, first for all areas defined as urban and rural in the DHS and then separately for urban areas divided by the four city class categories of size. This descriptive overview includes comparisons of three main indicators of access to urban amenities that are captured by DHS surveys discussed above (the proportion of households with electrification, access to clean water and improved sanitation) and the proportion of respondents who are considered recent migrants. The proportion of women who are recent migrants to their current location of residence is of interest here because it gives us an idea of whether there are differential rates of in-migration to urban areas of different size. Descriptive statistics are for the pooled sample of all women and are weighted at the country level to account for the multistage sampling design and by country population at the regional level.

Fertility

I then estimate total fertility rates (TFR) first for urban and rural areas, and then by city class size and for semi-urban categories at the regional level. TFR is a synthetic measurement of the total number of children a woman would have over her lifetime if she survived to the end of her reproductive years and experienced at each age the current age-specific fertility rates (ASFR). ASFRs are calculated by dividing the number of births to women in a specific age group (nearly always five-year age groups for women of reproductive ages of 15-49) by the number of person-years lived by all the women in that age group. The TFR is calculated by multiplying the sum of the ASFRs by 5. All ASFRs and TFRs here refer to period rates, as the birth histories used for these calculations are from a particular period rather than following a birth cohort through their reproductive years.

ASFRs and TFRs are computed using the *tfr2* Stata module, which was designed with the DHS data in mind, although it is flexible enough to be used with other survey data (Schoumaker 2013). The *tfr2* module consists of two parts: 1) the *tabexp* command that transforms data on birth histories into a table of births and exposures and 2) an analysis of birth history data. ASFRs and TFRs are estimated for each country for the five years prior to the survey date. Birth histories are first transformed into person-period data files, by splitting individual data files and contributing the number of births and months of exposure for each woman for a period in which the five-year age group is constant.

Though fertility rates are generally calculated for the three years prior to a survey, here I have extended this to five years in this analysis to provide a more accurate measurement for the small sample size of women in the “suburban” category. The pooled data is weighted by population size and controls for clustering at the primary sampling stage. Unlike with the Kaplan-Meier survival curves for under-5 mortality (explained below), a woman’s recent migration status is not taken into account with compiling fertility rate. As I am estimating the synthetic lifetime fertility of women in their current place of residence, it is the total number of births and not the location in which they occurred which is of interest here.

Under-5 mortality

In the last stage of the analysis I calculate under-five (U5) mortality rates – the probability of a child dying before reaching his or her fifth birthday. This analysis uses mortality rates for children under-5, rather than mortality rates for all ages, for the following reasons: 1) the availability of reliable data on under-5 survival rates in the DHS and 2) because of the disproportional effect early age mortality has a on overall mortality levels and life expectancy (Preston and Haines 1991) which make it possible to get a proxy measure of overall mortality levels from infant, child and U5 mortality rates.

I use Kaplan-Meier survival curves to estimate survival probabilities to age 5, and take the inverse of these results to calculate the probability of dying before age 5. Kaplan-Meier curves provide a nonparametric estimate of the survivor function *S(t)*, the probability of survival past time *t* (Cleves et al. 2010). All children born within the ten years preceding the survey are included, with children considered at risk of death until age 5 and then left-censored. Use of the Kaplan-Meier method allows estimates of survival to age five to be calculated for the most recent time period, rather than only for those children who were born more than five years before the survey.

The main advantage of using Kaplan-Meier survival curves, as opposed to the DHS method of calculating child mortality, is that it allow for accurate attribution of a child's exposure and, where it occurs, death, to where the child was living at the time of his or her death in cases where a child has moved prior to his or her fifth birthday (Bocquier et al. 2011). By permitting both right and left censoring, the Kaplan-Meier method can attribute any child deaths that occur to the residence at the time of death and likewise attribute a child's exposure to the risk of dying to both the place of residence before and after the move. As the DHS provides only general information on the type of previous place of residence but not enough detail on the specific location to match it to the four city class categories used in this analysis, it is thus not possible to attribute pre-migration exposure to accurately according to city class size. As a result, in this analysis children under-5 whose mothers changed residence are left censored after the last move into the city category in which they were living at the time of the survey. Thus for children who move before their fifth birthday, only their exposure for that time (and death, in instances when the child dies before five) are attributed to the place of current residence, and pre-migration exposure or deaths are not included. This is done to prevent misattribution of deaths from previous place of residence to the respective city category. The pooled data used for the Kaplan-Meier estimates is weighted by population size and includes accounts for clustering at the primary sampling unit.

Results

Descriptive Statistics

Table 6 presents the descriptive statistics by residence category. As expected, residents in urban areas are more likely to have household electricity, access to an improved drinking water source, and access to improved sanitation. Across the four urban class categories, there is a decline of the proportion of households with access to these urban amenities with decreasing city size. Despite this variation among urban areas, the proportion of households with access to these three urban amenities for even the smallest cities (Class 4) are well above the rural averages, with a distinct difference between even the smallest urban areas relative to those considered rural.

Table 7: Mean percent of households with household electricity, access to improved drinking water, improved sanitation and women who have moved to current location within the past five years (weighted)

Location	Electrification	Improved water	Improved sanitation	Recent migrants
All locations combined	0.38	0.64	0.40	0.11
Urban/Rural (DHS definition)				
Urban	0.74	0.82	0.70	0.14
Rural	0.15	0.52	0.20	0.09
City Classes				
Class 1 (> 1million)	0.86	0.86	0.84	0.12
Class 2 (150,000 - 1 million)	0.78	0.81	0.71	0.17
Class 3 (50,000 - 150,000)	0.64	0.82	0.57	0.15
Class 4 (< 50,000)	0.60	0.77	0.56	0.15
Re-categorized rural clusters				
Semi-urban (Class 1, 2 & 3)	0.71	0.96	0.79	0.17
Semi-urban (Class 4)	0.23	0.59	0.26	0.19
Semi-urban (imputed circles)	0.03	0.28	0.08	0.10

Source: Demographic and Health Surveys (1990-2011) for Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger and Senegal.
Recent migrants are those who have lived in their current place of residence for fewer than five years.

Electrification and improved sanitation, which are both directly linked to infrastructure, show the largest urban/rural differences. Over 70 per cent of urban dwellers overall have access to each of these amenities, compared to only a fifth of those in rural areas. Household electrification and access to an improved toilet also show the largest intra-urban differences; in both cases, there is a clear gradation with access greatest in the largest cities and most limited in the smaller ones. Proportional access to these two urban amenities also shows strong agreement: the proportion of respondents with access to improved sanitation is just slightly less than those with household electrification, suggesting a strong correlation between household electricity and improved sanitation for urban areas. In contrast, rural dwellers are slightly more likely to have access to improved sanitation (20 percent) than to electricity (15 percent), suggesting that the relationship between electricity and sanitation takes a slightly different form in rural areas, perhaps because improved toilet facilities in rural areas are more likely to be shared among households than in urban areas.

Access to improved water shows the smallest proportional difference between urban and rural areas overall (82 per cent compared to 52 per cent) and the least amount of variation among different city class sizes. This may be because access to safe drinking water is less directly linked to household infrastructure; whereas electricity and toilet access are measured at the household level (including access through a neighbor), potable water can be accessed at the neighborhood level or by purchasing bottled water – both ways which are linked to the local environment but not dependent on household infrastructure. Turning to migration, a higher proportion of urban dwellers (14 percent) that rural inhabitants (9 percent) have moved to their current place of residence within the past five years. Among cities, the largest cities have the lowest proportion of recent migrants (12 percent), while Class 2 cities have the highest (17 percent). For the smallest two categories of urban areas, approximately 15 percent of respondents have moved within the past five years.

Looking at the semi-urban "reclassified rural clusters", we see a clear distinction between the three semi-urban categories. Semi-urban clusters associated with larger cities (Classes 1, 2 and 3 cities) have proportions of respondents with access to these urban amenities similar to the larger urban areas - though interestingly access to improved water is much higher (nearly universal at 96 percent) than that found in any other urban areas. Rural categories reclassified to the smallest city category (Class 4) have proportional access to urban amenities that lies somewhere in between the averages for urban and rural areas: less than in urban areas but greater than in rural ones. Somewhat surprisingly, the last category of semi-urban (rural clusters that fall within GRUMP imputed circles) show urban characteristics well below the average for rural areas, with negligible household electrification and access to improved sanitation, and only a third of respondents reporting that they have access to improved water source.

Table 8: Descriptive statistics by city class category with largest city suburbs (original proportions for categories 2 & 3 in italics)

Urban area classifications	Electrification	Improved water	Improved sanitation	Recent migrants
With separate category for major suburban areas				
Class 1 (> 1million)	0.86	0.86	0.84	0.12
Class 2 (150,000 - 1 million)	*(0.78)* 0.77	*(0.81)* 0.80	*(0.71)* 0.69	*(0.17)* 0.17
Class 3 (50,000 - 150,000)	*(0.64)* 0.60	*(0.82)* 0.80	*(0.57)* 0.53	*(0.15)* 0.13
Class 4 (< 50,000)	0.60	0.77	0.56	0.15
Class 5 (suburbs)	0.94	0.97	0.87	0.18

Source: Demographic and Health Surveys (1990-2011) for Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger and Senegal.
Recent migrants are those who have lived in their current place of residence for fewer than five years.

Table 8 shows results for the descriptive categories after when segmenting and analyzing the suburb clusters (those from satellite cities of the largest urban areas) as a separate class category, and highlights the distinctive characteristics of these clusters. Respondents from these suburbs have nearly universal access household electricity, improved sanitation and improved water – higher proportions than any other city class category, even the largest cities to which they are adjacent. Those living in suburbs are also most likely of any category to have moved within the past five years.

Segmenting these suburbs leaves results for Class 1 and 4 unchanged (because Class 1 cities are the basis for constructing the "suburban category", and thus no clusters are from the Class 1 category, and no Class 4 cities meet the criteria for being considered a suburb), but results in noticeable changes for Class 2 and 3 cities (from which the suburbs are removed). When the suburban clusters are segmented, the already-similar Class 3 and 4 cities are nearly equal for all three amenities categories, with Class 3 even dropping below Class 4 with regard to access to improved water. This suggests that the suburbs play a small but important role in differentiating Class 3 cities from Class 4 for urban characteristics: without the suburbs, Class 3 cities have urban characteristics that are essentially the same as those for the smallest urban areas.

Table 9: TFR by residence type

Location	TFR	SE	*n women*	*n clusters*
Overall	**5.58**	0.024	*75,612*	*2,730*
Urban/Rural (DHS)				
Urban	**4.09**	0.034	*27,919*	*1,075*
Rural	**6.47**	0.032	*47,693*	*1,655*
City Class (urban areas only)				
Class 1 (> 1million)	**3.44**	0.059	*7,625*	*297*
Class 2 (150,000 - 1 million)	**4.07**	0.081	*4,987*	*174*
Class 3 (50,000 - 150,000)	**4.58**	0.087	*4,926*	*198*
Class 4 (< 50,000)	**4.80**	0.060	*10,381*	*406*
Re-categorized rural clusters				
Semi-urban (Class 1, 2 & 3)	**4.27**	0.229	*998*	*32*
Semi-urban (Class 4)	**5.80**	0.417	*421*	*19*
Semi-urban (imputed circles)	**7.45**	0.389	*582*	*20*

Source: Demographic and Health Surveys (1990-2011) for Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger and Senegal; calculations by author

Fertility

Table 9 displays TFR by residence category, with results confirming that fertility remains high across West Africa and TFR of just over 5.5. As expected, there is a stark difference between urban areas, where the average TFR is just over 4, and rural areas, where TFR surpasses 6.5 children. Also as expected, the largest cities (> 1 million) have the lowest TFR (3.44), almost one child per woman lower than the overall urban TFR.

There is a notable intra-urban TFR gradation with the four city class categories, with a difference in TFR of over half a child between the Class 1 and Class 2 cities (0.63) and again between Class 2 and Class 3 cities (0.51). The gradient begins to level off between Class 3 and Class 4 city categories, however, with a much smaller difference (0.22) between these two smallest urban categories.

The TFR for “semi-urban” re-categorized rural clusters also mirrors the pattern found in the descriptive statistics table for urban characteristics. The rural clusters that fall within the extents of Class 1, 2 & 3 cities have TFR of 4.27, which is somewhere in the middle of the urban averages. The semi-urban clusters associated with Class 4 urban extents have an aggregate TFR that fall between the average urban and rural levels (5.80), but closer to the rural (6.47) than urban (4.09) average. Interestingly, rural clusters located within GRUMP imputed circles have TFR that far surpasses even the rural average, at 7.45 children per woman. An explanation for this extremely high fertility is not immediately apparent, though it is perhaps not surprising considering the extremely low proportion of access to urban amenities among these clusters seen in Table 6. This category also appears to be highly influenced by two groupings of re-categorized clusters from Niger which have exceptionally high TFRs (between 8 and 10 children per woman), even for high-fertility Niger, suggesting there is something particular about these groups of clusters that is strongly influencing the results for this category. Variance, as measured by the standard error, is substantially higher for all semi-urban categories than for any other residential category, though this likely also reflects the much smaller sample sizes for these categories.

Table 10: TFR by residence including city suburban class categories

Urban area classification	***TFR without suburb category***	**TFR with suburbs**	**SE**	***n women***	***n clusters***
City Class (with suburb class)					
Class 1 (> 1million)	*3.44*	**3.44**	0.059	*7,625*	*297*
Class 2 (150,000 - 1 million)	*4.07*	**4.11**	0.084	*4,840*	*169*
Class 3 (50,000 - 150,000)	*4.58*	**4.83**	0.091	*4,613*	*182*
Class 4 (< 50,000)	*4.80*	**4.80**	0.060	*10,381*	*406*
Class 5 (suburbs)		**3.26**	0.246	*460*	*21*

Source: Demographic and Health Surveys (1990-2011) for Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger and Senegal

When the suburban clusters are segmented, the class 5 cities show the lowest fertility of any urban area, lower even than that of the Class 1 cities (but the variance is much higher than any category – due at least in part to the small number of women in this category: *n*=460). TFR in Classes 1 and 4 remain unchanged, but removing the suburban clusters from Classes 2 and 3 increases the TFR slightly for both categories (from 4.07 to 4.11 for and from 4.58 to 4.83, respectively). As with the descriptive overview of urban characteristics, the separate analysis of Class 5 clusters again has an equalizing effect on the TFR for Class 3 and 4 cities. In this case, increasing class 3 TFR enough to just surpass the TFR for class 4 (which remains unchanged at 4.80). When the suburbs are segmented as a separate category, we still see a sharp jump from Class 1 to Class 2 and again from Class 2 to Class 3, but we can now group Class 3 and 4 together as their adjusted TFRs are practically identical.

Table 11: Under-five mortality probabilities by residence category

Location	Under-5 mortality	*n* children	*n* clusters
Overall	**0.166**	*241,444*	*2,729*
Urban/Rural (DHS)			
Urban	**0.113**	*67,780*	*1,074*
Rural	**0.186**	*173,664*	*1,655*
City Class (urban areas only)			
Class 1 (> 1million)	**0.096**	*15,753*	*297*
Class 2 (150,000 - 1 million)	**0.097**	*10,877*	*174*
Class 3 (50,000 - 150,000)	**0.131**	*12,866*	*198*
Class 4 (< 50,000)	**0.127**	*28,284*	*405*
Re-categorized rural clusters			
Semi-urban (Class 1, 2 & 3)	**0.133**	*2,536*	*33*
Semi-urban (Class 4)	**0.206**	*1,823*	*23*
Semi-urban (imputed circles)	**0.254**	*1,932*	*21*

Source: Demographic and Health Surveys (1990-2011) for Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger and Senegal. Calculations by author.

Table 11 shows under-five survival probabilities by residence category. Across the countries included in this analysis, children in the region have on average a 17 percent chance of dying prior to their fifth birthday. Again, there is a substantial (and significant at the p<.01 for the log-rank test of equality) differential between urban and rural areas, with children born in urban areas approximately 7 percent more likely to reach age five than their rural counterparts.

The pattern of U5 mortality rates shows a slightly different pattern nu city class sizes. In contrast to the TFR, where there was a noticeable difference in fertility between the two largest classes of cities, survival chances are practically identical for Class 1 and 2 cities and the slight difference between the two categories is not statistically significant (p<.05). Notably, survival to age five is lower in Class 3 cities (.869) than in Class 4 cities (.873), although this difference is slight and not statistically significant. There seems to be a clearer grouping of under-five mortality across urban areas: Class 1 and 2 cities can essentially be grouped together, as can class 3 and 4. While the difference in under-five survival probabilities is not significant (p<.05) between Class 1 and 2 cities or between Class 3 and 4 cities, it is significant for all other combinations (e.g. between Class 1 and 3 or Class 2 and 4).

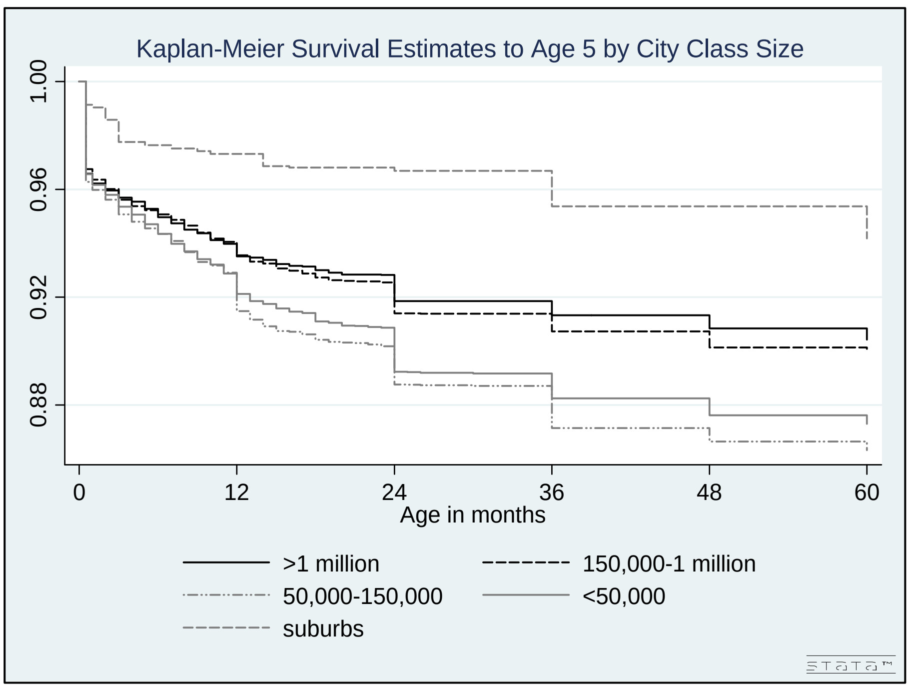
Table 12: Under-5 mortality probabilities with inclusion of suburb category

Location	***Without suburbs***	**Under-5 mortality**	*n* children	*n* clusters
City Class (with suburbs separated)				
Class 1 (> 1million)	***0.096***	**0.096**	*15,753*	*297*
Class 2 (150,000 - 1 million)	***0.097***	**0.100**	*10,594*	*169*
Class 3 (50,000 - 150,000)	***0.131***	**0.137**	*12,266*	*182*
Class 4 (< 50,000)	***0.127***	**0.127**	*28,284*	*405*
Class 5 (suburbs)		**0.058**	*883*	*21*

Source: Demographic and Health Surveys (1990-2011) for Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger and Senegal. Calculations by author.

As with TFR, the Class 5 cities appear to exhibit exceptional behavior for U5 mortality. Table 12 shows that Class 5 cities have the most under-five survival probabilities of any urban category, and surpassing even those of the largest cities by an impressive amount. This difference between the suburbs and Class 1 cities is particularly striking, with children living in Class 5 cities nearly 4 percent more likely to survive to age five than those living in the largest cities (or largest two categories of cities, as Class 1 and 2 are still nearly identical even after segmenting suburban clusters), a difference that is substantial and statistically significant (p<.05). Removing the suburban clusters from the Class 2 and 3 categories lowers survival probabilities for both these classes. The difference between Class 3 and 4 cities becomes greater, with Class 3 survival chances now even lower than those for Class 4 – though the difference between these two categories is still not statistically significant (p<.05).

<u>Graph 1: Kaplan-Meier survival curves to age 5 by city class category (including suburbs)</u>



Source: Demographic and Health Surveys (1990-2011) for Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger and Senegal.

The graphed Kaplan-Meier survival curves (Graph 1) illustrates clearly that children in Class 5 cities have the highest probability of surviving to age five. It also shows a clear coupling of U5 mortality rates among the remaining urban areas: for Classes 1 and 2 and then for Class 3 and 4. Graph 1 also shows that after the first year of life, children in

Class 3 cities have lower under-five survival chances than those who live in Class 4 (though the differences are not statistically significant at the p<.05 level). This graph helps illustrate the mixed picture of the "urban advantage" in child survival within urban areas: putting aside the small suburban sample, the largest cities have the highest child survival probabilities but the Class 3 cities, not Class 4, have the highest estimated U5 mortality. This suggests that although the urban child survival advantage persists, the advantage is not necessarily linearly correlated with city size.

To summarize the main findings: there is a clear gradient across city classes relative to access to urban amenities (measured by household electrification, sanitation and improved drinking water), fertility and under-5 mortality. The largest urban areas have the highest proportions of households with electrification, improved sanitation and access to improved water, as well as the lowest TFR and lowest child mortality rates. The second-largest cities also have the second-highest proportions of access to these urban amenities and the second-lowest TFR. Interestingly, under-five survival rates for class 2 cities are nearly identical to (and not statistically significantly different from) those for the largest cities. There is a noticeable drop in access to urban amenities and increase in both TFR and under-five mortality from Class 2 to Class 3 cities: TFR moves from 4.07 to 4.59 and under-five survival falls from 0.903 to 0.869, indicating are substantial and statistically differences in fertility and child mortality between Class 2 and Class 3 cities. These increases in fertility and U5 mortality rates essentially level off between Class 3 and Class 4 cities, as do the proportion of respondent households with access to the urban amenities used in this analysis. This, in turn, implies that there are fewer differences with the urban characteristics of fertility and mortality outcomes between these two categories of cities and the largest difference is between the biggest two city class categories (1&2) and smaller two classes (3&4).

Discussion

The analysis presented here provides evidence of a gradient of urban characteristics, fertility and child mortality rates across cities of different sizes. Overall, these differentials in TFR and under-5 mortality appear to reflect differences in access to urban amenities used here to approximate "urbanness". This strongly suggests that researchers and, in turn, policy makers may be overlooking important nuances in urban fertility and mortality rates and decline in West Africa. It may not be sufficient or accurate to rely solely on an urban rural dichotomy when estimating and reporting fertility and mortality rates for the region.

The nearly identical fertility and child mortality rates for Classes 3 and 4 is not altogether surprising, given that these cities share very similar urban characteristics – which become nearly identical once the large city suburbs are segmented– and the differences in the rates between them are not statistically significant. Still, the relatively high fertility and under-five mortality of Class 3, particularly compared to the smaller Class 4 cities, is of particular interest. These results seem to support the findings from Brockerhoff and Brennan's 1998 of child mortality disaggregated by city size for SSA as a region. They found that from the 1970s through the early-1990s, SSA showed substantial improvements in child survival in rural areas and towns and modest improvements in the largest cities, but declines in overall child survival probabilities in smaller urban areas. Although their study used slightly different city size categories and was focused on trends over time, their findings seem to add support to indications found here that it may be SSA's smaller cities, but not the smallest "urban" areas, that are most at risk for stalling or declining health outcomes with rapid urban growth.

Interestingly, Class 5 suburban clusters not only look "ultra" urban, in terms of urban characteristics, they also act very urban, with regard to very low TFR and under-five mortality. These large city suburbs appear to exhibit very urban behavior, as measured here by demographic outcomes, not simply reflect infrastructure spill-over (in terms of urban characteristics as shown in the descriptive statistics) from their adjacent cities. There is something particular about respondents who live in these areas, and this could imply that these small satellite cities adjacent to the largest ones (at least those captured in the DHS) are wealthier suburbs directly connected to the large cities rather than areas settled by recent migrants from rural or smaller urban areas as part of a step-wise migration to the largest cities. Regardless, it is clear that they have characteristics and demographic outcomes strikingly different from other cities of similar size, making a strong argument for the need to consider these suburban/satellite cities separately from other small cities. It may be likewise just as important not to simply roll them into the urban agglomerations to which they may be associated since their fertility and U5 mortality is substantially lower than even these largest cities.

Moving further down the urban gradient, however, even the smallest urban areas show substantially more favorable fertility and child mortality outcomes compared with rural areas. The significantly different ($p<.01$) characteristics and outcomes between even Class 3 and 4 cities relative to those considered rural implies that cities of all sizes are indeed "urban" and systematically different from rural areas. Even the smallest urban areas are not simply larger or more populous versions of rural villages. This clear gradation in urban characteristics and fertility and mortality rates between the smallest urban areas and rural areas challenges the notion put forward in previous research that many of these small cities are essentially large villages with "environmental and health conditions similar to those in rural villages" (Montgomery and Ezeh 2005). To the contrary, it seems that a little bit of urban goes a long way in bringing down fertility and U5 mortality rates.

Does this sharp divide of TFR and U5 mortality between smaller urban and rural areas in turn imply that it suffices to use only the urban/rural dichotomy when looking at residential differences in fertility and U5 mortality in West Africa? These distinct differences in urban characteristics and demographic outcomes between even the smallest cities compared to rural areas could be used to argue that the most important distinction is between rural areas and *any* area considered urban. However, referring back to the intra-urban estimates, we find that the difference in fertility rates between rural areas and small cities is nearly the same as that between the smaller and larger/largest cities: the difference in TFR is only between the smallest cities and the largest cities1.36, only slightly less that difference 1.67 between class 3 cities and rural areas. For fertility, then, the absolute difference in TFR is as wide between rural areas and the two categories of smallest cities as it is between these smallest cities and the largest cities.

For under-five mortality, however, the absolute difference in survival probabilities between rural areas and smallest cities is nearly twice that of the difference (0.059) of between smallest cities and largest cities (0.031). This suggests again that these intra-urban differences in fertility and mortality are important, but perhaps more important when considering fertility than mortality. This may also be a reflection of increased interventions for and substantial improvements in infant and child mortality seen in much of urban and rural SSA in recent decades, success apparently not yet as widely replicated for family planning.

Results here also show that semi-urban clusters (those designated as rural but falling within GRUMP urban extents) are very aptly described as "semi-urban," not simply because they are near urban identified areas but in that they appear neither fully urban or rural but have features of both (Tacoli 2003). The first two categories have semi-urban characteristics, with respondents in these clusters have access to urban amenities lower than the urban category(ies) they are associated with but higher than the average for the rural category in which they were originally designated. Demographic outcomes of the semi-urban categories mirror the pattern expected given the level of urban characteristics for each of these groups: clusters in the first semi-urban category look and act more urban than the others – but they also "look" more urban (according to the descriptive statistics for urban characteristics) than they act (with higher fertility and under-five mortality rates). Semi-rural class 4 clusters, on the other hand, look fairly urban but act rural, with TFR and child survival rates much closer to the average for rural areas. Reclassified clusters in the third category, however, have demographic characteristics that are well below the average for rural residents. The last category of semi-urban clusters (those located within GRUMP imputed circles) remain a bit of a mystery, in that their urban characteristics are well below even the rural average and their TFR and child mortality rates are far higher than those in rural areas (although this attenuated somewhat when the two groups of clusters from Niger in this category are removed).

Finally, this analysis could have implications for urban population projections, as the substantial intra-urban differentials in demographic outcomes found in this analysis imply that using national-level urban fertility and mortality estimates may overlook important differences in inputs for sub-national urban growth projections. This is particularly true for fertility, which varies substantially across city class sizes and is also considered the most important component of projecting population growth as the multiplier effect of fertility means it has the greatest effect on population growth (O'Neil and Balk 2001). Correctly accounting for fertility is and particularly important for contemporary developing countries, such as those in West Africa, where natural growth is the primary driver behind urban growth in the developing world, accounting for an estimated 60% of urban growth (Chen, Valente and Zlotnik 1998). Balk and colleagues (2009) quantified the key role fertility plays a s driver of city growth rates in Africa by showing that a 1-child drop in the TFR is associated with a decline in city population growth rates of 0.395-0.490 percentage points. This implies that the fertility differentials across city size in SSA found here will have a differential effect on city growth rates for cities that is not inconsequential. The findings here also show that it is certainly possible, given detailed cluster location information from the DHS, to link localized household survey and demographic data to specific cities or locations, at least broadly by city class category. Future research that aims to estimate fertility and mortality in sub-Saharan Africa using DHS data should capitalize on available GIS data to create an urban continuum rather than relying on a strict urban/rural dichotomy that may obscure important intra-urban differences in fertility and mortality.

Limitations and Future Research Directions

This study has several limitations that must be acknowledged. First, even though based on the most recent census, the city class categories are not exact. The census data cannot be independently verified and the region's rapid urban growth in recent years may mean that some of the census population numbers are largely estimates. Thus, although this study seeks to classify urban areas by comparable sizes, the classifications are likely not always exact, particularly with the smaller urban areas. As a result, these class categories should be considered more general categories meant to demonstrate overall patterns in urban characteristics and demographic outcomes by urban area size rather than precise measurements of the thresholds at which fertility or mortality rates patterns change.

Second, while the very low fertility and child mortality rates found in suburban areas may accurately represent current patterns of fertility and mortality in these places, it is also possible they reflect two potential data issues not captured by the DHS: the temporary nature of many of the residents in these areas and potential biased sampling if only the more established and wealthier suburbs are sampled. The high proportion of recent migrants in class 5 cities (and likewise perhaps the highest proportion of out-migrants, which cannot be measured by the DHS) may reflect temporary moves to the suburbs by younger, unmarried women, who may live and work for several years before leaving (either to move to the adjacent city or to return to their home city or rural village). Alternatively, this could be a factor of under-representing poor and slum areas in its survey sampling, and the remarkably low fertility and child mortality rates found in the suburbs may be a result of selective sampling of the most economically well-off suburbs, rates which may be more in line with other urban areas of similar size if more disadvantaged suburbs were equally sampled. For these reasons, the results presented for Class 5 cities should be interpreted with some caution.

Finally, even within West Africa, there is substantial variation across countries in terms of fertility and mortality regimes (which are generally associated with a country's level of economic development) and which may in turn have a different impact on intra-urban differentials. These intra-urban differentials may in part be a reflection of where individual countries find themselves within the transition from regimes of high to low levels fertility and child mortality. At the moment, however, it is very difficult to get meaningful samples for different city class sizes with the more limited number of countries with the necessary data, particularly reliable GIS datasets, when segmented by high or low fertility or mortality. With an increasing number of DHS surveys reliably including GIS information on survey clusters, more research in the near future may be able to more accurately examine whether the urban gradation in city size and fertility and mortality rates show different patterns across countries with different overall levels of fertility and mortality.

Conclusion

The persistent urban/rural differential in research on SSA, and in particular West Africa, obscures substantial variation in TFR and U5M. Findings here show a clear, but not always linear, gradation in fertility and mortality rates, with the lowest rates in the biggest cities. The main exceptions to this, however, are for suburban areas adjacent to the largest cities, which have the most favorable fertility and child mortality rates, and the class of smaller cities with population of 50,000-100,000, which show the least favorable rates for all cities – slightly higher than but not significantly different from the class of smallest cities (<50,000). These finding suggest that Class 5 suburbs should be considered separately from other small cities and that the smaller urban areas may pose the greatest cause for concern about the detrimental health effects associated with rapid urban growth. Generally speaking, clusters that are designated by the DHS as rural but that appear to fall within urban extents have urban characteristics, fertility and child mortality rates that lie between the averages of rural and urban areas. These findings imply it that research on fertility and mortality throughout SSA should look beyond the simple urban/rural dichotomy. This study also suggests that differential rates of fertility, in particular, should perhaps be considered in future projections of urban growth rates nationally and regionally in SSA, at least broadly by city population size.

APPENDIX

Appendix A: Cox proportional hazards model for survival to age 5 by country

	Benin	Ghana	Kenya	Mali	Niger	Nigeria	Senegal	Uganda	Zambia	Zimbabwe
Residence (ref: rural)										
Urban	0.871	0.938	1.061	0.762***	0.655***	0.759***	0.665***	0.998	1.012	0.840
RGLCs	0.783	0.609*	1.004	0.580***	0.545***	0.653**	0.778	0.862	1.145	
Mother's age at birth (ref: 20-35)										
<20 years	1.120	1.129	1.783***	1.155*	1.205*	1.277***	1.195*	1.128	1.149	1.141
>35 years	1.113	1.249	1.474**	1.055	1.077	1.285***	1.384***	1.037	0.843	1.083
Short birth interval (<24 mo.)	1.639***	1.779***	1.483***	1.668***	1.599***	1.783***	1.435***	1.732***	1.580***	2.444***
First born	1.193*	1.462**	0.824	1.585***	1.293***	1.086	1.569***	1.427***	1.229*	1.046
Mother's education (ref: no education)										
Primary	1.010	0.953	0.985	0.868*	0.923	0.921	0.727**	0.887	1.026	0.929
Secondary or higher	0.634**	0.700**	0.814	0.491***	0.679	0.750***	0.699	0.662**	0.852	0.85
Wealth (ref: poorest third)										
Middle third	0.901	1.002	0.983	1.044	1.161*	0.946	0.814**	0.903	0.771***	1.023
Richest third	0.861*	0.827	0.952	1.022	1.081	0.820***	0.673***	0.876	0.793**	0.895
Water source (ref: unimproved)	0.990	1.054	0.89	0.997	0.986	0.929	0.893	0.991	0.936	1.189
Toilet type (ref: unimproved)	0.888	1.238	0.753*	0.931	0.972	1.065	0.999	1.023	0.989	1.018
Later time period (2005-2010)	0.749***	0.786*	0.795*	0.772***	0.683***	1.020	0.8756**	0.832*	0.638***	0.802*
N	21,685	6,571	12,553	25,185	17,415	36,102	18,238	16,600	14,497	9,334

[a]Source: DHS Surveys 1995-2010 (Benin, Ghana, Kenya, Mali, Niger, Nigeria, Senegal, Uganda, Zambia, Zimbabwe)
Exponentiated coefficients; * p<.05, ** p<.01, *** p<.001

BIBLIOGRAPHY

Allison, P. D. 1994. Using panel-data to estimate the effects of events. *Sociological Methods & Research* 23(2): 174-199.

Antai, D. and T. Moradi. 2010. Urban area disadvantage and under-5 mortality in Nigeria: the effect of rapid urbanization, *Environmental Health Perspectives* 118(6): 877-883.

Antai, D., S. Wendren, R. Bellocco and T. Moradi. 2010. Migration and child health inequities in Nigeria: a multilevel analysis of contextual- and individual-level factors, *Tropical Medicine and International Health* 15(12): 1464-1474.

Antoine, P. and F. G. Mbodji. 1991. La mortalité des enfants au Sénégal, *African Population Studies* 5: 18-35.

Avogo, W. and V. Agadjanian. 2008. Childbearing in crisis: War, migration and fertility in Angola. *Journal of Biosocial Science* 40(5): 725-742.

Balk, D., T. Pullum, A. Storeygard, F. Greenwell and M. Neuman. 2004. A spatial analysis of childhood mortality in West Africa, *Population, Space and Place* 10: 175-216.

Beauchemin, C. and P. Bocquier. 2004. Migration and urbanisation in Francophone West Africa: An overview of the recent empirical evidence. *Urban Studies* 41(11): 2245-2272.

Bocquier, P. 2005. World Urbanization Prospects: an alternative to the UN model of projection compatible with the mobility transition theory. *Demographic Research* 12: 197-236.

Bocquier, P., N. J. Madise and E.M. Zulu. 2011. Is there an urban advantage in child survival in sub-Saharan Africa?, Evidence from 18 countries in the 1990s. *Demography* 48(2): 531-558.

Bocquier, P., D. Beguy, E. M. Zulu, K. Muindi, A. Konseiga and Y. Ye. 2011. Do Migrant Children Face Greater Health Hazards in Slum Settlements? Evidence from Nairobi, Kenya. *Journal of Urban Health-Bulletin of the New York Academy of Medicine* 88: 266-281.

Brockerhoff, M. 1994. The impact of rural-urban migration on child survival, *Health Transition Review* 4(2): 127-149.

Brockerhoff, M. and X. Yang. 1994. The impact of migration on fertility in sub-Saharan Africa. *Social Biology* 41(1-2): 19-43.

Brockerhoff, M. 1995. Fertility and family planning in African cites: the impact of female

Migration, *Journal of Biosocial Science* 27(3): 347-358.

Brockerhoff, M. (1998). Migration and the Fertility Transition in African Cities. In R. E. Billsborrow (ed.) *Migration, Urbanization and Development: New Directions and Issues*. Norwell, MA, Kluwer Academic Publishers.

Brockerhoff, M. and E. Brennan. 1998. The poverty of cities in developing regions. *Population and Development Review* 24(1): 75-114.

Chattopadhyay, A., M. J. White, C. Debpuur, et al. 2006. Migrant fertility in Ghana: Selection versus adaptation and disruption as causal mechanisms. *Population Studies* 60(2): 189-203.

Cleveland, D. A. 1991. Migration in West Africa - a Savanna Village Perspective. *Africa* **61**(2): 222-246.

Chen, N., P. Valente and H. Zlotnik. 1998. What do we know about recent trends in urbanization? Migration, Urbanization, and Development: New directions and issues. New York, United Nations Population Fund (UNFPA)**:** 59-88.

Cleves, M., W. Gould, R.G. Gutierrez and Y. Marchenko. 2010. *An Introduction to Survival Analysis Using Stata, Third Edition*. College Station, Texas, Stata Press.

Cleland, J., S. Bernstein, A. Ezeh et al. 2006. Family planning: the unfinished agenda. Lancet 368(9549): 1810-1827.

Cleland, J. and C. Wilson 1987. Demand Theories of the Fertility Transition - an Iconoclastic View. *Population Studies* 41(1): 5-30.

Cohen, B. 1993. Fertility Levels, Differentials, and Trends. In Karen A. Foote, Kenneth H. Hill, and Linda G. Martin (eds.), Demographic Change in Sub-Saharan Africa, pp. 8-67. Washington, DC: National Academy Press.

Cohen, B. 2004. Urban growth in developing countries: A review of current trends and a caution regarding existing forecasts. *World Development* 32(1): 23-51.

Doll, C. N. H. and S. Pachauri 2010. Estimating rural populations without access to electricity in developing countries through night-time light satellite imagery. *Energy Policy* 38(10): 5661-5670.

Dorelien, A., D. Balk and M. Todd. 2013. What Is Urban? Comparing a Satellite View with the Demographic and Health Surveys. *Population and Development Review* 39(3): 413-439.

Dyson, T. 2010. Population and Development: The Demographic Transition. London, UK, Zed Books.

Easterlin, R. A. (1975). Economic Framework for Fertility Analysis. *Studies in Family Planning* 6(3): 54-63.

Fay, M., D. Leipziger, Q. Wodon and T. Yepes. 2005. Achieving child-health-related Millennium Development Goals: The role of infrastructure, *World Development* 33(8): 1267-1284.

Fotso, J. C. 2007. Urban-rural differentials in child malnutrition: trends and socioeconomic correlates in sub-Saharan Africa, *Health and Place* 13(1): 205-223.

Fotso, J. C., A. C. Ezeh, N. J. Madise, and J. Ciera. 2007. Progress towards the child mortality millennium development goal in urban sub-Saharan Africa: the dynamics of population growth, immunization, and access to clean water, *BMC Public Health 7*(1), 218.

Global Rural-Urban Mapping Project (GRUMP). Accessed July 20, 2013 at http://sedac.ciesin.columbia.edu/data/collection/grump-v1

Goldstein, S. 1973. Interrelations between Migration and Fertility in Thailand. *Demography* 10(2): 225-241.

Gould, W. T. 1998. African mortality and the new 'urban penalty', *Health and Place* 4(2): 171-181.

Gunther, I. and K. Harttgen. 2012. Deadly Cities? Spatial inequalities in mortality in sub-Saharan Africa, *Population and Development Review* 38(3): 469-486.

Haines, M. R. 1995. Socio-economic differentials in infant and child mortality during mortality decline: England and Wales, 1890-1911. *Population Studies* 49(2): 297-315.

Henderson, J. V., A. Storeygard and D. N. Weil. 2012. Measuring Economic Growth from Outer Space. *American Economic Review* 102(2): 994-1028.

Kandeh, B. S. 1989. Spatial variations in infant and child mortality levels in Sierra Leone, *African Population Studies* 2: 18-38.

Kearns, G. 1988. The urban penalty and the population history of England, in A. Brandstom and L.G. Tedebrand (eds), Society, Health and Population During the Demographic Transition. Stockholm, Alqvist and Wikesell**:** 213-236.

Kirk, D. and B. Pillet 1998. Fertility levels, trends, and differentials in sub-Saharan Africa in the 1980s and 1990s. *Studies in Family Planning* 29(1): 1-22.

Kulu, H. 2005. Migration and fertility: Competing hypotheses re-examined, *European Journal of Population* 21(1): 51-87.

Lee, B. S. 1992. The Influence of Rural-Urban Migration on Migrants Fertility Behavior in Cameroon. *International Migration Review* 26(4): 1416-1447.

Macassa, G., G. Ghilagaber, et al. 2003. Trends in infant and child mortality in Mozambique during and after a period of conflict, *Public Health* 117(4): 221-227.

Macro International. 1996. Sampling Manual. *DHS-III Basic Documentation No.6.* Calverton, MD.

Mitchell, J. C. 1990. Social factors in child mortality in a sample of urban women, in B. Fetter (ed), Demography from Scanty Evidence: Central Africa in the Colonial

Era. Boulder, Colorado and London: Lynne Reinner, pp. 235-244.

Montgomery, M. R. 2008. The urban transformation of the developing world. *Science* 319(5864): 761-764.

Montgomery, M. R. 2009. Urban poverty and health in developing countries, *Population Bulletin* 64(2).

Montgomery, M. R. and A. C. Ezeh. 2005. The health of urban populations in developing countries: An overview, in S. Galea and D. Vlahov (eds.), Handbook of Urban Health: Population, Methods and Practice. New York, Springer Science, pp. 201-222.

Montgomery, Mark. 2011. "The Demography of the Urban Transition: What We Know and Don't Know." In Martine, G., McGranahan, G, Montgomery, M. and R. Fernandez-Castilla, (eds.), The New Global Frontier: Urbanization, Poverty and Environment in the 21st Century.

Mosley, W. H. and L. C. Chen. 1984. An analytical framework for the study of child survival in developing countries, *Population and Development Review* 10:25-45.

National Research Council. 2003. Cities Transformed: Demographic Change and Its Implications in the Developing World. Washington, DC, The National Academies Press.

Omondi, C. O. and E. H. Ayiemba. 2005. Fertility differentials in Kenya: The effect of Female Migration. *African Population Studies* 20(2): 25-42.

O'Neill, B. and D. Balk. 2001. World population futures. *Population Bulletin* 56(3): 3-38.

Oucho, J.O. and W.T.S. Gould. 1993. Internal migration, urbanization and population distribution. In Karen A. Foote, Kenneth H. Hill, and Linda G. Martin (eds.), *Demographic Change in Sub-Saharan* Africa, pp. 8-67. Washington, DC: National Academy Press.

Parrado, E. A. 2011. How High is Hispanic/Mexican Fertility in the United States? Immigration and tempo considerations. *Demography* 48(3): 1059-1080.

Potts, Deborah. 2008. The Slowing of sub-Saharan Africa's urbanization: evidence and implications for urban livelihoods. E*nvironment & Urbanization* 21(1): 253-259

Preston, S. H. and M. R. Haines 1991. Fatal Years: Child Mortality in Late Nineteenth-Century America. Princeton, N.J., Princeton University Press.

Preston, S., Heuveline, P. and M. Guillot. 2001. *Demography: Measuring and Modeling Population Processes.* Malden, MA: Blackwell Publishing.

Romaniuk, A. 2011. Persistence of High Fertility in Tropical Africa: The Case of the Democratic Republic of the Congo. *Population and Development Review* 37(1): 1-28.

Rutstein, S. O. and G. Rojas 2003. *Guide to DHS Statistics*: *Demographic and Health*

Surveys Methodology. Calverton, MD, ORC Macro.

Rutstein, S. O. and J. Kiersten 2004. The DHS Wealth Index. *DHS Comparative Reports No. 6*. Calverton, MD, ORC Macro.

Rutstein, S. and G. Rojas. 2006. Guide to DHS Statistics. Calverton, Maryland.

Schoumaker, B., Vause S., and Mangalu, J. 2010. Political Turmoil, Economic Crisis and International Migration in DRC Congo, in Demographic Responses to Economic and Environmental Crises. Proceedings of the IUSSP Seminar, Kahiwa, Japan, Reitaku University.

Schoumaker, B. 2013. A Stata module for computing fertility rates and TFRs from birth histories: tfr2. *Demographic Research* 28: 1093-1144.

Shapiro, D. and O. Tambashe. 2002. Fertility transition in urban and rural areas of sub-Saharan Africa: Preliminary evidence of a three-stage process. *Journal of Africa Policy Studies* 8: 103-127.

Shapiro, D. and B. O. Tambashe. 1994. The impact of women's employment and education on contraceptive use and abortion in Kinshasa, Zaire. *Studies in Family Planning* 25(2): 96-110.

Stephenson, R., Z. Matthews, and J.W. McDonald. 2003. The impact of rural-urban migration on under-two mortality in India. *Journal of Biosocial Science* 35(1): 15-31.

Van de Poel, E., O. O'Donnell, and E. Van Doorslaer. 2007. Are urban children really healthier? Evidence from 47 developing countries. *Social Science and Medicine* 65(10): 1986-2003.

Van de Poel, E., O. O'Donnell, and E. Van Doorslaer. 2009. What explains the rural-urban gap in infant mortality: household or community characteristics? *Demography* 46(4): 827-850.

Tacoli, C. 2003. The links between urban and rural development. *Environment and Urbanization* 15(1): 3-12.

United Nations, Department of Economic and Social Affairs, Population Division. 2010. *World Population Prospects: the 2010 Revision.* *http://esa.un.org/unup/* New York.

United Nations, Department of Economic and Social Affairs, Population Division. 2012. *World Urbanization Prospects: The 2011 Revision.* *http://esa.un.org/unup/*

United Nations, Department of Economic and Social Affairs, Population Division. 2013. *World Population Prospects: The 2012 Revision.* http://esa.un.org/unpd/wpp/index.htm

United Nations Human Settlements Program [UN-Habitat]. 2003. The Challenges of Slums: Global report on human settlements. London, UN-Habitat.

________ 2010. The State of African Cities 2010: Governance, Inequality and Urban

Land Markets. Nairobi, UN-Habitat.

Van de Poel, E., O. O'Donnell, and E. Van Doorslaer. 2009. What explains the rural-urban gap in infant mortality: household or community characteristics? *Demography* 46(4): 827-850.

Van de Poel, E., O. O'Donnell, and E. Van Doorslaer. 2007. Are urban children really healthier? Evidence from 47 developing countries, *Social Science and Medicine* 65(10): 1986-2003.

Wang, Limin. 2002. Determinants of child mortality in LDCs: Empirical findings from demographic and health surveys, *Health Policy* 65: 277-299.

Williamson, J. G. 1982. Was the industrial revolution worth it? Disamenities and death in 19th Century British towns, *Explorations in Economic History* 19(3): 221-245.

White, M. J., et al. 2005. Urbanization and the fertility transition in Ghana. *Population Research and Policy Review*. 24(1): 59-83.

White, M.J., S. Muhidin, et al. 2008. Urbanization and fertility: an event-history analysis of coastal Ghana. *Demography* 45 (4): 803-816.

Woods, R. 2003. Urban-rural mortality differentials: An unresolved debate. *Population and Development Review* 29(1): 29-44.